論文 / 著書情報
Article / Book Information

題目(和文)	
Title(English)	A social system simulation based on human information processing
著者(和文)	小林一郎
Author(English)	Kobayashi Ichiro
出典(和文)	学位:博士(工学), 学位授与機関:東京工業大学, 報告番号:甲第3103号, 授与年月日:1995年12月31日, 学位の種別:課程博士, 審査員:
Citation(English)	Degree:Doctor (Engineering), Conferring organization: Tokyo Institute of Technology, Report number:甲第3103号, Conferred date:1995/12/31, Degree Type:Course doctor, Examiner:
学位種別(和文)	博士論文
Type(English)	Doctoral Thesis

A Social System Simulation Based on Human Information Processing

by

Ichiro KOBAYASHI

Supervised by

Professor Michio SUGENO

Dissertation
Submitted in Partial Fulfillment of the
Requirements for the Degree of
Doctor of Engineering

at
Department of Systems Science Tokyo Institute of Technology

1995

Acknowledgements

The author wishes to thank his supervisor Professor Michio Sugeno for his faithful supervising of him, and also thanks Professor Toshiaki Murofusi, Dr. Seiichiro Sakurai, Dr. Akira Utsumi for their useful discussions with him.

He would like to give special thanks to Professor Christian Matthiessen. If he had not received his heartful and useful support, he could not have finished writing his dissertation.

He also would like to give special thanks to Dr. Howard A. Winston for his useful discussions with him, reviewing his dissertation, and friendship with him.

Many people have provided valuable assistance in various ways while this dissertation was being written. He would like to collectively thank them all: Ms. Kuniko Miyakawa for her assistance for his official procedures in his study life at Tokyo Institute of Technology and her kindness to him; Dr. Michel F. Griffin for reviews, providing useful comments, and friendship with him; Dr. Gai-Kark Park, Dr. Takahiro Yasukawa, Dr. Soon Hak Kwon, Mr. Yoshiyuki Fukuyama, Mr. Junji Nishino, Dr. Katsushige Fujimoto, Mr. Yutaka Maeda, and other members of Sugeno laboratory for providing useful comments, and their friendships with him; Mr. Daisaku Ueno, Mr. Masaya Watada, and Ms. Asami Kaneko for their friendships with him.

He also gives special thanks to Kenji Sagawa, Akemi Sagawa, Haruka Sagawa, Yurika Sagawa, and Jiro Kobayashi. They always cheered him up and supported his study life.

His best thanks go to his parents, Yoshio Kobayashi and Chieko Kobayashi. They did not only give an opportunity to work on this dissertation, but also always supported and helped him willingly. He prouds of being a son of them. And, he loves and respects them deeply.

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Chapter 1

Introduction

1.1 Motivation and Purpose

The present time is called the age of information. The information industry has made remarkable progress, and with this progress, information has come to control and influence human behavior in society. Thus, our society of today can be thought as an information-oriented society. To deal with a huge amount of information, computers have spread throughout society, and with this spread, various kinds of information techniques have also made remarkable progress. In particular, recently we often hear the word, "*multimedia*[1]", this word is a key word symbolizing the present-day progression of information techniques. All the information techniques , including the multimedia technique, have developed for saving a huge amount of information, achieving the higher efficiency of communication, and realizing human comfortable communication systems. However, the only system which exists that can achieve these goals so far is the human brain - except for saving a huge amount of factual information. This fact makes us recognize the most useful communication system is the human communication system, and leads us to construct an information system imitating human information processing. Therefore, as the purpose of our work, we aim to realize human information processing in a computer.

When we consider human information processing, we have to consider that the use of language plays a central role in it. This idea comes from philosophers who investigated human intellectual activities from viewpoint of the uses of semiotic systems including language[2], such as Ludwig Wittgenstein(1889-1951), Charles Sanders Peirce(1839-1914), and so on. They gave

[1] *"Multimedia"* means dealing with various kinds of information simultaneously.

[2] For this reason they are sometimes called linguistic philosophers.

us excellent considerations about the relation between human intelligence and the role of language and semiotic systems. We apply their ideas to realize a type of computing based on human intellectual information processing, and we call our proposed computing "*intelligent computing*[3]." The basic concept of intelligent computing is based on using language as the informational currency of computer processing. Therefore, we need a framework of understanding language: what language is, how language should be defined in a computer, and so on. We apply systemic functional linguistic theory to this framework, because the concept of this linguistic theory has much in common with the ideas of the above philosophers. By using these ideas and the theory, we proposed several methods for using language in information processing. As the representative methods which we proposed, we can cite a linguistic model for expressing human thinking processes, how to express the functional aspects of language –including information fusion based on language–, and representing social context.

As an example of human intelligent information processing, we consider a human thinking process, especially, we show a process of estimating the future trend of a social system[4]. When we estimate the future trend of a social system, we usually use a mathematical model which describes a social system approximately using structured equations with numerical data. There are, however, many cases where social scientists can get better results from a simulation than from a simulation based on a mathematical model. We think the reasons for this are that they use various kinds of information in their estimating process, understand all information linguistically and apply this information to their estimating process, and so on. Considering these facts, in this paper, as the main purpose of our work, we model a human thinking process with linguistic expressions, and apply it to simulating the future trend of a social system as a forecast model. Hence, we can also propose a new simulation method which has a quite different viewpoint from conventional simulation methods.

As an example of our proposed methods for simulating a social system, we will show a simulation which estimates the future trend of foreign exchange rates, in particular, we deal with the yen dollar rate.

[3]In this paper, "*intelligent computing*" indicates a computing based on human linguistic behaviours.

[4]In this paper, a social system means a causal system which exists in a society.

1.2 Organization of the remainder of this dissertation

This dissertation consists of seven Chapters. In Chapter1, we have introduced the major concept and the overview of our work. We shall elaborate on these, as follows, in Chapter2 through Chapter7.

Chapter2: Simulation and Artificial Intelligence

In this chapter, we review the history of simulation and artificial intelligence. We discuss the importance of our approach to social system simulation.

Chapter3: Intelligent Computing

In this chapter, we discuss the background of intelligent computing, and its basic approaching to representing human intelligence in a computer. From this, we propose several methods for representing human intellectual information processing based on the role of language: a linguistic model, how to express functional aspects of language computationally, and how to represent social context in a computer.

Chapter4 : A Social Activity: Foreign Exchange Rate Forecast

In this chapter, we show the result of analysis of the foreign exchange rate forecast activity. Since we are constructing a foreign exchange trend forecast system based on a forecaster's estimating process, we need to analyze a detailed investigation of the estimating activity. The knowledge we extract is based on books, interviews with foreign exchange dealers and economists, and articles in economic newspapers.

Chapter5: Foreign Exchange Rate Forecast System

In this chapter, we talk about the construction of the implemented system which estimates the trend of foreign exchange rates. The system consists of three main parts for: economic conditions recognition, natural language processing, and inference. We will give detailed explanations of them.

Chapter6: Simulation Example

In this chapter, we show an example of a simulation in order to show how our proposed methods are applied and work. In the simulation example, we considered the fact that the yen rate shot up due to the statement by Mr. Malford, the U.S. Treasury Undersecretary, and actual numerical data between January 1991 and April 1992, and show the system's estimating process making use of them.

Chapter7: Conclusions

In this chapter, we review our approach. We discuss the significance of our proposed simulation method and computing, and consider what we found through our approach. Finally, we discuss the conclusion of our research and discuss our future work.

Chapter 2

Simulation and Artificial Intelligence

In this chapter we review the technology of simulation with artificial intelligence[75, 107]. First, we review the history of simulation, proposed so far, by reviewing the history of simulation software.

The evolution of simulation software can be divided into five periods[84]:

- 1955-1960,
  – the era of custom programming. Each application required rewriting of all necessary software.
- 1960-1966,
  – the first-generation simulation languages. Guided by K.D.Tocher's General Simulation Program, the first versions of GPSS, SIMULA, CSL, SIMSCRIPT, and GASP were introduced. These packages form the foundation for today's simulation software. SIMULA was the first object-oriented language. GASP was the first hybrid language allowing mixed modeling of discrete and continuous systems.
- 1967-1970,
  – the second-generation simulation languages. Primary these were revised versions of the first-generation languages. The publication in 1967 of the "CSSL Report" for continuous system simulation language established the equation-oriented approach as standard.

- 1971-1978,

  – the era of new features for existing languages. Interactive features appeared early in this period.

- 1979-1989-present(1994),

  This period reflects a change in the paradigm for the simulation process. Whereas previously the focus was on writing the program that performed the simulation, the focus has now become the model underlying the program. The use of graphic display interfaces and of development environments, such as TESS, also grew during this period. As a recent trend of simulation languages, many languages that include artificial intelligence (AI henceforth) technology have been developed, for example, OPS5, KL-ONE, and so on. These languages were developed primarily for building expert systems, not for simulation. However, during this latest period the relation between AI technology and simulation engineering has been getting closer.

According to this overview of the development of simulation languages, the history of the development of simulation methods is the history of the development of simulation languages. The simulation developers have explored useful tools for modeling and simulating a real system.

For many years, simulation languages have been written in general-purpose procedure-oriented languages [1] such as FORTRAN. This is the reason why numerical data is primarily used for simulating a system for long periods. However, system simulation does not have to be performed by only using numerical data, because there are many other elements that should be considered to simulate a system. Moreover, conventional simulation based on numerical data cannot produce results similar to those produced by humans. From these reasons, simulation developers focus on AI techniques to solve these problems. In particular, expert system technology has recently been applied to various kinds of simulation. We believe that this is the reason why a number of useful tools for building an expert system have some developed and, simulation developers came to be able to use them and to require the same high quality results produced by

[1] Five generations of general languages are also recognized[81]: first, machine languages; second, assembly languages; third, general-purpose higher-level languages such as FORTRAN; fourth, interactive(natural-language interface, graphics, etc.), specialized(spreadsheets, simulation languages, etc.), and application generator languages; and fifth, intelligent languages. The goal for fifth-generation languages is that they include the knowledge of the expert programmer so that the user can write programs for his or her needs without having programming expertise.

experts. This removed some problems associated with system modeling from only the numerical relation of system input-output data, system simulation by only using mathematical equations, and so on. Further, it provided user-friendly environments and enabled simulation developers to build more realistic, robust models that yield more reliable and useful results.

With the spread of simulation with AI technologies, there appears various kinds of simulation methods. Qualitative simulation and qualitative reasoning have become widely discussed topics in the recent AI literature. In particular, the qualitative simulation method, which can deal with qualitative information to simulate a system, has developed and is a useful method for describing the dynamics of physical systems. Many qualitative simulation methods have been studied so far[75]. A well-established mathematical model may be applicable in many situations for any of the four following reasons[14]:

1. Observational data may be uncertain or incomplete.

2. Precise mathematical models of the underlying physical processes may be unavailable or too complex for efficient reasoning.

3. The results of mathematical modeling must be further interpreted before they can be used by human or automated control systems.

4. Mathematical models carry only part of the modeling burden. Specifically, they cannot conveniently account for the appearance or disappearance of objects in the situation being modeled, and do not account for the processes by which an appropriate model is formulated.

Thus, although we would like to model the physical dynamics of an ill-structured system such as a social system, they cannot be expressed with well-established mathematical equations. The qualitative simulation method, on the other hand, can reason with incomplete data, and allows for description of system processes in terms of qualitative expressions such as $\{ -, 0, + \}$. Thus, the demand for this type of simulation method has recently increased. For these reasons, qualitative simulation is a major simulation method in use today.

As a simulation method which can deal with ambiguity and quantitative information, we can, first of all, cite a simulation method using fuzzy theory. Fuzzy theory can introduce human sensory information, expressed linguistically, into a simulation process and provides a system modeling technique using linguistic expressions. Much work on simulation using fuzzy theory

has been studied so far [104, 103, 105, 106, 60, 1, 124]. Wenstop and Kickert[104, 103][45] have introduced models which simulate a social system[2] using fuzzy theory. Their models are called verbal models. A verbal model is a system model described linguistically in terms of fuzzy propositions. By using fuzzy propositions to express a model of a real system, we can deal with incomplete and ambiguous information in a simulation process. Moreover, since fuzzy inference[3] has aspects of quantitativeness and qualitativeness, fuzzy theory might be able to bridge the gap between traditional studies in mathematical modeling and symbolic modeling in AI systems.

From what was mentioned above, we know that it is very important to consider what kind of tool we should use for modeling and simulating a real system. When modeling a real system, classical simulation methods based on only numerical information use mathematical equations for modeling a system, and qualitative simulation methods use qualitative equations, in particular, the fuzzy simulation method uses fuzzy propositions. However, if we would like to simulate a system as human beings do, we should consider human simulation methods and build a simulation model like human beings build in their heads. They do not use mathematical equations and precise information such as differential equations and numerical data, but they can produce good results from a simulation, sometimes a better result than that from a simulation based on numerical data. The reason for this is that they linguistically express all information that they observe, and simulate a system with this translated linguistic information. We can, therefore, say that natural language is a powerful tool for expressing the physical dynamics of a system. In this context, there has recently appeared some work which uses natural language as a tool for modeling the dynamics of a system[9, 3, 10]. Fishwick and Beck[9, 10] have proposed a simulation model using natural language for modeling the physical dynamics of a system. They regard the model as a human cognitive model for forecasting the future trend of a system. In their work, however, natural language is not used to present the information in a simulation process, but is used as a tool for describing a real system: In their system, natural language, given as input information to the system, is analyzed to build a mathematical model, a simulation is performed by using that model, and a scenario expressed with natural language is produced as the simulation result.

On the other hand, we think natural language must be a tool for human thinking as linguistic philosophers have proposed. Considering this, we propose a new simulation method using

[2]In their models, social models are described with system dynamics as proposed by J.Forrester[25].

[3]Fuzzy inference is inference with rules described with linguistic expressions using fuzzy sets.

language as the information of simulation processes, like humans do. This means that we consider natural language from the viewpoint that natural language plays a main role in human intelligence, in other words, a human thinking process can be performed by the use of language. Therefore, we do not produce a mathematical model from natural language information, but produce a linguistic model. On this point, there is a big difference between Fishwick and Beck's concept of a simulation model and ours. Thus, for our approach we propose a new simulation method that focuses on how a particular social group's intellectual activity is based upon their use of language and their customs. This represents how information processing based on the group's sense of values. We discuss and investigate the uses of language based on customs, in detail, in the following chapter, in order to introduce this concept in simulation.

Chapter 3

Intelligent Computing

In this paper, we propose a new framework for intelligent computing and apply it to develop a novel type of simulation. This is the core concept of our new proposed simulation method. The basic concept of our proposal is based on using language as the informational currency of computer processing. This idea comes from the philosophy of such linguistic philosophers as Ludwig Wittgenstein and Charles Sanders Peirce. According to Wittgenstein's latter philosophical investigations(1933-1951)[111], human intellectual activities are performed through the use of language. He proposed the concept of a 'language game' and made thoughtful investigations of the relation between language and human intellectual activity. The language game was the main philosophical investigation in his latter period, and it indicates that language plays a very important role in human intellectual activity and that this activity also depends on custom. Wittgenstein focused on the uses of language in daily life and showed that language meanings are determined by the uses of language in a particular social activity. Thus, we focus on social activity in a particular social group(i.e., custom) in order to understand how information processing can be based on the use of language. Custom is described and represented as cultural constraints in social semiotics. As a linguistic theory which describes linguistic systems from the viewpoint of social semiotics, we can cite systemic functional linguistic theory. This linguistic theory provides us with a basic concept about the relation between a linguistic system and its social environment, and it enables us to deal with information in a social semiotic or linguistic way.

We explain the background of intelligent computing in the following section.

3.1 Background of Intelligent Computing

The basic approach of conventional logic theory, as represented by Descartes's work, is to consider everything rationally. In other words, the basic concept of this theory is to express all phenomena logically with the deductive method. Thus, uncertainty, common sense and other concepts which can not be explained with logic were disposed of by logic as being meaningless.

There are many attempts to explore language by taking a logical approach in the field of linguistics. We can take up Chomsky's work as the most representative one[13]. Chomsky proposed generative grammar [1], and it came to be said that he is the linguist who changed linguistics into a science because his approach to exploring language is based on the deductive method. In this sense, we may say he is the Descartes of linguistics. His idea was very innovative and was accepted by computer engineers in the 1960's because his theory is explicit and thus easy to implement in a computer. The foundation of many of today's natural language processing techniques might be based on his ideas.

There were, however, many linguistic philosophers who were opposed to dealing with language rationally. We can nominate Ludwig Wittegenstein(1889-1951) as a remarkable person among them. He is a representative philosopher of this century and gave us excellent ideas about the relation between human intelligence and language. He investigated the relation between the universe and philosophical identity through language and proposed the concept of 'image theory' in the early period of his philosophy(1913-1929)[110]. However, he rejected this early work in his latter period when he proposed the concept of a 'language game'. The big distinction between his work in these periods is his different point of view on the concept of 'meaning'. The concept of 'language game' is regarded as all the acts performing by language. He emphasized the role of language in human intelligence by saying "Language is itself the vehicle of thought(§ 329 [111])." Moreover, in the concept of a language game he focused on the role of practical knowledge based on customs in human intellectual activities and declared that descriptions of human intellectual activity should place much less emphasis on mental activities than on social activities [59]. In fact he declared that the meaning of language can only be determined by how

[1] Generative grammar consists of sets of rules to generate tree structures of sentences. Since 1957 this theory has been used to explore linguistic systems in order to find rules that explain the grammatical structure of sentences since 1957. Thus, the history of generative grammar is the history of work to develop effective sentence generation rules, and with the spread of this theory, the purpose of the work has moved to considerations of how to generate all grammatical sentences with such rules.

language is used in social contexts. He concluded that human intelligence is based on the daily language, life style, and so on included in customs.

As well as Wittgenstein, Charles Sanders Peirce(1839-1914) [2] regarded the role of semiotics and language in human intellectual activities as also being very important. He studied human inference from a semiotics perspective and declared that inference is the basis of human intelligence[121]. He said that human thought consists of language and other semiotic systems, therefore, humans can only understand things that can be conveyed by semiotic systems. Moreover, he also said that as the complexity and variety of human experience, knowledge and thought increase, the meaning of their linguistic expressions must also increase in richness and scope, and vice versa[122].

For the reasons mentioned above, we should focus on semiotic systems when we consider human intelligence. Although conventional logic has disposed of common sense, uncertainty, and other concepts included in language and in other semiotic systems, they are really an important quality of human intelligence and exist in our daily lives. Thus, we should notice them when we build a model of human thinking to describe thought processes. To deal with the uncertainty connected to language and to consider language from a social semiotic perspective, we introduce fuzzy theory and systemic functional linguistic theory. Fuzzy theory provides a basis for describing the uncertainty inherent in language, and systemic functional linguistic theory is a functional linguistic theory based on social semiotics.

Zadeh proposed fuzzy logic theory in 1965[125]. This theory is based on a quite different concept than conventional logic theory, because fuzzy theory has been studied as a way of introducing human subjectivity into science, while, conventional logic theory's approach has removed human subjectivity from science. However, human subjectivity is closely related to language and also plays a very important role in human intelligence[87]. In particular, Zadeh's idea is an innovative way to deal with uncertainty by using linguistic expressions in inference. By using this theory, we can deal with uncertainty and realize linguistic inference based on the character of language. As Wittgenstein and other linguistic philosophers said, we should notice customs(i.e., conventional constraints[3]) to understand the meaning of language. That is to say, language will have meaning only by being used in a social context, and the use of language is

[2] A representative American philosopher of pragmatics and modern logic theory.

[3] Conventional constraints is constraints shared by members of a particular social group. They builds up custom of a particular social group.

decided by the sense of values of each social group. We, therefore, should first describe the cultural background of a social group and its activities through social semiotics.

As a linguistic theory that considers language from the point of view of social interaction in daily life, we can take up systemic functional linguistic theory. This linguistic theory is a functional linguistic theory[4], has focused on the uses of language in social interaction, and has introduced the concept of social semiotics to consider linguistic systems. The basic concept of this linguistic theory was proposed by B.Malinowski (1884-1942)[51], who was a cultural anthropologist and ethnographer. J.R.Firth(1890-1960) extended his ideas and adapted them to fit into a linguistic theory. Recently, M.A.K.Halliday(1925-) is a leading representative of SFLT. Halliday's work is currently being extended further by other researchers in systemic functional linguistics. Halliday says that language plays a very important role for human beings growing up as social animals[30]. Systemic linguists consider language to be a social semiotic system, and have explored language from a social semiotics perspective.

3.2 Systemic Functional Linguistic Theory

As a linguistic theory that considers language from the viewpoint of social semiotics, we can, first of all, take up systemic functional linguistic theory(SFLT henceforth). SFLT is a functional linguistic theory, and has focused on the uses of language in social interactions, in other words, it describes the relation between language and the social environment which surrounds language from a social semiotic perspective. The basic precepts of SFLT were proposed by Malinowski early in the twentieth century[51], and extended by Firth in the 1950's, and more recently by Halliday and his colleagues, primary in England and Australia.

Systemic grammar developed somewhat independently of American generative linguistics and it approaches language structure from a different starting point. This linguistic theory regards language as a social semiotic system. In particular, it has a basic concept that "**all texts are manifested by context**[35][114]." We will explain, in turn, the terms and the basic concepts discussed in SFLT.

[4]Functional linguistic theory regards language as social interaction, and takes an approach to discussing linguistic systems pragmatically.

3.2.1 Text

Text is regarded as a semantic unit in SFLT. This means that a text is formed through a social interaction, and has a social meaning. The meaning of a text is determined by the selection of its meaning potential [5] from social codes[30]. Social codes consist of the sense of values in a particular social group, and are expressed as social semiotic systems (see below). Since a text is embedded in a social context, the selection of its meaning potential is performed by that context. The relation between context and text is shown in Fig.3.1.

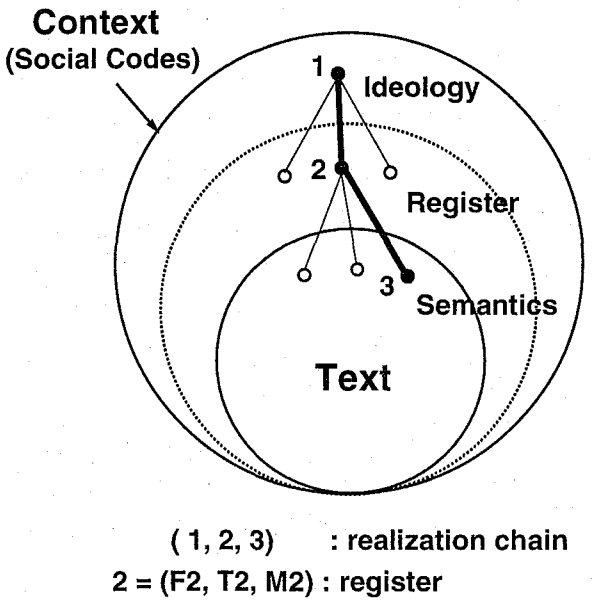

Figure 3.1: Relation between context and text

3.2.2 Context

The context corresponds to that which we call social code, and consists of two different kinds of context in SFLT: 'the context of culture' and 'the context of situation'. The context of culture corresponds to ideology, common sense, and so on which are based on the sense of values in a particular social group. The context of situation is a linguistic environment of a social interaction. The semiotic structure of the context of situation is formed out of the three sociosemiotic variables of field, tenor, and mode. Field indicates 'what takes place in

[5]The meaning potential is the set concept of a concept of all successive refinements of that shared by members of a particular social group.

the discourse', Tenor indicates 'who takes part in the discourse', and Mode indicates 'what channel is used in the discourse'. A pattern of field, tenor, and mode, can be thought of as resonating in a semantic system. A register is a semantic configuration typically associated with a set of situation types under consideration, and it thus specifies a range of meaning potential [6]. The specification of the register by the social context is in turn controlled and modified by social code. A social code consists of many systems: linguistic, genre, register, ideologic, and so on[117][54][57][53]. Each system [7] has its own internal organization and is connected to other systems in a realization chain[8]. Thus, systems are part of a multi-stratified relationship. From what has been said, we can understand that the selection of meaning potentials are controlled by social codes, hence, linguistic system is manifested by social codes. Therefore, we can understand the reason why the basic concept of SFLT is "a text is manifested by its context."

Let us overview the relation between language and context. Language embedded in a context and together they are comprised of a set of systems ordered in symbolic abstraction[57]. That is, these systems are stratified as shown in Fig.3.2.

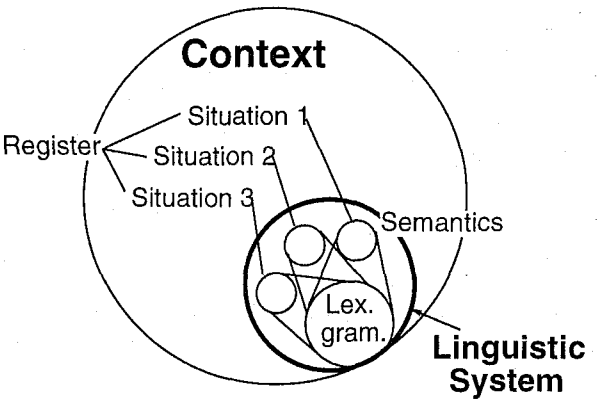

Figure 3.2: Stratification of language in context

[6]That is, a register is a set of field, tenor, and mode triplets.

[7]In SFLT, the limits of information reference can be expressed with a related network called the '*system network*.' Although the system network is basically a network for describing grammar, some work on applying it to descriptions of context has been reported[52, 53]. Therefore, the system network can visually represent social code by graphically expressing the relationships of conventional constraints. Basic units of the network are found in notational conventions[36].

[8]A realization chain indicates the social semiotic relationship of selecting meaning potentials from each of these systems. It bridges the gap between the semiotic content of high-level cultural meanings and the semantic content of low-level linguistic meaning through a series of intermediate strata.

In addition to discussing the relation between the meaning of a text and its context, it is also very important to discuss the structure of that text. Because a text reflects its context, the structure of a text also reflects its context. When we consider the structure of a text from the viewpoint of social semiotics in a particular social group, we will find that each social group has its own forms for texts [9]. The structure of a text includes an activity sequence that has obvious affinities with various concepts developed in AI and cognitive psychology (e.g., frames, scripts, scenarios and schemata). Hasan has thoroughly explored the structure of texts [10] which is linguistically manifested[35].

3.2.3 SFLT in Natural Language Processing

There are many applications of systemic functional grammar(SFG henceforth) in natural language processing. As the most famous example, we can, first of all, cite the work by Terry Winograd[108]. He developed a very famous AI application called the 'blocks world.' His work was the first attempt to implement a natural language understanding system, and SFG was applied to describe the system's linguistic grammar. Subsequently, many natural language processing systems using SFG were developed. In particular, much natural language generation work using SFG has been developed by Matthiessen [55, 56], Matthiessen & Bateman [58], Bateman [6, 7, 5, 8], Patten [74], etc. We think the reason why SFG can be applied to text generation is that the basic concept of SFLT (i.e., 'all texts are manifested by context') is a very natural concept for this process.

SFLT has provided us with many useful theoretical backgrounds to develop various computing applications. Halliday and Matthiessen are trying to construct a human experience [11] model by drawing its theoretical base from SFLT[37].

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[9] As mentioned before, texts indicate events existing with a social meaning.

[10] It is called '*genre structure*'.

[11] Here, experience is defined as "the reality that we construct for ourselves by means of language." The structure and organization of experience is usually thought of as knowledge, having the form of conceptual taxonomies, schemata, scripts and the like. However, Halliday and Matthiessen offer an interpretation that is complementary to this, treating experience not as knowing but as meaning; and hence as something that is construed in language. In other words, they are concerned with the construction of human experience as a semantic system, and since language plays the central role not only in storing and exchanging experience but also in constructing it, they use language to interpret experience (i.e., as our interpretative base). Thus, they do not call their model a knowledge base, but instead a meaning base[37].

In order to realize a type of computing based on human intellectual activities, we need to consider how to represent the ideas of the above linguistic philosophers and SFLT computationally. We will show, in turn, the basic ideas related to this issue in the following.

3.3 Context Representation

If the basic concept of intelligent computing is to build a human thinking model based on the uses of language, then, we should use language as the informational currency of computer processing. To use language in such a way, we first have to represent the environment under which language is used for human intellectual activities and consider how humans deal with observed information under that environment. We can apply the concept of contexts in SFLT to this problem. Before representing the environment as something which corresponds to contexts in SFLT, we should reconsider 'the context of situation'. The context of situation seems to be defined from the viewpoint of a linguistic system, in other words, it is defined based on the lexico-grammatical characteristics of a particular situation. This approach is a bottom-up approach to deciding situation types. We, however, consider and distinguish situation types from the viewpoint of human information processing. This is the reason why we think that they should be defined based on social codes that include linguistic and other semiotic systems. That is to say, we assume that language is not the only tool for defining situation types, but that the other semiotic systems also play a role in doing so. In this sense, we define context as the environment in which semiotic systems exist. We represent custom in a particular social group by considering the group members' behavior in dealing with observed information under particular situations. Therefore, we focus on the relation between situations and knowledge [12]. This means that language and other semiotic systems are used by applying practical knowledge based on custom to an observed situation. From this idea, we can regard contexts as consisting of relations between situations and practical knowledge. Thus, we are mostly concerned about the question of how this relationship should be represented.

Generally speaking, situation can be regarded as the limits of information reference. Here, we can assume that limits of information reference are decided based on custom. Therefore, we introduce social semiotics to decide situation types. We show an overview of situation recognition

[12] In this paper, knowledge is synonymous with the constraints humans obey. In situation semantic theory, these corresponds to conventional, nomic, and necessary constraints[4].

in a social semiotics perspective in Fig.3.3[13].

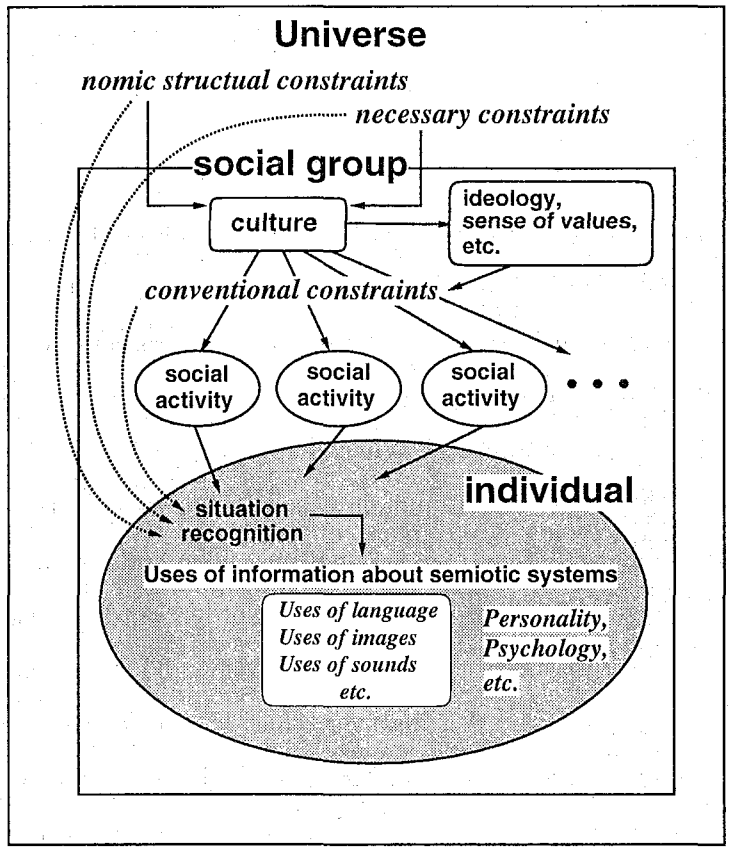

Figure 3.3: An overview of situation recognition

Fig.3.3 shows how situations are recognized. Culture, the origin of custom, is partly determined by physical environments and influences human spiritual life. Thus, the customs developed in a culture, and exist as various kinds of conventional constraints. Moreover, there exist various kinds of social activity that respect the conventional constraints and sense of values of a particular social group. In each social activity, those situation variables which should be recognized are decided based on these constraints. Humans also deal with the observed information in a way that depends on their sense of values. We think that human situation recognition activity can be regarded as a habit of human intelligent activity in a social semiotic sense. This

[13]The three types of constraints in Fig.3.3 –nomic structural, necessary, and conventional constraints– are explained in situation semantic theory. So, I will give brief definitions here. Nomic structural constraints correspond to natural laws. Necessary constraints correspond to necessary relations holding among the properties. Conventional constraints correspond to constraints that exist in a particular social group.

is the reason why we assume that a human being is a large-scale expert-system having customary knowledge.

3.3.1 Situation

As mentioned above, context is represented by the relation between situation and knowledge. In this section, we consider how that relation is derived by considering how situations are defined.

Situation Semantic Theory

As a theory of situations, we can, first of all, cite situation semantic theory proposed by Barwise and Perry[4]. Situation semantic theory(SST henceforth) is a theory which attempts to create an informational semantic theory. The framework of this theory is based on the idea of situations being composed of 'partial' descriptions of the real world. In fact, a real situation cannot be described completely. Thus, it is described by a set of basic pieces of information called 'infons' [14] σ_i. On the assumption that a situation S has already been given, it is described in the following form:

$$S \models \sigma_1, \sigma_2, \cdots, \sigma_n$$

This expresses that the situation S 'supports' the infons σ_i (i.e., the infons are concluded in the situation.)

In SST, a situation is a basic entity as are individuals, features, relations, etc., and has its own features and relations with other events. We live in an environment like that, are given information from that environment, and perform various kinds of activity. Humans and all other organisms live in the same reality and derive meaningful and relevant information relevant based on interactions between themselves and their environment. (In general, SST is based on ecological realism.) Accordingly, a situation is classified and individualized in ways that are uniquely suitable for each organism. In SST, to share the elements in each situation is called 'uniformity', and depending on this uniformity, each situation can be classified and assigned to a situation type. As examples of the elements, we can cite object, space-time, location, property

[14] A situation is represented by a set of Austinian propositions. Austinian proposition is usually expressed as s $\models \sigma$. The big difference between Austinian proposition and Russellian proposition is that the former deals with portion of the reality as its subject, on the other hand, the latter deals with the entirety of the reality as its subject.

[15], relation, and so on. Therefore, they are used in cases where situation types are classified. In SST, the meaning of a sentence is not determined by truth or falsehood, but by identifying what information flows in which portion of reality. In a word, the focus moves from the determination of truth or falsehood to the flow of information.

Generally speaking, if we are given a situation type 'smoke comes from something', then, we can easily infer another situation type 'something burns'. The reason for this is that we can recognize many constraint relations among situation types. In other words, we can say that we 'attune' ourselves to constraint relations in terms of SST[16]. Various kinds of constraints defined in SST are as follows[4]:

- **Necessary constraints**

  Constraints that arise from necessary relations holding among the properties that we recognize are called *necessary constraints.* For example, every woman is a human, every kiss is a touch, and every dog is a mammal.

- **Nomic constraints**

  There are inviolable patterns in nature. These patterns are usually called natural laws, and we call them *nomic structural constraints*

- **Conventional constraints**

  Another type of pattern is a *conventional structural constraint.* These are constraints that arise out of explicit or, more often, implicit conventions that hold within a community of living beings. An example of this sort of constraint is the relation between the ringing of a bell and the end of class.

- **Conditional constraints**

  Conditional constraints are not a fourth kind of constraint, as our numbering might suggest. Rather, this classification cuts across the grain of the other constraints. Conditional constraints are those which hold only in certain conditions.

The most important and useful advantage of SST is that it makes it possible to consider theoretically a portion of reality by adopting Austin's propositions to describe a situation. That

[15] A property can be thought of as a unary relation.

[16] The core concept of SST is the notion of a constraint. Constraints give rise to meaning; attunement to constraints makes life possible. Attunement to constraints is what allows an agent to pick up information from one situation and apply it to another.

is to say, it makes it possible to treat portions of and the limitations of information reference. This differs from set theory based on Russel's propositions. This problem is too involved to be treated here in detail. Moreover, as mentioned above, SST is based on the concept of ecological realism. This approach is different from our approach to describing situations, because our approach is based on social semiotics[17]. Although SST provides us with many useful investigations about how to treat situations (e.g., it can be applied to solving the frame problem[64], and other problems related to the efficiency of computation), we only use some basic concepts and terms proposed in SST in this paper.

3.3.2 Situation Recognition

We will explain situation recognition in terms of the key concept of 'attune'. The idea of 'attune' in SST is that humans follow various kinds of constraints unconsciously, and behave according to the sense of values of a particular social group. There, however, seems to be a lack of systemizing attunements to situations in SST. Therefore, it is not clear how the limits of meaningful information reference should be defined, how situation recognition should be defined, and so on. On this point, if we apply social semiotics to this problem, we can have a policy to represent situation recognition.

Members of a particular social group attune themselves to various constraints which exist in a particular social group, and they deal with the observed information obeying the constraints. This means that they have typical patterns of information processing that reflects their common sense of values, and we regard situation recognition activity as also being one of these patterns. Therefore, the information which exists in these typical patterns would be not regarded as important, and is not needed to explain the reason why the information exists. On the other hand, when the information, which cannot be explained by using ordinary information processing patterns, is observed, the observer tries to understand the meaning of the information. With this activity, he sets up limits of information reference in his head to understand the information. This can be thought of as an early step of situation recognition activity. Using this procedure, we try to clarify situation recognition activity based on custom. To clarify this activity, we consider the question of how the limits of information reference (i.e., a situation type) is decided.

[17] In SFLT, a situation is regarded as being defined from the viewpoint of the cognitive subject. Thus, various projections of the reality can be considered. On the other hand, we assume that the definition of situation type depends on customs in a particular social group, and humans do not have so many kinds of situation types.

Situation type

We assume that a situation type is defined by the constraints to which human beings attune themselves. Therefore, in order to represent a situation type in terms of custom, we should define it by knowing what constraints are included in it, and also specify, if constraints exist, a situation type that we assume includes them. Thus, situation types are systematized by reflecting the organization of constraints in social semiotic systems. On this point, there is a difference between situation semantic theory and our concept of situation recognition.

Constraints

We explore the character of the constraints[18] that define a situation type. As mentioned above in SST, there are several kinds of constraints having different characteristics. We can generally say that we attune ourselves more strongly to nomic and necessary constraints than conventional constraints. Therefore, we find that there exists, with regard to attunement to a situation, an order of priority among the constraints. In this paper, we say that '**the level of attunement is high**' when the constraints attune to a situation strongly(i.e., other situation types also share the same constraints), and we say that '**the level of attunement is low**' when the constraints attune to a situation weakly(i.e., the situation has its own unique constraints). This order of priority of the constraints determines the level of attunement in a situation, and shows what constraints are concluded in a situation. This can be summarized as follows:

Non-specific constraints exists $\longrightarrow$ **The level of attunement is high**
Specific constraints exists $\longrightarrow$ **The level of attunement is low.**

For example, let us consider the fact that we live on the earth. We conform to lots of environmental constraints which the earth gives us. We do not feel they are specific, and deal with them unconsciously. Thus, we say that we attune ourselves to the constraints strongly, and that the level of attunement is high. Furthermore, let us consider the case in which we drive a car. We conform to the specific constraints in the driving activity. These constraints are specific for the activity, so, it is not necessary that every person must have them. Thus, we say that we attune ourselves to the constraints weakly because it is a specific case and the level of attunement is low.

[18] In this paper, constraints is synonymous with knowledge.

We show the domain, or domains, of these constraints in Table.3.1.

Table 3.1: Domain of constraints

Level of Attunement	**Domain of Constraints**	**Frequency of Appearance of the Constraint**
strongest	Human existence environment	nomic, necessary
strong	Particular social group	conventional
normal	Particular social activity	conventional
normal	Human intellectual activity	mostly conventional

Generally, the regions containing different kinds of constraints are related by the following inclusional relationships.

particular social activity $\subset$ particular social group $\subset$ human existence environment

Human intellectual activity is also restricted by the constraints of its physical, social, and mental environments. Constraints generally indicate what information we should get from an observed situation, and what problems we should solve, and how we should solve them. We can, therefore, say that the behaviors, including the social meanings, are performed by obeying the conventional constraints of a particular social group.

Next, let us consider how humans process observations. From now on, for the sake of convenience, we call a situation which includes constraints attuning at a high level, '**a typical situation type**', and a situation which includes constraints attuning at a low level, '**a specific situation type**'. Generally speaking, the constraints in a specific situation type are regarded as more valuable information than the constraints in a typical situation type. The reason for this is that constraints routinely concluded are not useful for solving problems and have no effect on state changes. Thus, we may say that almost all of human inference is performed by using the constraints attuning at a low level. However, we should also keep in mind that the constraints attuning at a low level cannot exist without the constraints attuning at a high level.

From these considerations, we can explicate the relation between situations and knowledge. There is a close relation between situations and knowledge because situation type is determined by knowledge conventional constraints.(i.e., situations are classified according to conventional constraints.) Thus, knowledge is defined by considering the definition of a situation type. This means that the content of knowledge has to be in harmony with situation types. In this paper,

we assume that the human thinking process mainly consists of applying practical knowledge based on conventional constraints. Thus we regard memory-oriented knowledge representation[19] as very important to expressing human thought, as opposed to inference-oriented knowledge representation. This is because we assume a human being as a large-scale expert system having practical knowledge, and we think that the central role in human thinking processes should not be explained by mathematical methods (i.e., 'correct deductive inference') but instead by common sense, conventional judgment, and such knowledge which consists of practical knowledge. We consider representing memory-oriented knowledge from the viewpoint of the functional aspects of storing and applying constraints.

3.3.3 Knowledge Representation

Many knowledge representation methods have been proposed. As examples of popular knowledge representation methods, we can cite production rules, frames, and semantic networks. Such knowledge representations were developed based on various concepts for AI applications. However, we can generally say that they were developed by imitating human knowledge from a cognitive science perspective[20], that is, they were developed by imitating human memory ability, psychological characteristics, and so on. They were not developed by considering the relation between situations and knowledge, but can, in most cases, be regarded as useful for representing typological and ontological knowledge. We think that typological modeling of knowledge is based on the result of arranging observed information from the world, and hence it is hard to say that this knowledge representation is natural for representing human intelligence. Moreover, ontological modeling of knowledge seems not to be able to provide a policy for processing that information. We believe that human knowledge is used for solving problems (i.e., it should be practical knowledge), but not for representing the world. Therefore, in this paper, we take a different approach to knowledge representation from the conventional knowledge representation approach. We consider the role of custom in a particular social group, and represent human knowledge based on custom, (i.e., practical knowledge), assuming that human intellectual activity mainly consists of applying pieces of practical knowledge. In particular, since we represent practical knowledge, we should focus on constraints based on custom, that is, conventional con-

[19] Here, memory-oriented knowledge indicates the knowledge which stores lot's of conventional constraints of a particular social group.

[20] In this paper, we use the term 'cognitive activity' to express human mental activity.

straints. Conventional constraints necessarily exist in social situations, therefore, we cannot define knowledge without considering situations. Accordingly, we investigated functional aspects of practical knowledge, and we proposed three basic types of situation-based knowledge: 'inheritable knowledge', 'structured knowledge', and 'restricted knowledge'. We assume that practical knowledge consists of these types of knowledge for solving problems and accomplishing purposes in a social activity. The reason why we define these types of knowledge is motivated by principles in SFLT because SFLT provides us with ideas about the construction of linguistic systems. Language is a social phenomena manifested by social context, and human intellectual activities can also be a social phenomena. Because, as mentioned above, language plays a central role in human intelligence, we can model human intelligence by considering how linguistic systems are described in SFLT. Accordingly, we are going to express the relation between text and context mentioned in SFLT in human information processing terms. In SFLT, text is manifested by selecting meaning potentials from multi-stratified system networks, which form the sense of values of a particular social group. In our approach, we express the above relation functionally by representing hierarchical relations among situation types and three types of situation-based knowledge which consist of practical knowledge. We summarize the relation between our proposed representation method for human information processing based on custom and the basic concept of SFLT in Table 3.2.

Table 3.2: Comparison between our method and SFLT's

	Our Representation Method	**SFLT**
Context Representation	Relation between Situation and Constraints **(Inheritable Knowledge)** **(Restricted Knowledge)** **(Structured Knowledge)**	**Context of Culture** (sense of values, common sense) **Context of Situation** (The situation directly related to a linguistic system) **Genre Structure**
Description of the Context	Hierarchical Relation of Situation Types	Multi-Stratified Relation described with System Network

We will show detailed explanations of three types of situation-based knowledge.

- **Inheritable knowledge**

  This type of knowledge can be thought of as the constraints that attune at a high level, that is, it exists in typical situation types. It can be applied to any given situation type by inheritance through other situation types and is defined by considering the relation between situations and knowledge. This means that a situation must raise the efficiency of information processing. For example, if we are not given all available information, but have to infer something by using what is given, we can use contextual information to infer the missing information. In order to realize this process, we have to use an inheritance mechanism in our knowledge representation. In the sense that this knowledge type represents meta-knowledge, we can say that it corresponds to the context of culture in SFLT.

- **Structured knowledge**

  Structured knowledge corresponds to sequential procedural knowledge like scripts[21]. This type of knowledge represents the serial structure of a social activities. It corresponds to the genre structure of a text in SFLT, and (like inheritable knowledge) is also included in the context of culture, and is codified based on conventional constraints associated with a social activity. It plays a very important role in recognizing a situation, solving a problem, forecasting the future of an event, etc., which are built on the foundation of the human thinking structure.

- **Restricted knowledge**

  In this paper, the type of knowledge which is applied to a specific or a particular situation is called restricted knowledge. Restricted knowledge corresponds to the knowledge which exists in the context of situation in SFLT. Specific knowledge, such as which experts have, also belongs to this type of knowledge.

Our proposed knowledge representation method may be expressed with frames. However, it is not equivalent to frames. This is because our proposed knowledge representation is based on representing customs associated with the relation between situations and knowledge, that is, it is based on social semiotics. We have proposed some ideas, such as how to deal with information efficiently in a social semiotic sense, in our representation of contexts.

[21]The concept of a script was proposed by Schank[80].

3.4 Linguistic Model

Considering what we mentioned above, we propose a new model called a linguistic model for simulating a social system.

Wenstop[104, 103] and Kickert[45] have introduced models which simulate social systems using fuzzy theory and are constructed based on system dynamics. Their models are called verbal models and are system models described in terms of fuzzy propositions. These models consist of descriptions of mathematical expressions and use fuzzy sets as the informational currency of inference. The most outstanding characteristic of their models is that they express the dynamics of a system linguistically using fuzzy sets, and use them as a simulation model. Beck and Fishwick[9, 10] have proposed a qualitative simulation model of human cognitive processes involved in determining language meaning. They have suggested that qualitative simulations can be generated as a particular kind of cognitive model. This idea is similar to our concept for generating a simulation model. However, we do not focus on human cognitive activity, but also on human social activity when we model a human thinking process as a simulation model. Wittgenstein says that one of the basic characteristics of the use of language is obeying a *rule* [22] (§202, [111]), and obeying a *rule* is not an independent event, but it is a feature of an action performed in a context(§217, [111]). Therefore, we attempt to represent a human thinking model as a simulation model based on custom and the uses of language. The basic concept of a linguistic model is that it expresses a human thinking model and is generated based on context by following conventional constraints. This concept is the same as "All texts are manifested by context" in SFLT. The linguistic model does not consist of verbal descriptions of mathematical expressions but instead consists of human beings' practice or experience in solving problems in a social activity. Moreover, language is used as processing information in the model. Thus, the model has the same functions which language has. These are outstanding characteristics in our proposed model.

The comparison among linguistic models, mathematical models, and other models related to linguistic description is shown in Table 3.3.

The detailed construction of a linguistic model will be explained in Chapter 5.

[22] Here a *rule* means a conventional constraint in a particular social group.

Table 3.3: Comparison of models

Model Name	Mathematical Model	Verbal Model	Human Cognitive Model	Linguistic Model
Model Developer	—	**Wenstop&Kicker (1976,1979)**	**Fishwick&Beck (1989,1991)**	**Sugeno & Kobayashi (1993)**
Target of the Model	Structure of Object System	Social System	Human Thinking Process from a Cognitive Science Perspective	Human Thinking Process from a Social Semiotic Perspective
Method to Describe the System	Differential Equations	Fuzzy Rules	Qualitative Equations	Practiced Knowledge based on Custom & Fuzzy Rules
Information Processed in the Simulation	Numerical Data	Fuzzy Sets (Linguistic Values)	Textual Information	Textual Information & Numerical Data
Information of Inference	Numerical Information	Fuzzy Sets (Linguistic Values)	Qualitative Information	Language (Functions of language are realized in the model.)
Note	—	—	—	Information Fusion Contextual Information Processing

We will explain the functions of language, in detail, in the following section.

3.5 Functions of Language

The functions of language[23] include[12]:

- Information exchange(i.e., communication)
- Feeling expression
- Social interaction
- Information recording
- Human thinking

[23]There are many ideas about the functions of language. The linguist and philosopher of language Roman Jakobson has classified the functions of natural language into six categories: referential, connotative, poetic, phatic, metalingual, and emotive[41]. In this paper, however, we list the functions found in a linguistic encyclopedia[12].

In this paper, we focus on human thinking. In order to build a computational model of human thinking based on language, we have to be able to express language in a computer. However, we cannot express the real nature of language in a computer, therefore, we express some characteristics of language computationally so that we can model aspects of linguistic behavior in a computer.

We will describe several such aspects of language as follows:

1. **Information fusion**

   Language can be used to aggregate or unify various kinds of information. Human beings routinely aggregate information obtained through their five senses using language.

2. **Various forms**

   Language includes various forms of linguistic information. We consider three kinds of linguistic information in this paper: symbolic, qualitative, and quantitative linguistic information.

3. **Efficiency of information**[24]

   The meaning of language is decided by context. Because the meaning of a word depends upon its context, different uses of the same word will generally be associated with different meanings.

4. **Association of words**

   Words can be associated by considering all their possible meanings.

In this paper, we focus on the former three functions of language in information processing. In particular, we explain the concept of information fusion based on language in the next section.

Information fusion based on language

The concept of information fusion based on language depends on the fact that human beings aggregate information obtained through their five senses using language. This motivates the idea of unifying various kinds of information with language. This method will be useful for raising the efficiency of inference in a computer simulation, because it allows us to deal with information uniformly. In this paper, we assume that language consists of three kinds of linguistic

[24]This idea is the same as the idea of 'the efficiency of language' in situation semantic theory.

information: quantitative, qualitative, and symbolic. Each kind of information (e.g., numerical, natural language, etc.) is translated into one of these three linguistic categories of information. A fuzzy set can assume each form of linguistic information, because it has a fuzzy label that corresponds to qualitative and symbolic linguistic information, and its membership function corresponds to quantitative information. Therefore, it is very useful for changing one form of linguistic information to another. Hence, using fuzzy sets as the information of computer processing is very useful for achieving our proposal to fuse information in the common medium of language. However, we should notice that this does not mean fuzzy sets are used as language in information fusion, but rather as a tool for changing the forms of information. In this paper, as an example of information fusion with language, we merge numerical information and textual information.

3.6 Understanding based on Custom

It is impossible to clearly define an algorithm for the human understanding process because exploring the concept of 'understanding' is a philosophical problem, and there are many aspects, processes, and various kinds of activity associated with it. Roger C.Shank, a well known AI scientist who explores human intelligence from a cognitive perspective, described the understanding process as an explaining process, and explored various kinds of understanding by exploring different kinds of explaining[79]. In this paper, however, we do not focus on various understanding styles, but illustrate the most typical style of understanding based on custom.

We believe human understanding activity is also a social activity based on custom, and can be regarded as a problem solving activity. Thus, it is performed by applying inheritable, structured, and restricted knowledge because these three types of knowledge were defined as expressing the social codes exhibited in a particular social activity by a particular social group. Knowledge is applied by recognizing a situation that differs from an ordinary state (i.e., an attuned situation) because a deviation from an ordinary state needs to be explained. This is the core concept of problem solving activity. The same procedure is used when a linguistic model is constructed, during and used for problem solving. In summary, we can say that humans construct a linguistic model to understand observed information.

We will describe a typical understanding procedure as follows:

1. Observe unusual or interesting information.
2. Decide on a situation type from observed information.
3. Relevant information is inherited through a hierarchy of situation types, that is, available inheritable knowledge is applied to solving problems in this stage.
4. Structured knowledge is applied to constructing a procedure for problem solving, and restricted knowledge in the situation type is applied to solving problems.

Through this process, an appropriate linguistic model for problem solving is constructed.

The overview of information processing during an understanding activity is shown in Fig. 3.4.

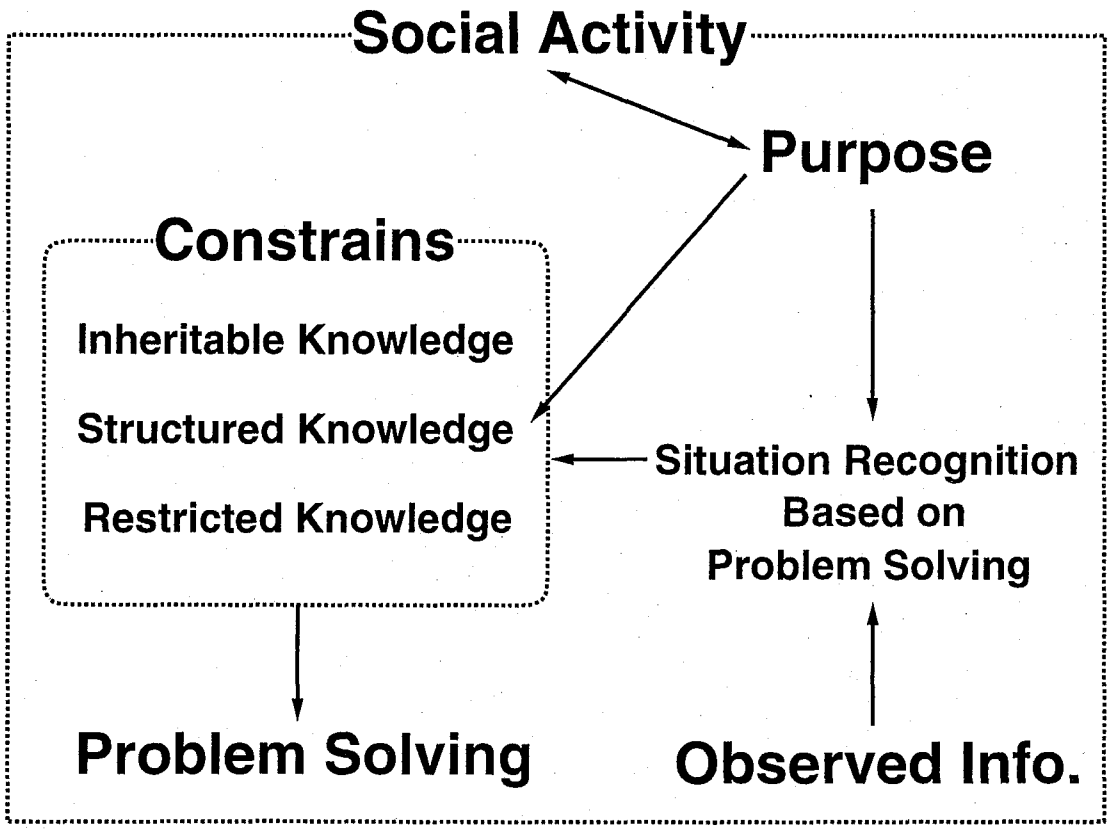

Figure 3.4: Overview of Understanding Activity

3.7 Overview of Proposed Information Processing

A basic purpose of proposing intelligent computing is the hope of developing improved information processing systems. With the progress of the information industry, high quality and high performance systems have been required. Here, high quality systems are human comfortable systems, and high performance systems are systems having significant information processing ability. As mentioned in the introduction, the only system which exists with these properties is the human brain. Considering this fact, we have proposed several methods to represent human information processing in this chapter. We believe that a system imitating human information processing will be required in the near future.

We illustrate an overview of our proposed information processing scheme in Fig. 3.5.

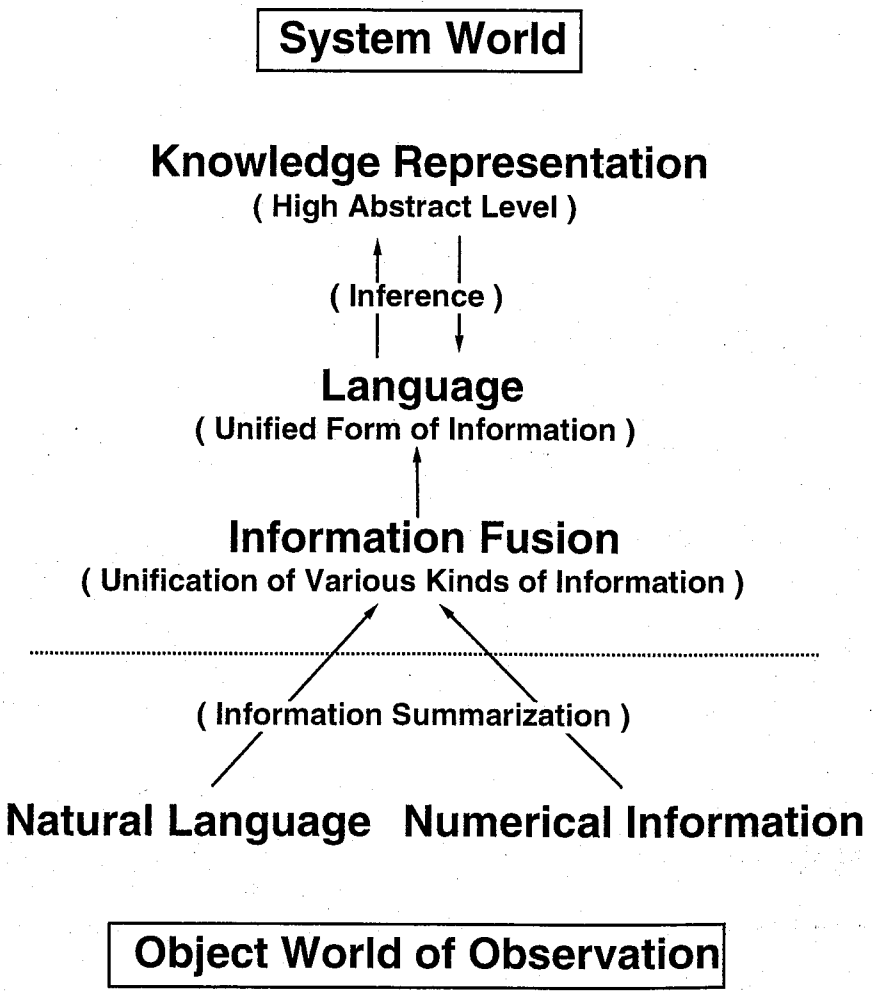

Figure 3.5: Overview of Proposed Information Processing

Various kinds of information in the object world of observation are translated into language by information fusion. (In Fig.3.5, we show two kinds of object information: natural language and numerical information.) According to this, all information is summarized semantically and made comparable with each other at a common level of information abstraction. If this unified information is expressed with language, then we can raise the efficiency of information processing. This means that we do not need to deal with each kind of information individually. This can provide an innovative revolution for the information industry, because we can reduce the development cost for a system that processes various kinds of information. (This method might be the basis for a future multimedia information processing industry.)

To use language as the medium of information processing and to represent human information processing in a computer, we discussed how humans process observations by reviewing some investigations by linguistic philosophers of the role of language in human intelligence. We also proposed how to represent information processing based on custom –more concretely, we proposed a relation between situations and knowledge that can be used for realizing human information processing in a computer.

Accordingly, we may be able to use language as the medium of information processing. In our proposal, knowledge should be expressed with natural language, because we believe that knowledge and natural language are one and the same. If knowledge is represented with highly abstract natural language expressions, it can be flexible enough to respond to any observed information. This means that knowledge, as well as natural language, can only be understood by considering its context, and the most suitable knowledge can be applied to solving problems. As a result, we do not need to develop complex reasoning mechanisms and can reduce the amount of knowledge in a system. We can, therefore, make intelligent information processing efficient.

Chapter 4

A Social Activity : Foreign Exchange Rate Forecasting

To demonstrate a social system simulation based on human intellectual activity, we take up the foreign exchange rate (FER henceforth) forecasting as an example of such a simulation. Since our proposed simulation method depends on information processing based on customs and the uses of language, we need detailed explorations of FER forecast activity to understand how information in this domain is influenced by customs. We are going to show the results of these explorations in this chapter. Domain knowledge was extracted from articles in economic newspapers, interviews with economic researchers, foreign exchange dealers, and so on.

4.1 Main causes of FER changes

There are many elements which influence foreign exchange rates: world news, release of economic indices, statements by very important person(s) (VIP henceforth), and so on. We apply our proposed methods (i.e., information fusion based on language and a linguistic model) to simulating the future trend of FERs, especially, yen-dollar trends. The main causes of FER change are shown in Fig. 4.1. (The detailed elements in each cause are described in Appendix A.)

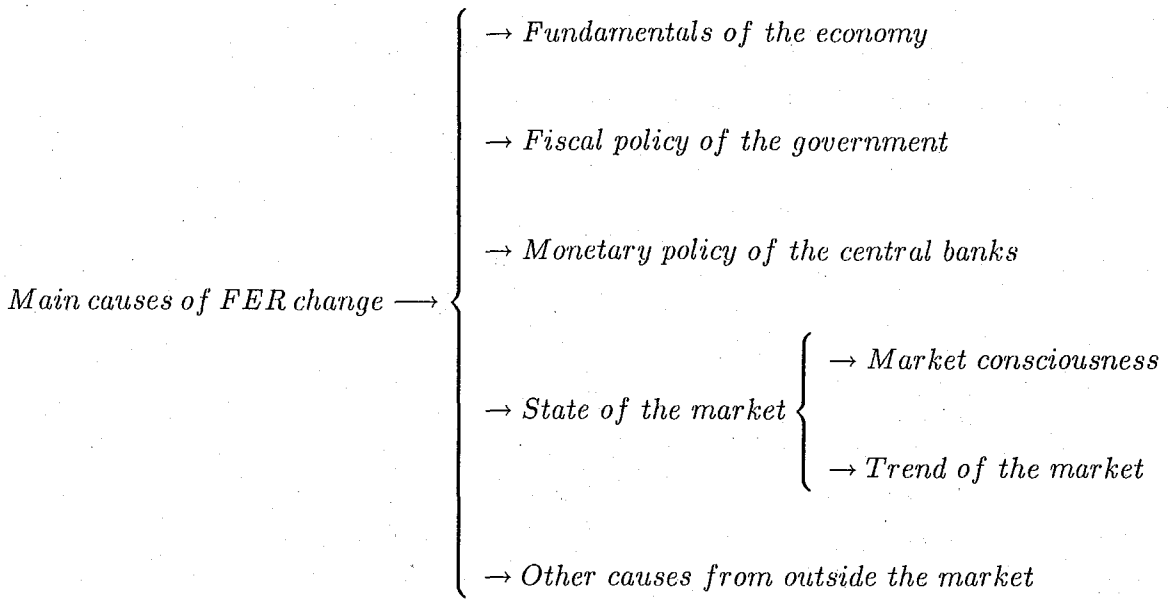

Figure 4.1: Main causes of FER changes

Generally speaking, when we estimate the trend of the yen-dollar rate, we have to take account of the economic trends in Japan, the U.S., and Europe. Therefore, in this paper, we focus on the former two economic trends, and German economic trends are taken to be as representative of economic trends in Europe.

4.2 Forecaster's estimation model

The developed system is constructed based on actual FER forecasters' knowledge. A FER forecaster's model for estimating FER changes is shown in Fig. 4.2.

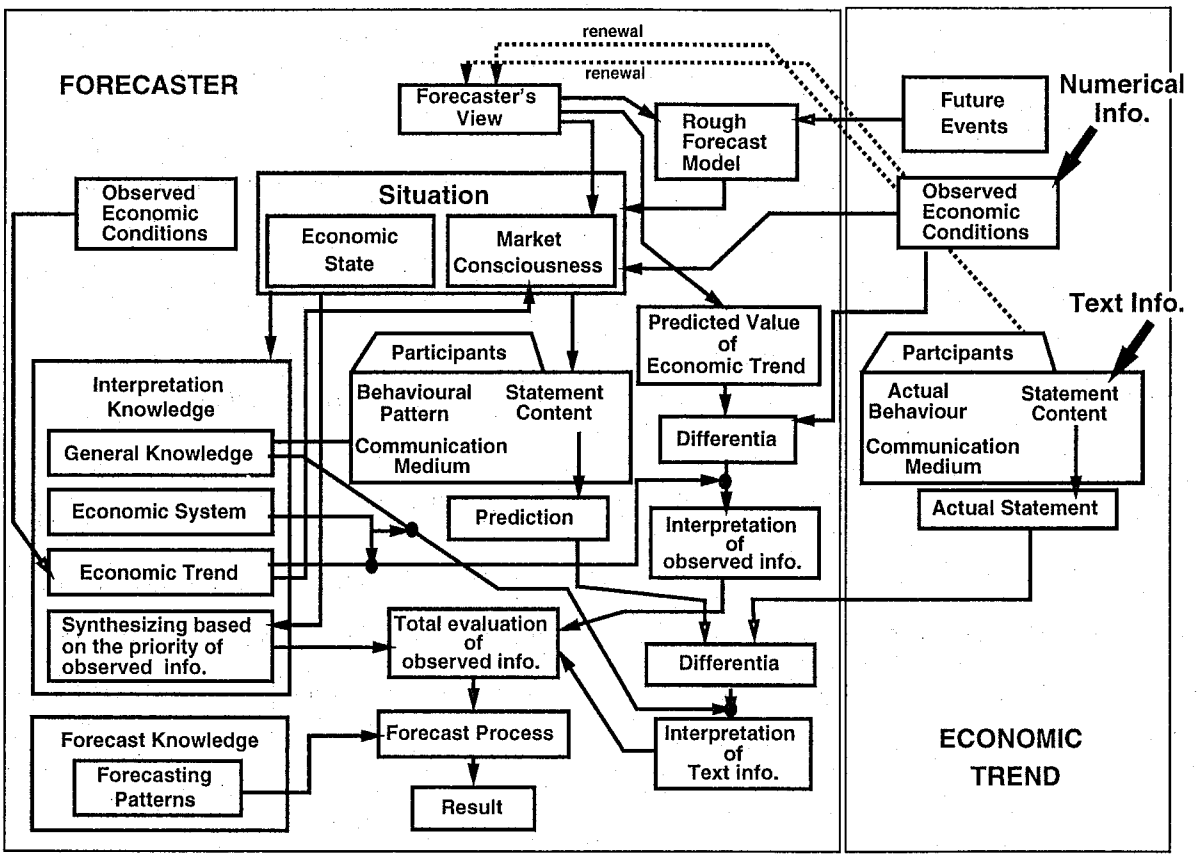

Figure 4.2: FER forecaster's estimation model

FER forecasters (simply forecaster(s) henceforth) have their own views on the trends of economic conditions, therefore, they first create a rough forecast model based on their views and their knowledge of upcoming economic events. Further, they start to recognize economic conditions that obey the created model. In other words, situation recognition depends on forecasters' views and concerns about economic conditions. A forecaster has common knowledge for understanding observed information, for FER forecasting, and so on, based on typical economic conditions, therefore, we can say that he shares the same sense of values with other forecasters. Generally speaking, forecasters estimate beforehand the value of economic indices, the content of VIP statements, the trends of the market, etc., which cause FER changes, and they act on

the results of their prediction. If later observations are different from these predictions, their reaction to the observed information will be large.

4.3 Information used in the estimating process

In this section, we show the information used in the estimating process.

Numerical Information

Announcements of economic indices are treated as numerical data in the system. Economic indices used to determine economic conditions in the estimating process are as follows:

U.S.A.

Trade

- Government Expenditure
- New Orders to Manufactures
- New Orders to Durable Goods
- Exports
- Imports
- Trade Balance(Exports)
- Trade Balance(Imports)

Product

- Business Inventories
- Industrial Production
- Average Hourly Earnings
- Unemployment Rate
- Non-farm Employment
- Personal Consumer Price Index
- Wholesale Price Index

Bond & Stock

- Financial Surplus
- Financial Deficit
- Stock Price(D-J 30 Industrials Average)

Long-Term Money Rate

- Housing Starts
- Wholesale Price Index
- Corporate Profits
- GDP Private Construction Investment
- Money Supply
- Long-Term Government Bond(30-year)

Price

- Wage Level
- Production Price Index
- Consumer Price Index
- Industrial Capacity Utilization
- Industrial Production

Short-Term Money Rate

- Treasury Bill Rates(3-Months)
- FF Rate
- Official Discount Ratio

Goods

- Oil Price(WTI)
- CRB Index
- Reuter's Index

JAPAN

Bond & Stock

- Financial Deficit
- Financial Surplus
- The Nikkei Stock Average
- Consumer Price Index
- Wholesale Price Index

Business Cycle & Money Rate

- Sales of Department Stores
- Indexes of Operating Ratio
- GNP Growth Ratio
- Certificates of Deposit(3-Months)
- Official Discount Rate
- Money Supply
- Long-Term Government Bonds(10-years)

Trade

- Exports
- Trade Balance(Exports)
- Imports
- Trade Balance(Imports)

GERMAN

Economy

- Short-Term Money Rate
- Long-Term Money Rate
- Official Discount Rate
- Money Supply

Situational Information

Situational information corresponds to information which helps to foretell the trend of the market: the trend of investors' investments, the official attitude of the government and banks, and so on, which cannot be obtained from numerical information or natural language information directly, but can be obtained from newspapers, TV news, etc. Several types of situational information used to determine economic conditions in the estimating process are shown below.

U.S.A

- Investment trends of institutional investors
- Investment trends of export-import companies
- Trends of FRB's intervention in the market
- FRB's monetary policy on the market

JAPAN

- Investment trends of institutional investors
- Investment trends of export-import companies
- Trends of Bank of Japan's intervention in the market
- Bank of Japan's monetary policy on the market
- Trends of Japan's domestic demand

GERMAN

- Economic trends

Natural Language Information

When we estimate the future trend of foreign exchange rates, statements by VIPs (who have a strong influence on the foreign exchange market) are also regarded as important information. Thus, we treat a VIP's statement as natural language information input to the system. When we understand the statements made by VIPs, we have to consider their social status and the media they used, because these are regarded as very important to decide whether or not to have

confidence in their statements. The content of predictable government and bank statements are shown in Figures 4.3 and 4.4, respectively. These correspond to *field* components in the context of situation in SFLT. The social status of VIPs (i.e., *tenor*), whose statements are thought to influence the market, is shown in Fig. 4.5. The media used by VIPs (i.e., *mode*) are shown in Fig. 4.6. (We use *system network* to illustrate the schemes.)

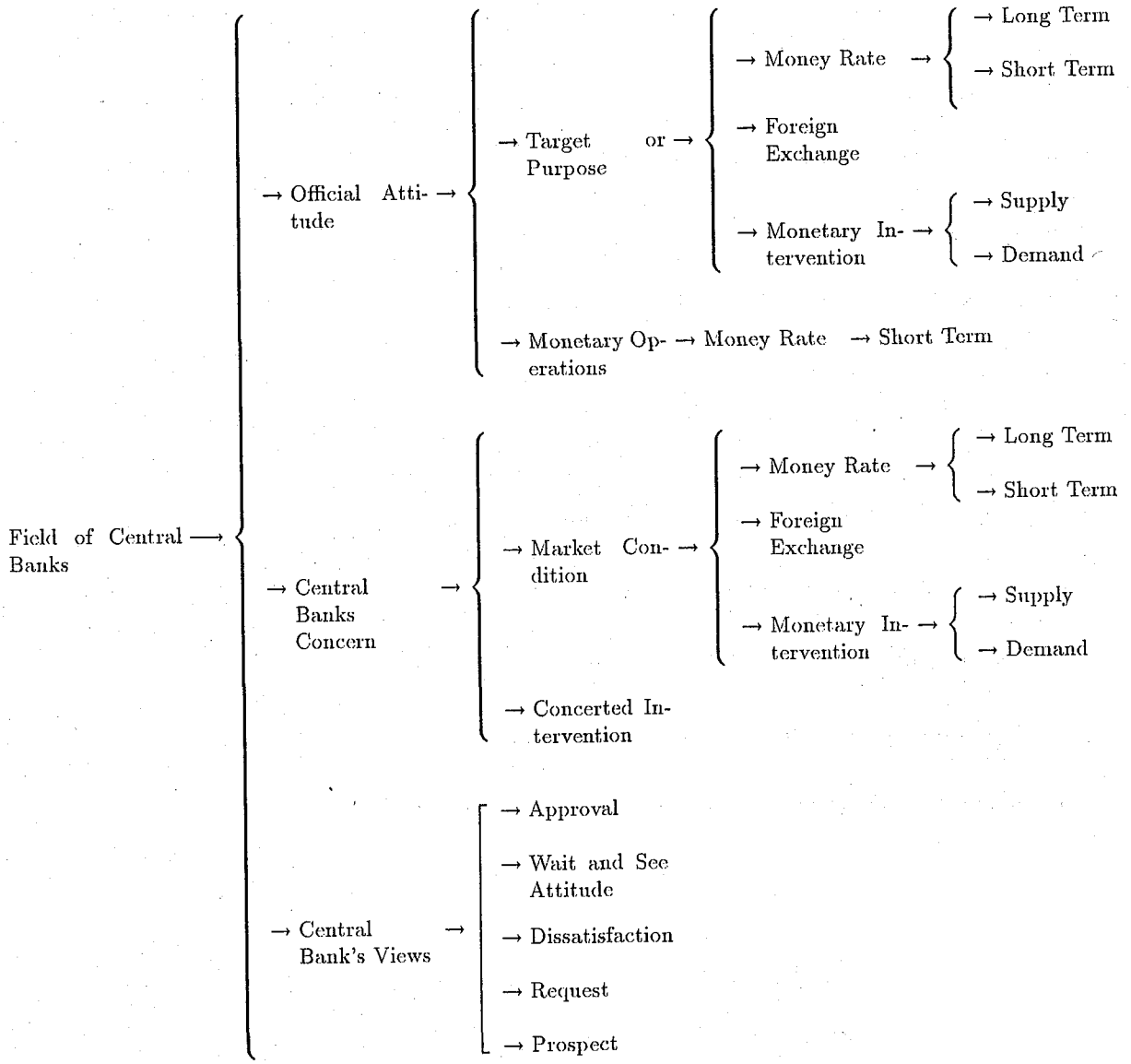

Figure 4.3: Field of Central Banks

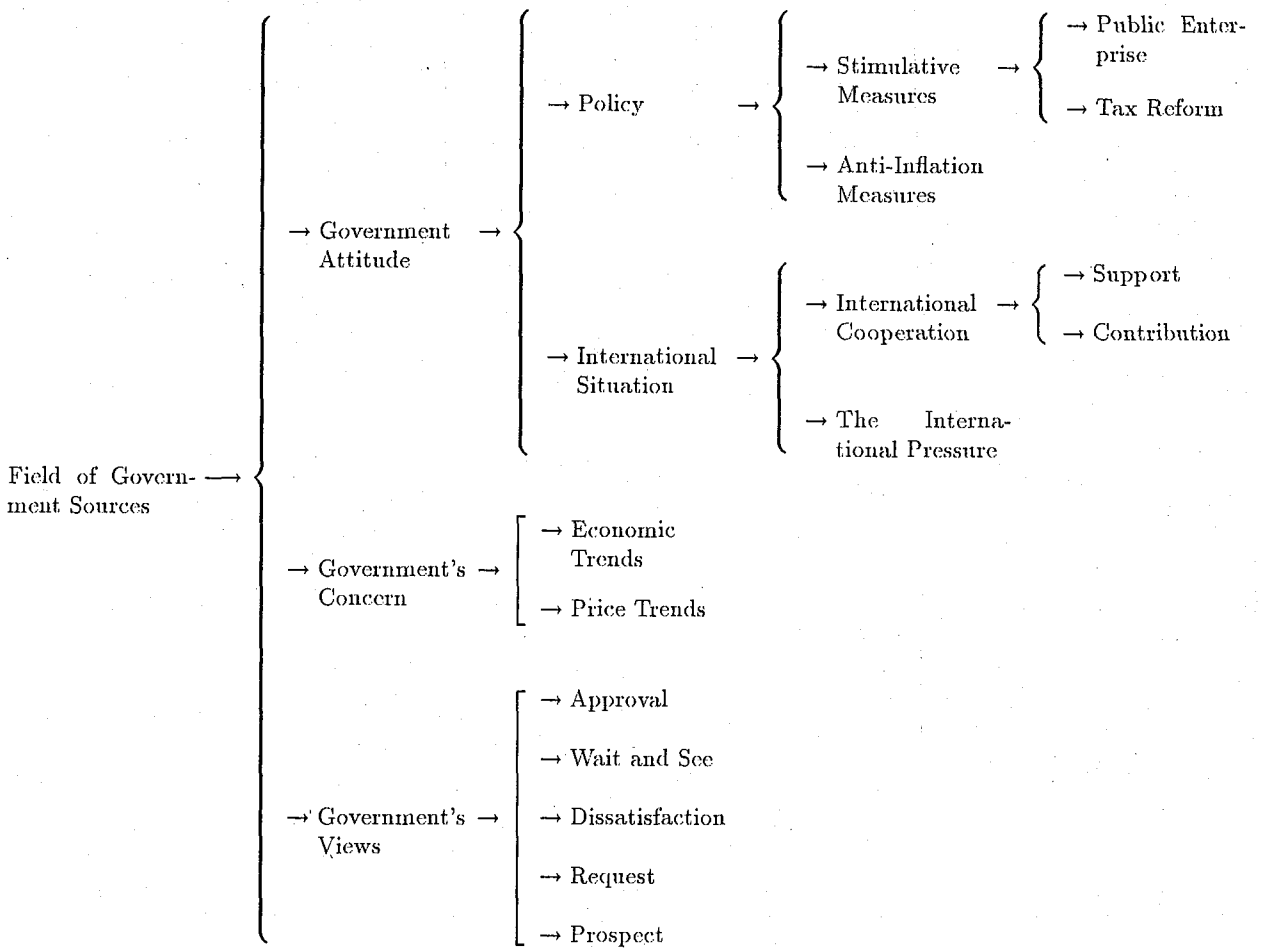

Figure 4.4: Field of Government Sources

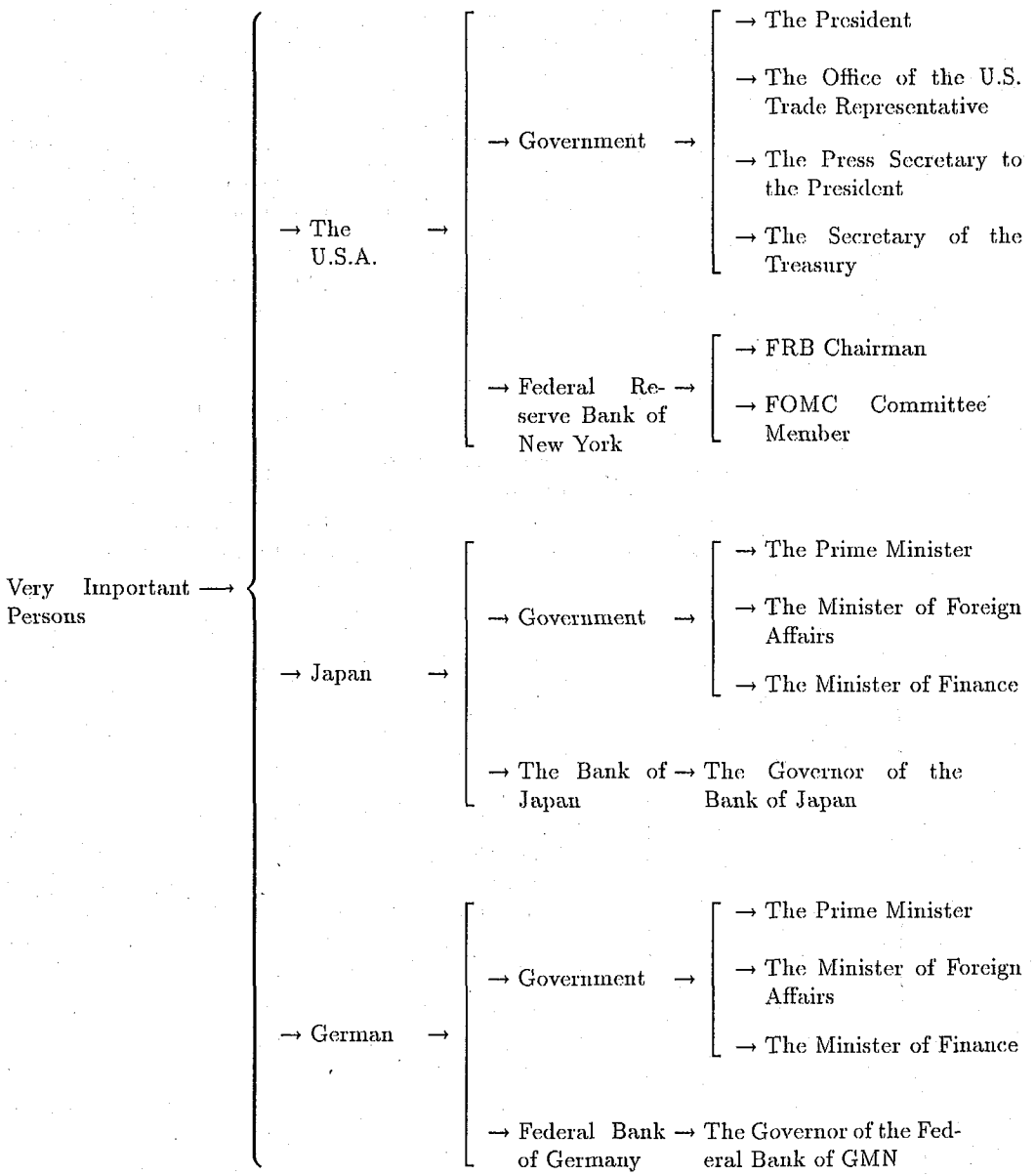

Figure 4.5: Social Status of VIPs (Tenor)

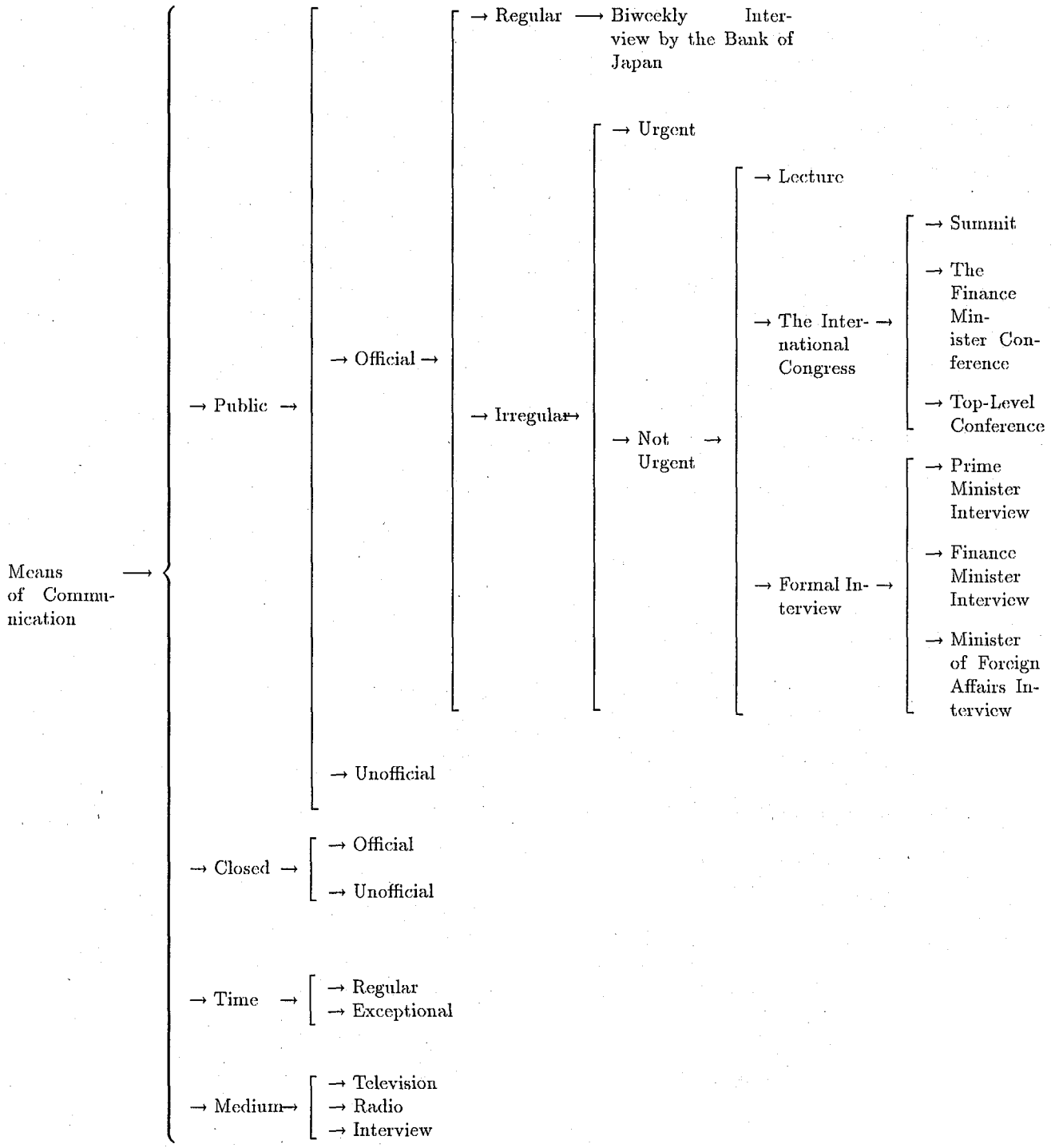

Figure 4.6: Media used by VIPs (Mode)

Chapter 5

FER Forecast System

In this chapter, we will explain a developed prototype system which gives support to estimating the future trend of FERs.

5.1 Basic Concept of FER Forecast System

We aim to construct a system able to imitate a forecaster's FER change estimation process. A forecaster's FER estimation activity is regarded as a social activity in a particular social group, so we built a system based on the result of analyzing this activity. Generally speaking, forecasters estimate the trend of FERs by considering economic conditions. This means that forecasters build forecast models which reflect current economic conditions. Based on this fact, we built a system which generates a suitable model for FER forecasting from observed economic conditions. This concept corresponds to "Text is manifested by context" in SFLT. We also show the validity of our proposed methods in a forecasting process – that is, we demonstrate a knowledge representation for expressing customs, use language as the informational currency of computer processing, and use a linguistic model for the model generation process. The overview of the process of forecast model generation is shown in Fig. 5.1.

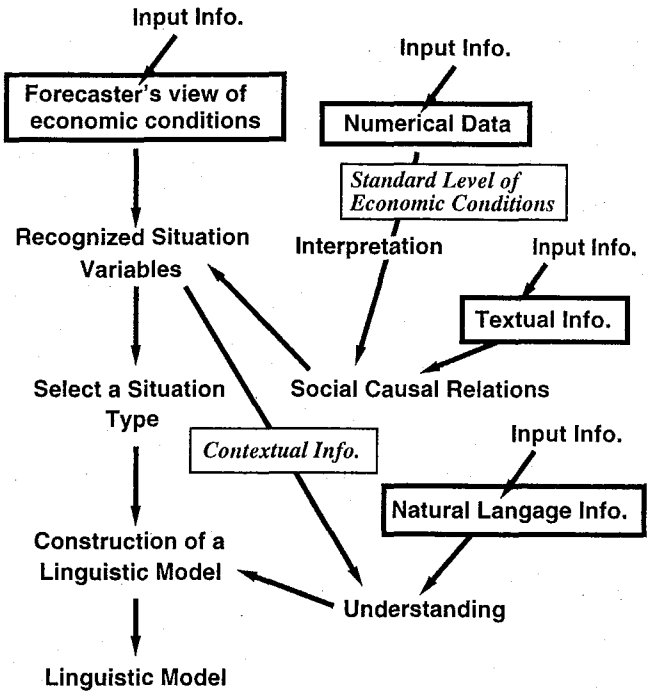

Figure 5.1: Overview of the process of forecast model generation

5.2 Specification of FER Forecast System

The specification of the system is shown in Table 5.1.

Table 5.1: Specification of FER forecast system

forecasting target	trend of FER (yen-dollar rate)
forecasting range	a week $\sim$ a month
input information	approximately sixty economic indices (as numerical data), trends of the market (as situational info.), statements by VIPs (as natural language info.), forecaster's view of economic conditions
output information	future trend of FER (yen-dollar rate)

The forecasting target is the trend of the yen-dollar rate. The forecasting range is an interval from a week to a month. This interval is decided by considering the influence on FER changes by the statements of VIPs. (Most economic indices are announced monthly.) Situation variables which should be recognized are decided by considering the character of the input information. This means that each piece of input information has its own influence on the market depending on the existence of information. As numerical input information to the system, we use approximately sixty economic indices observed from January 1991 to April 1992. (Numerical data can be found in Appendix B.) We treat the statements by VIPs who influence foreign exchange markets as natural language information. As situational information, we treat market trend information (e.g., the attitude of FRB monetary policy) extracted from economic newspapers, TV news, etc. Moreover, the forecaster's view of economic conditions tells us how to process the given information. By using this information, the system builds a forecast model reflecting economic conditions and suitable for forecasting, estimates FER changes using the model, and finally shows the future trend of the yen-dollar rate as output information.

5.3 Construction of FER Forecast System

Our FER system has been implemented on a Sun4 workstation and is written in the SICStus Prolog language. It also includes components written in the C language. The construction of the FER forecast system is shown in Fig. 5.2.

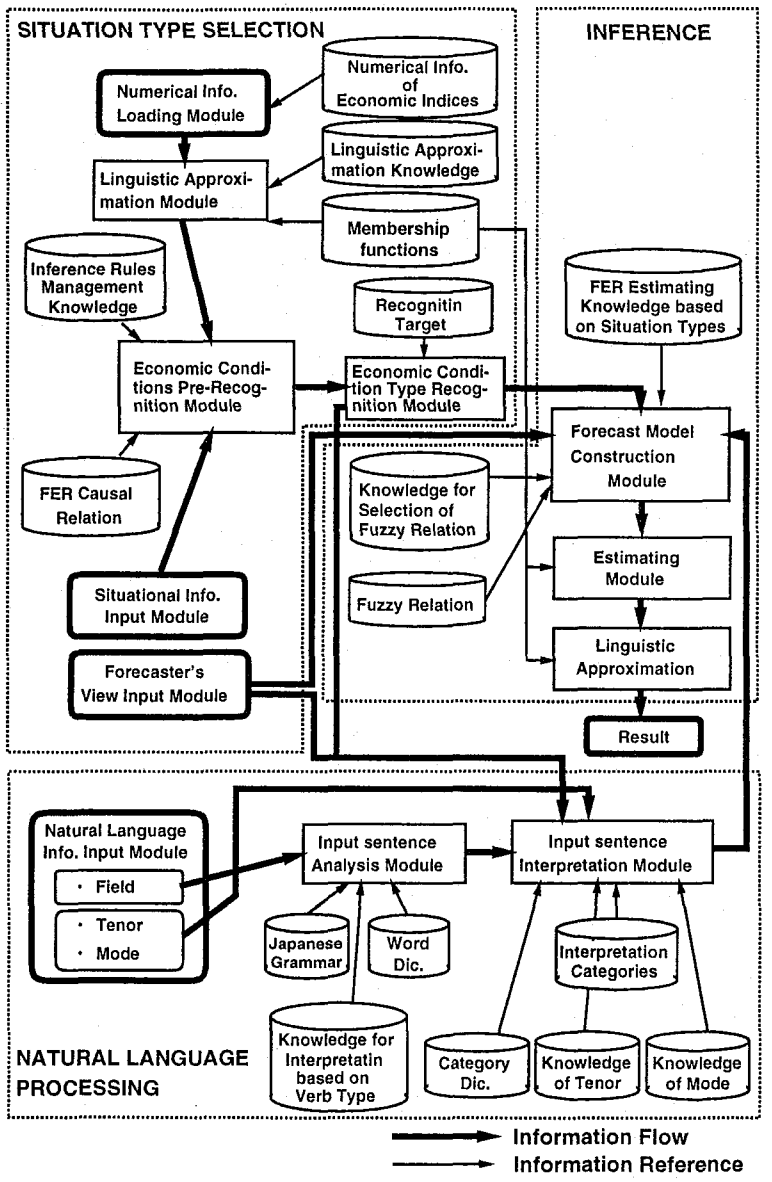

Figure 5.2: Construction of FER forecast system

The FER forecast system consists of three main processes: **situation type selection**, **natural language processing**, and **inference**. We show each part in detail in the following sections.

5.4 Situation Type Selection

This process consists of three main modules: **linguistic approximation**, **economic conditions pre-recognition**, and **economic condition type recognition**. Basically, this part works to translate the observed input information into linguistic information (i.e., numerical and situational information is translated into linguistic information) and decides on a suitable situation type (i.e., economic condition type) for estimating the future trend of the yen-dollar rate.

5.4.1 Linguistic Approximation Module

This module translates the observed numerical data of approximately sixty economic indices into the most suitable linguistic expressions consistent with current economic conditions. It should be performed by taking into account standard levels of indices appropriate for current economic conditions and by applying knowledge of economic conditions[1]. We will show a basic way of accomplishing this translation.

First, we should decide how to interpret numerical data. In the system, in order to know current economic states, the tendencies of "change on year[2]" economic long term trends (i.e., current values compared with the previous year) are available, and to know current economic trends, the tendencies of "change on month" or "change on quarter" economic short term trends (i.e., current values compared with the previous month or term) are available. An illustration of these viewpoints of economic state is shown in Fig. 5.3.

[1]This corresponds to linguistic approximation knowledge in Fig. 5.2.

[2]It is expressed as the value one hundred less than the seasonally adjusted variation ratio. Change of month and change on quarter data are also expressed in this way.

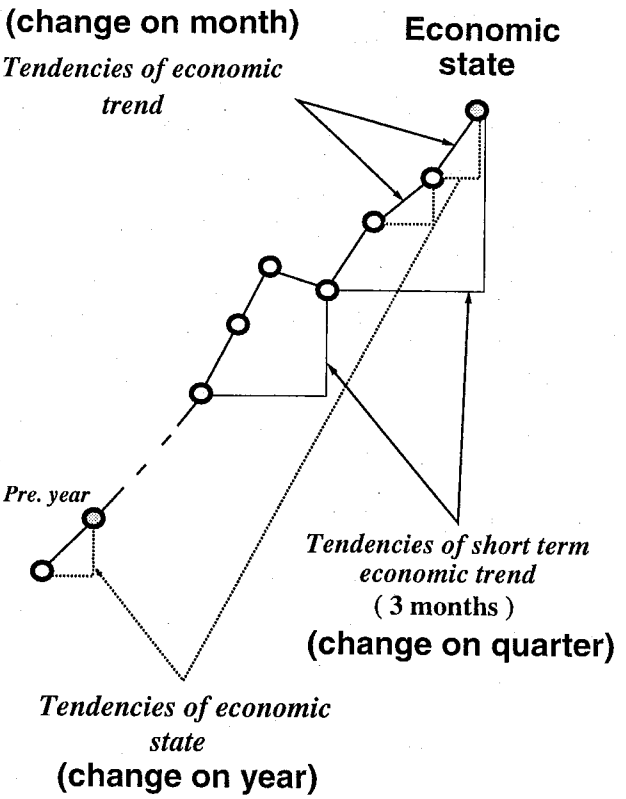

Figure 5.3: Viewpoints of Economic State

Standard economic conditions values are expressed with fuzzy sets. (Standard economic index values are found in Appendix C.) By using fuzzy sets to express standard economic values, we can raise the relevancy of expressing observed values linguistically (see [27]). The procedure for selecting the most suitable linguistic expression is shown below.

$$A' = Obs_{index} - Astd_{index} \tag{5.1}$$

$$s(i) \equiv \frac{\| A_i \cap A' \|}{\| A_i \cup A' \|} \tag{5.2}$$

$$f(i_0) = \max_i s(i) \tag{5.3}$$

where, Obs_{index} : Observed numerical data of the index

$Astd_{index}$: Value of the standard level of the index (expressed with a fuzzy subset)

A_i : Linguistic label in the observed range of the index (expressed with a fuzzy subset)

s : Function for deciding the similarity between A_i and A'.

f : Function for choosing the most suitable linguistic expression

i : i = 1,$\cdots$,5

$\|\cdot\|$: Cardinality of fuzzy set

The most suitable linguistic expression A_{i0} for an observed numerical datum is selected through this procedure, and it is expressed with fuzzy propositions like that shown below,

$$X_{1t} \textit{ is } F, X_{2t} \textit{ is } G, \ldots, X_{nt} \textit{ is } H$$

where, X_{1t} ,X_{2t} ,..., X_{nt} : Situation variables at time t.

F, G, ..., H : Values of situation variables.

We show an example of approximating of a numerical value of an economic index.

Ex. U.S. Non-farm Employment

	Change on Month	**Change on Year**
Standard level	0.0 %	1.0 %
Observed range	-0.3 $\sim$ 0.3 %	0.0 $\sim$ 2.0%
Observed value	+0.184%	+0.164%

After the linguistic approximation procedure, we get the result shown below.

Non-farm Employment(change on month) is *very high.*

Non-farm Employment(change on year) is *high.*

We will show the knowledge that is applied when translating numerical data into linguistic expressions in the following paragraph.

U.S. Economic Indices

We use three months Treasury Bill Rates and the official discount ratio as representative indices for the U.S. short-term money rate. "Generally speaking, the change of the official discount ratio would follow the fluctuation of FF rate. That is, Federal Reserve Bank (FRB) would raise the official discount ratio, if the spread between Federal Funds (FF) rate and the official discount ratio is large (approximately 2.5 %), and on the contrary, lower the official discount ratio, if the spread is small (approximately 0.5 %)[50]." From this statement, we can express the state of the official discount ratio linguistically with the fuzzy sets shown in Fig. 5.4.

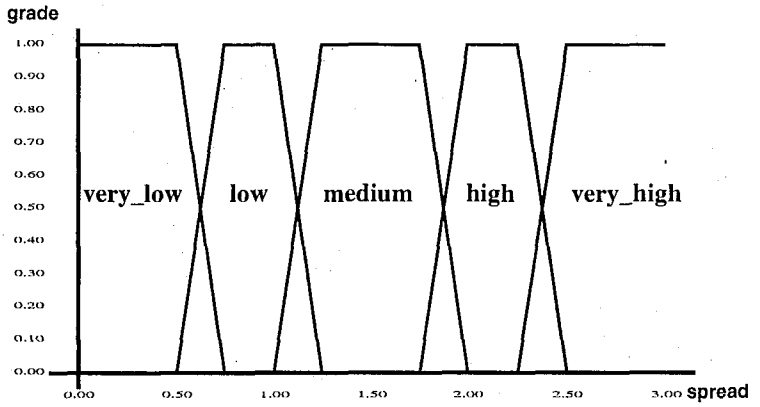

Figure 5.4: State of the official discount ratio

From the statement, "with regard to Treasury Bill Rates, it is about 0.9% lower than FF rate[50]," we define the fuzzy sets shown in Fig. 5.5.

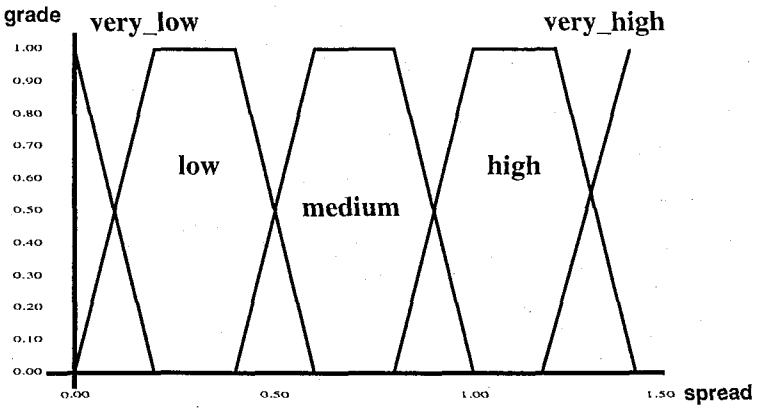

Figure 5.5: State of Treasury Bill Rates

JPN Economic Indices

Concerning the JPN official discount ratio, a proper linguistic expression is given by the relative evaluation based on JPN economic trends. The rules which decide the state of the official discount ratio are as follows:

Linguistic Translation Rule	
Antecedent	**Consequent**
JPN Economic Trends	**Relative Evaluation Standard Value(%)**
very high	*(7,6,5,4)*
high	*(6,5,4,3)*
normal	*(5,4,3,2)*
low	*(4,3,2,1)*
very low	*(3,2,1,0)*

Linguistic Expression	**Relation between Observed Value and Relative Evaluation Standard Value**
very high	Observed Value $\geq$ S1
high	S1 $>$ Observed Value $\geq$ S2
normal	S2 $>$ Observed Value $\geq$ S3
low	S3 $>$ Observed Value $\geq$ S4
very low	S4 $>$ Observed Value

Here, S1, S2, S3, and S4 indicate relative evaluation standard values, which are expressed as (S1, S2, S3, S4).

GMN Economic Indices

Concerning the GMN official discount ratio, a proper linguistic expression is similarly given by the relative evaluation based on GMN economic trends. The rules which decide the state of the official discount ratio are as follows:

Linguistic Translation Rule		
Antecedent	**Consequent**	
GMN Economic Trends	**Relative Value(%)**	**Evaluation Standard**
very high	*(9,8,7,6)*	
high	*(8,7,6,5)*	
normal	*(7,6,5,4)*	
low	*(6,5,4,3)*	
very low	*(5,4,3,2)*	

Linguistic Expression	**Relation between Observed Value and Relative Evaluation Standard Value**
very high	Observed Value $\geq$ S1
high	S1 > Observed Value $\geq$ S2
normal	S2 > Observed Value $\geq$ S3
low	S3 > Observed Value $\geq$ S4
very low	S4 > Observed Value

5.4.2 Economic Conditions Recognition Module

In this module, the system recognizes economic conditions through linguistic rules which express the causal relations of the foreign exchange system. (The linguistic rules are placed in Appendix D.) Here, we should notice that the causal relations do not consist of mathematical equations, but rather linguistically expressed rules which are obtained through interviews with economic researchers, foreign exchange dealers, economic books, and so on. They are, however, not fuzzy rules(cf. [27]). We show the relations which the system has as follows.

U.S. Trade

The causal relations of U.S. Trade are shown in Fig. 5.6.

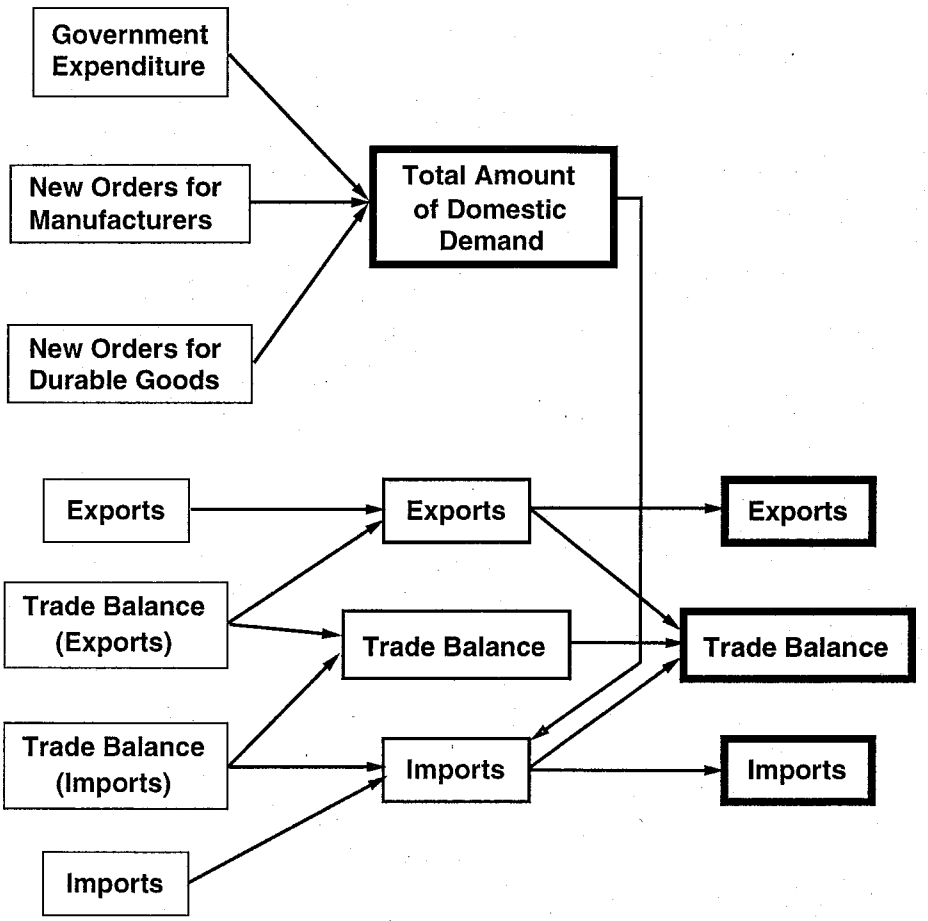

Figure 5.6: U.S. Trade Causal Relations

Recognized Situation Variables

- Exports Trend
- Trade Balance Trend
- Imports Trend
- Total Amount of Domestic Demand

U.S. Production Causal Relations

The causal relations of U.S. Production are shown in Fig. 5.7.

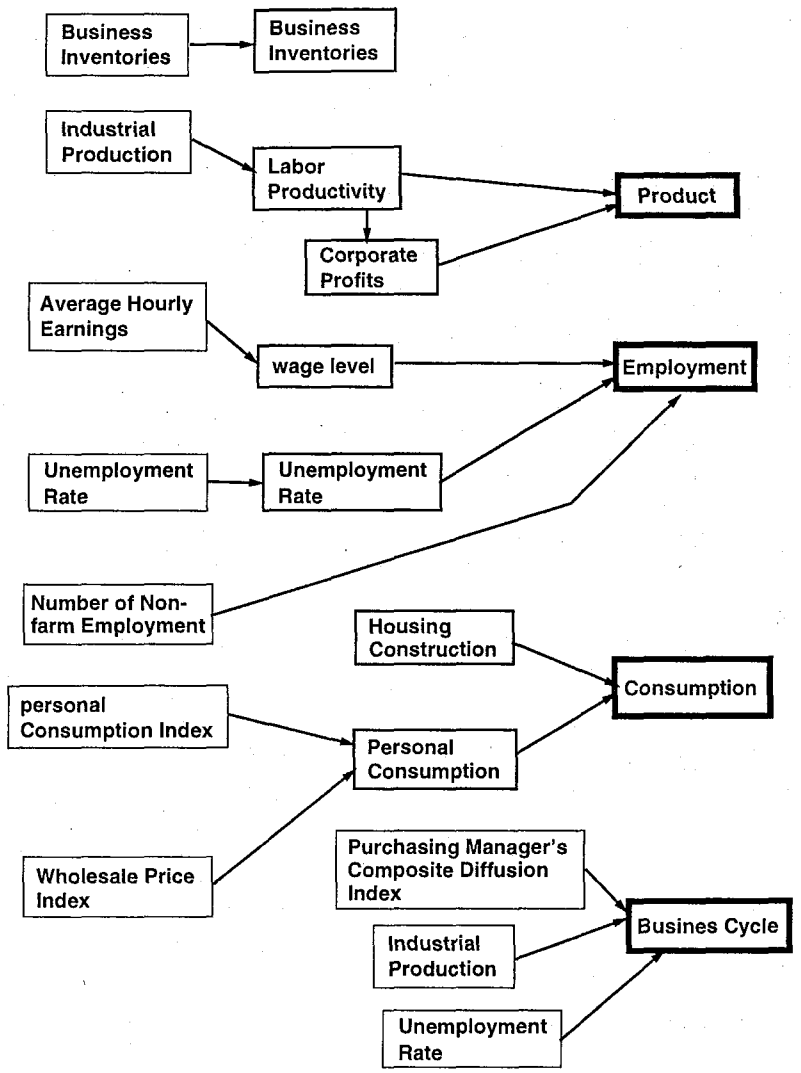

Figure 5.7: U.S. Product Causal Relations

Recognized Situation Variables

- Business Inventories Trend
- Labor Productivity
- Wage Level
- Unemployment Rate
- Economic Trends
- Personal Consumption Trend
- Production Trend
- Employment Trend
- Consumption Trend

U.S. Bond & Stock

The causal relations in the U.S. Bond & Stock market are shown in Fig. 5.8.

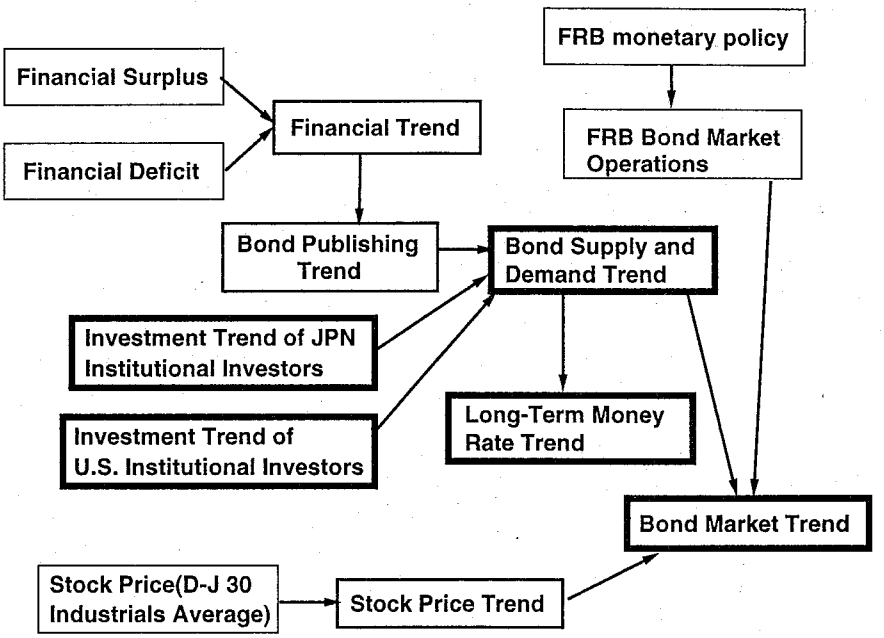

Figure 5.8: U.S. Bond & Stock Market Causal Relations

Recognized Situation Variables

- Financial Trend
- Bond Publishing Trend
- Investment Trend of JPN institutional Investors
- Investment Trend of U.S. Institutional Investors
- FRB monetary policy
- FRB Bond Market Operations
- Bond Supply and Demand Trend
- Bond Market Trend
- Stock Price Trend

U.S. Long Term Money Rate

The causal relations that determine the U.S. Long Term Money Rate is shown in Fig. 5.9.

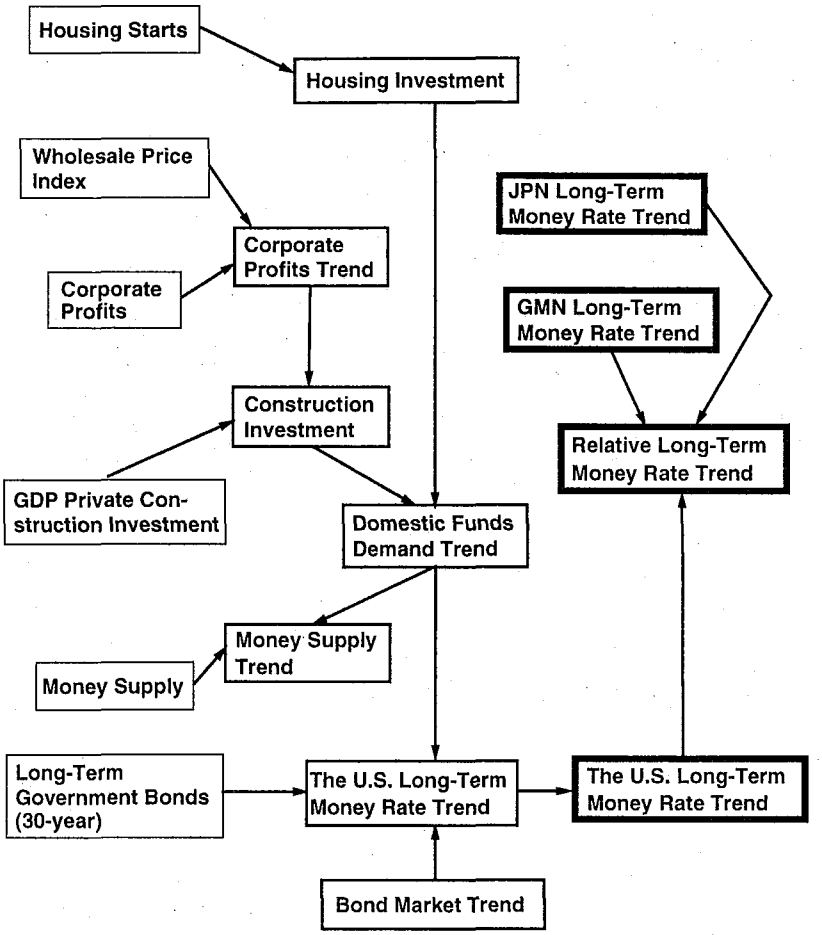

Figure 5.9: U.S. Long Term Money Rate Causal Relations

Recognized Situation Variables

- Housing Investment Trend
- Construction Investment Trend
- Domestic Funds Demand Trend
- JPN Long-Term Money Rate Trend
- GMN Long-Term Money Rate Trend
- U.S. Long-Term Money Rate Trend
- Corporate Profits Trend
- Money Supply Trend
- Bond Market Trend
- Long-Term Money Rate Trend
- Relative Long-Term Money Rate Trend

U.S. Price

The causal relations that determine U.S. Price Levels are shown in Fig. 5.10.

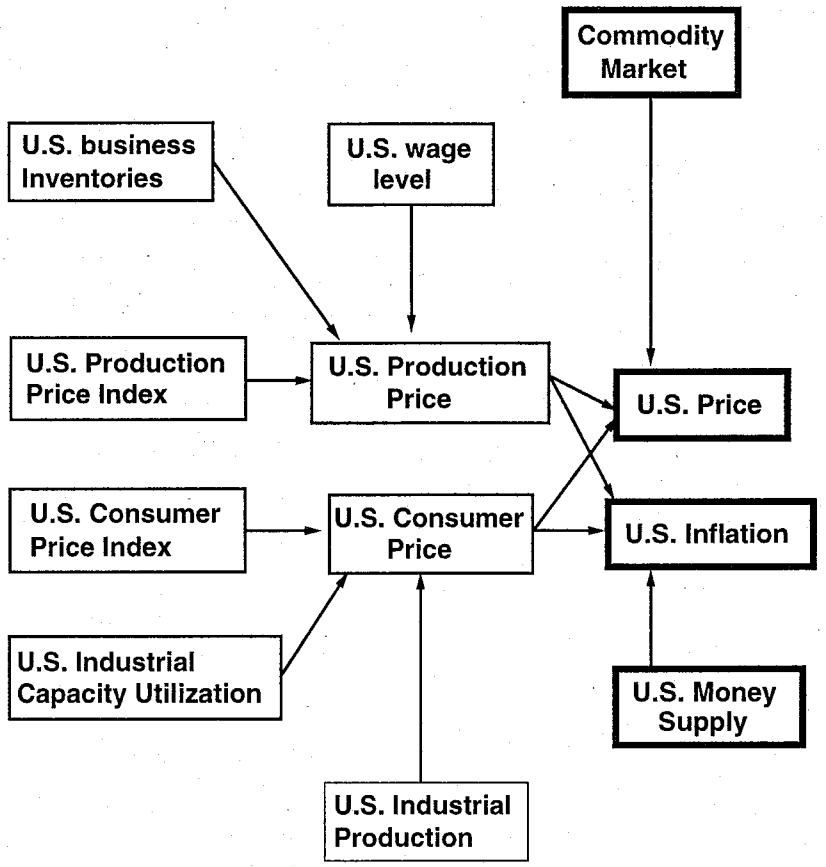

Figure 5.10: U.S. Price Level Causal Relations

Recognized Situation Variables

- Production Price Trend
- Consumer Price Trend
- Price Trend
- Inflation Trend

U.S. Short-Term Money Rate

The causal relations that determine the U.S. Short-Term Money Rate are shown in Fig. 5.11

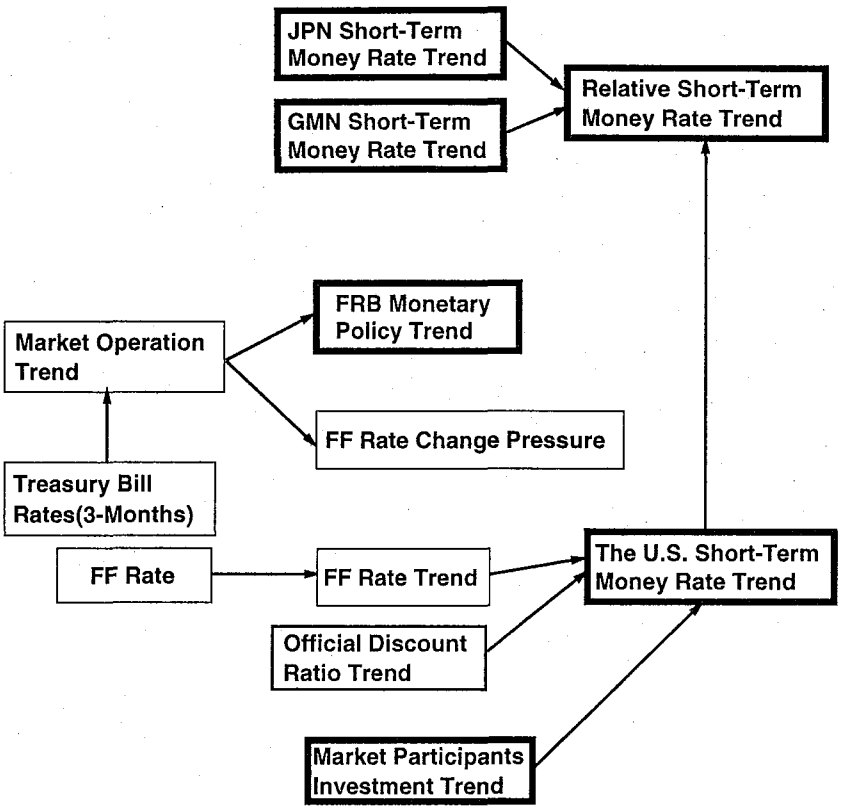

Figure 5.11: U.S. Short-Term Money Rate Causal Relations

Recognized Situation Variables

- Market Operation Trend
- FF Rate Change Pressure
- FF Rate Trend
- Official Discount Ratio Trend
- Relative Short-Term Money Rate Trend
- U.S. Short-Term Money Rate Trend
- Market Participants Investment Trend

U.S. FRB Policy

The causal relations that determine U.S. FRB Policy are shown in Fig. 5.12.

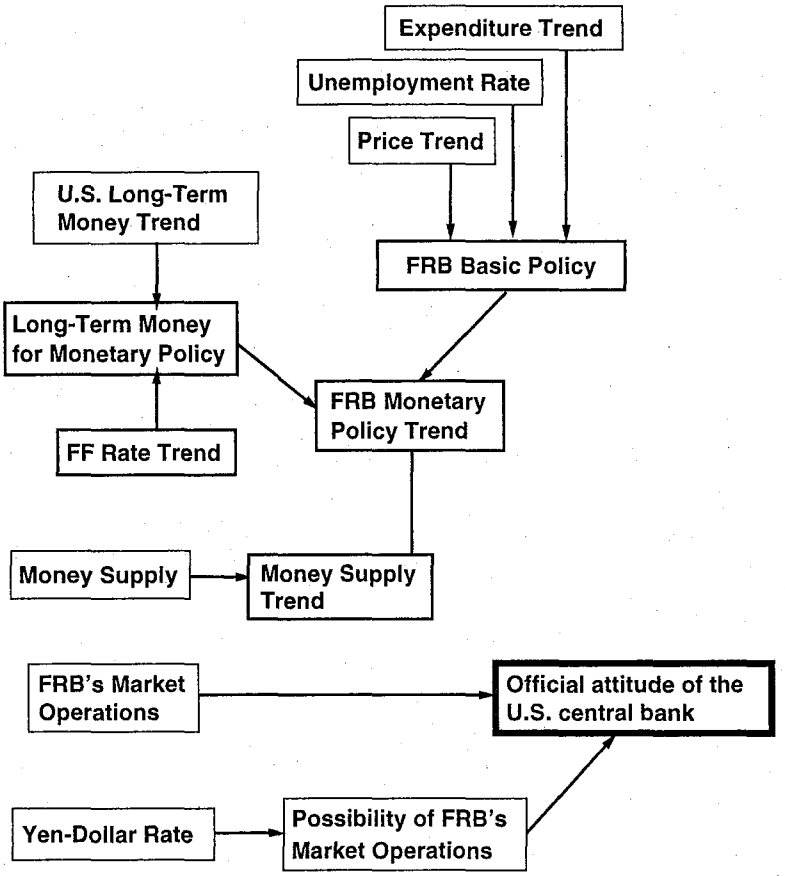

Figure 5.12: U.S. FRB Policy Causal Relations

Recognized Situation Variables

- FRB Basic Policy
- FRB Monetary Policy Trend
- Possible FRB Market Operations
- Official Attitude of the U.S. Central Bank

U.S. Commodity Market

The causal relations in the U.S. Commodity Market are shown in Fig. 5.13.

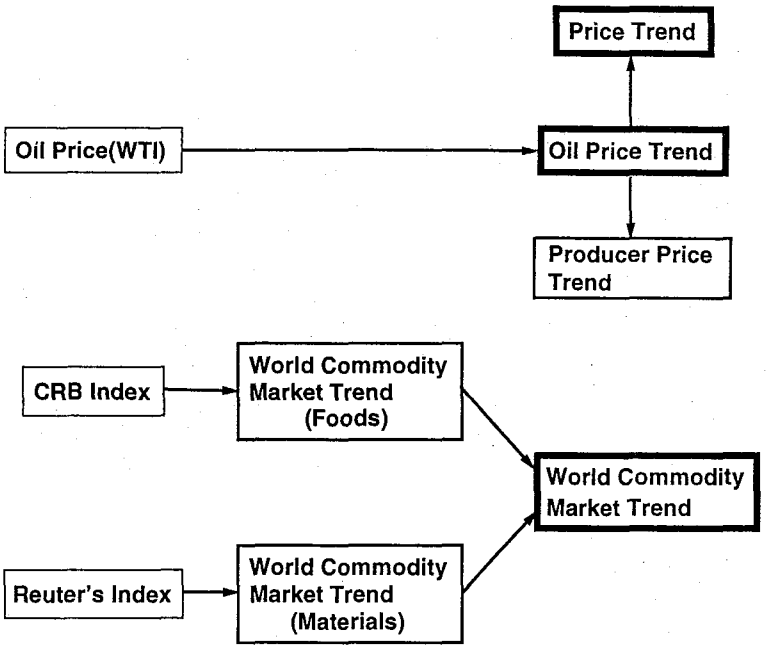

Figure 5.13: U.S. Commodity Market Causal Relations

Recognized Situation Variables

- Oil Price Trend
- World Commodity Market Trend(Foods)
- World Commodity Market Trend(Materials)
- World Commodity Market Trend(Price)

JPN Bond & Stock

The causal relations in the JPN Bond & Stock market are shown in Fig. 5.14.

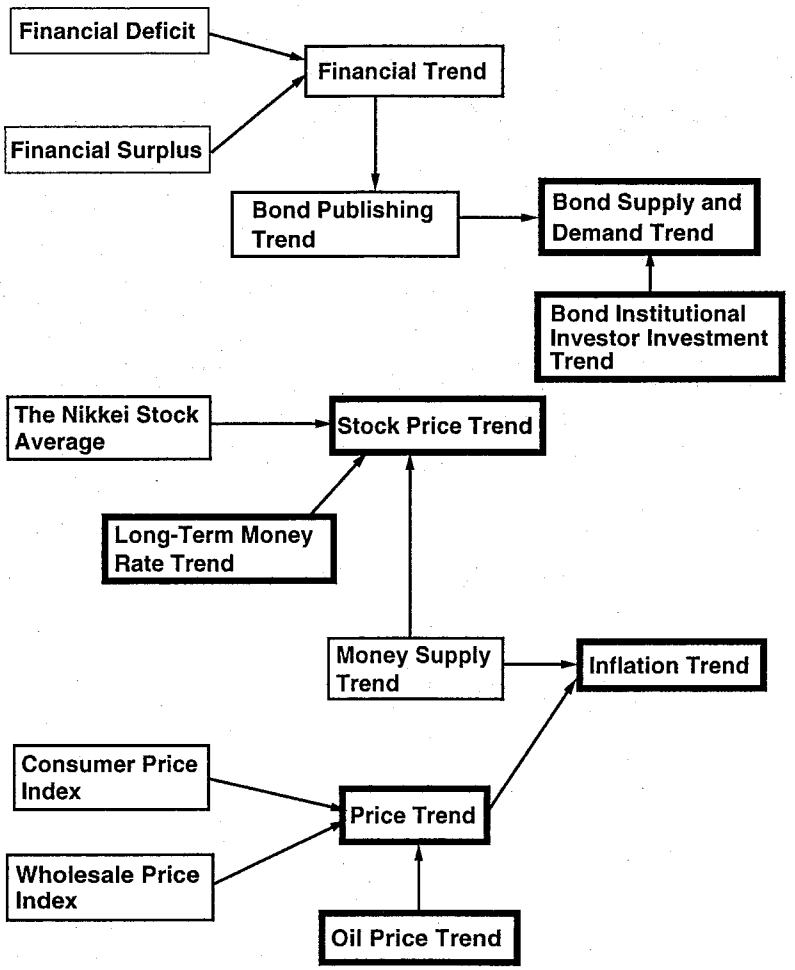

Figure 5.14: JPN Bond & Stock Market Causal Relations

Recognized Situation Variables

- Financial Trend
- Bond Publishing Trend
- Bond Supply and Demand Trend
- Bond Institutional Investor Investment Trend
- Stock Price Trend
- Inflation Trend
- Price Trend
- Oil Price Trend

JPN Money Rate & Economic Trends

The causal relations that determine the JPN Money Rate & Business Cycle Trend are shown in Fig. 5.15.

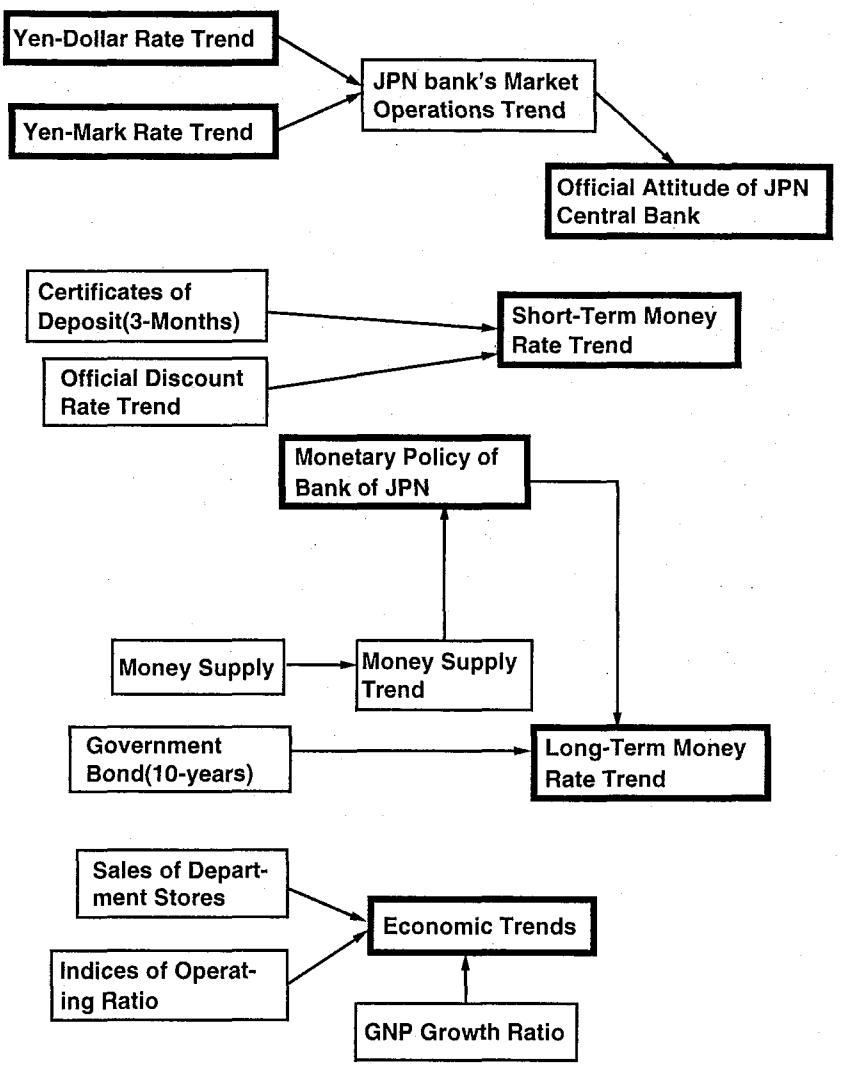

Figure 5.15: JPN Money Rate & Economic Trends Causal Relations

Recognized Situation Variables

- JPN Bank's Market Operations Trend
- Official Attitude of JPN Central Bank
- Short-Term Money Rate Trend
- Monetary Policy of JPN Central Bank
- Long Term Money Rate Trend
- Economic Trends
- Money Supply Trend

JPN Trade

The causal relations determining JPN Trade are shown in Fig. 5.16.

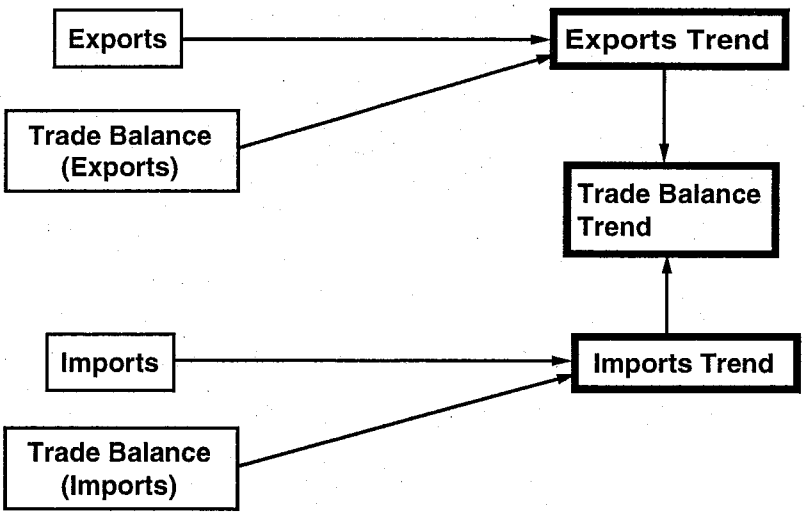

Figure 5.16: JPN Trade Causal Relations

Recognized Situation Variables

- Exports Trend
- Imports Trend
- Trade Balance Trend

GMN Economy

The causal relations in the GMN Economy are shown in Fig. 5.17.

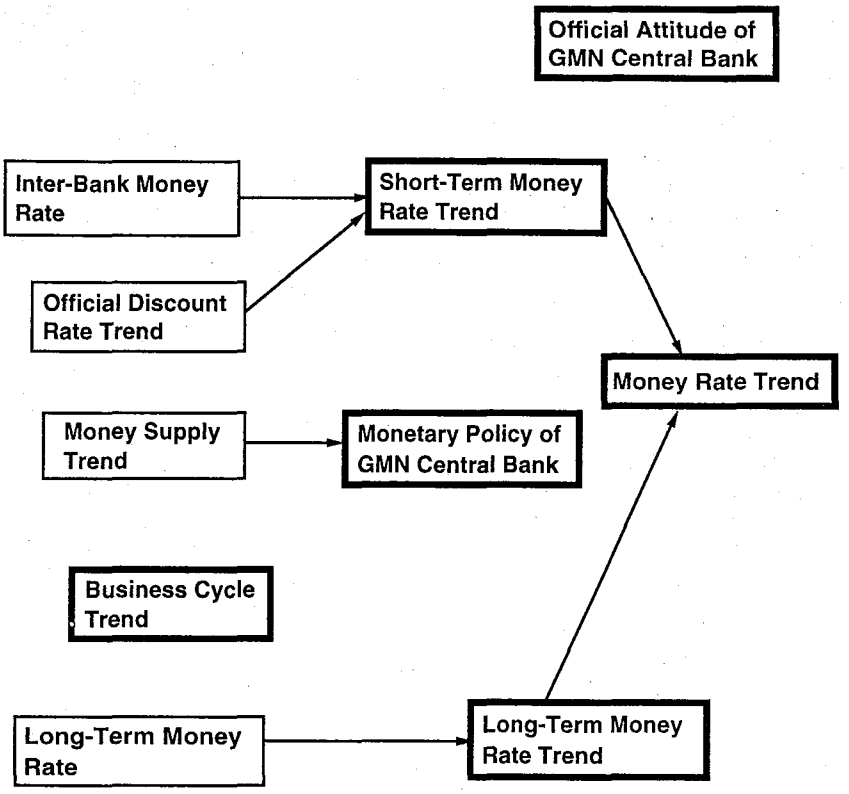

Figure 5.17: GMN Economy Causal Relations

Recognized Situation Variables

- Official Attitude of GMN Central Bank
- Short-Term Money Rate Trend
- Money Rate Trend
- Monetary Policy of GMN Central Bank
- Long Term Money Rate Trend

5.4.3 Economic Condition Type Recognition Module

Depending on the observed numerical values of the economic indices, the system recognizes an economic condition type suitable for forecasting. In this module, the system determines an economic condition type by observing the state of twelve key economic variables for estimating the future trend of the yen-dollar rate. These variables are obtained through the analysis of forecast scenarios from economic newspapers. Generally speaking, when forecasters recognize an overall economic condition, they first recognize the state of these economic variables and then begin to recognize an economic situation in more detail. A forecaster's view of economic conditions input to the system is also selected from these twelve economic variables to decide the situation variables which should be recognized. The twelve economic variables are shown in Table 5.2.

Table 5.2: Twelve Economic Variables

U.S. Business Cycle	JPN Business Cycle
U.S. Trade	JPN Trade
U.S. Long-Term Money Rate	JPN Long-Term Money Rate
U.S. Short-Term Money Rate	JPN Short-Term Money Rate
U.S. Stock	JPN Stock
U.S. Price	JPN Price

Here, we should consider how to distinguish an economic condition type from other economic condition types. First, we should analyze the kinds of information forecasters consider. Generally speaking, they focus on any unusual state of an economic condition (i.e., states that differ from the standard level of economic conditions at a certain time) because there are many ways that the unusual state can move the current economic condition to other, very different, economic conditions. Thus, we assume that forecasters recognize and gather information based on observed unusual economic conditions. This common activity shared by forecasters leads us to think that forecasters generally have common sense of values for FER forecasting, and know typical economic condition types and methods of solving problems. This can be regarded as the activity based on conventional constraints in FER forecasting activity.

Considering these things, economic condition types are distinguished based on the state of the above twelve economic variables as differentiated from the standard levels for the economic

conditions at a certain time. An overview of the hierarchical relation of economic condition types is shown in Fig. 5.18.

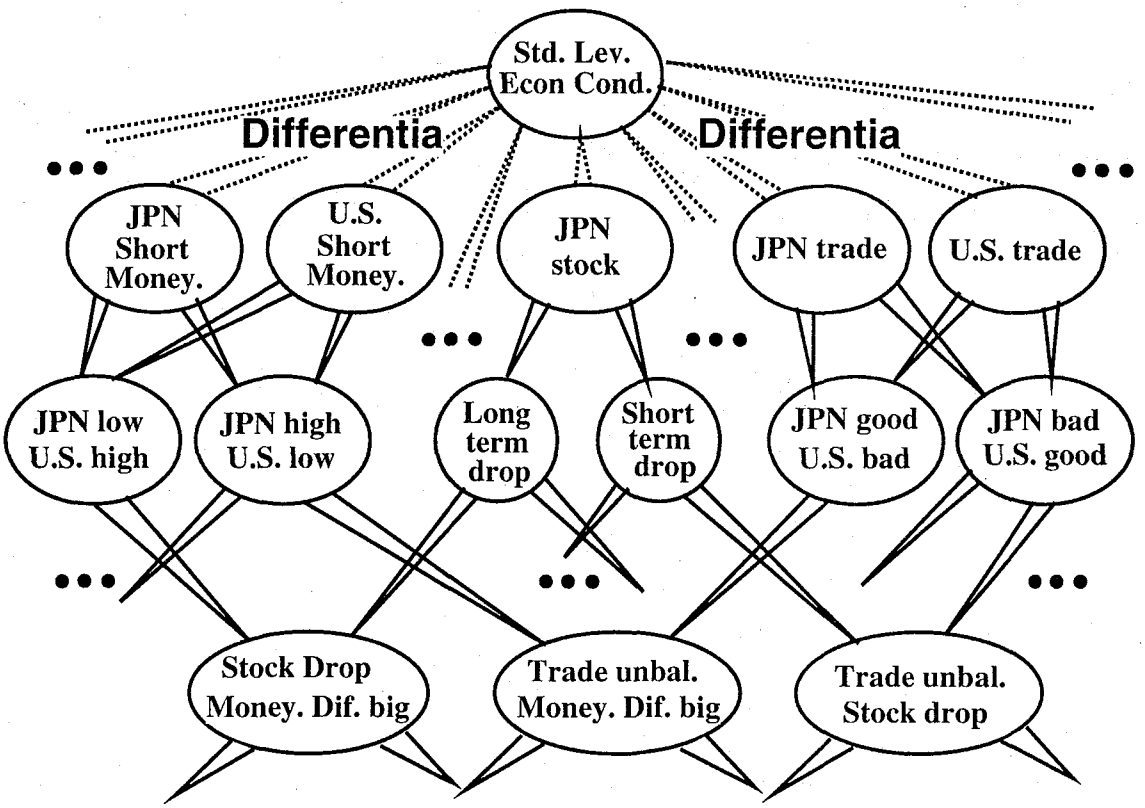

Figure 5.18: Overview of the hierarchical relation of situation types

Among the key economic variables, the business cycles and foreign trade figures are judged by observing their long term trends – change on year. The economic states of the other variables are judged by observing their short term trends – change on term or month.

5.4.4 Situational Information for Recognition of Economic Conditions

Situational information is given to the system in the form of qualitative linguistic expressions or natural language text. As qualitative information, the user can give one of five fuzzy labels: *very low*, *low*, *medium*, *high*, *very high* to the system, and for natural language text, the system observes almost the same procedures as the natural language understanding process (see below). An overview of situational information processing is shown in Fig. 5.19 (We explain the process of analyzing natural language information in the following section.)

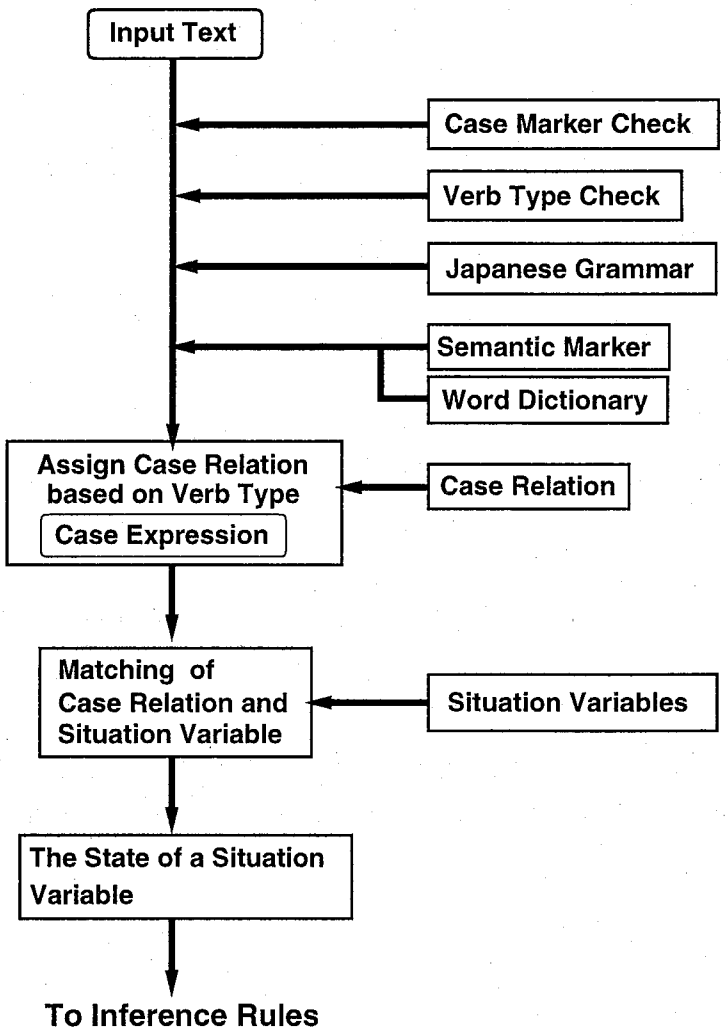

Figure 5.19: Overview of Situational Information Processing

5.5 Natural Language Processing

Natural language processing in the system is implemented only for the purpose of forecasting the foreign exchange rate. In particular, it only aims to understand statements by VIPs. First, we analyzed how forecasters understand statements by VIPs from economic newspapers, interviewed economic researchers, and so on. Based on the results of this analysis, we realized a natural language understanding for the purpose of simulation. This part consists of two main modules for: **natural language information analysis** and **natural language information interpretation**. An overview of the natural language processing in the system is shown in Fig. 5.20. (An example of this processing procedure will be shown in Chapter6.)

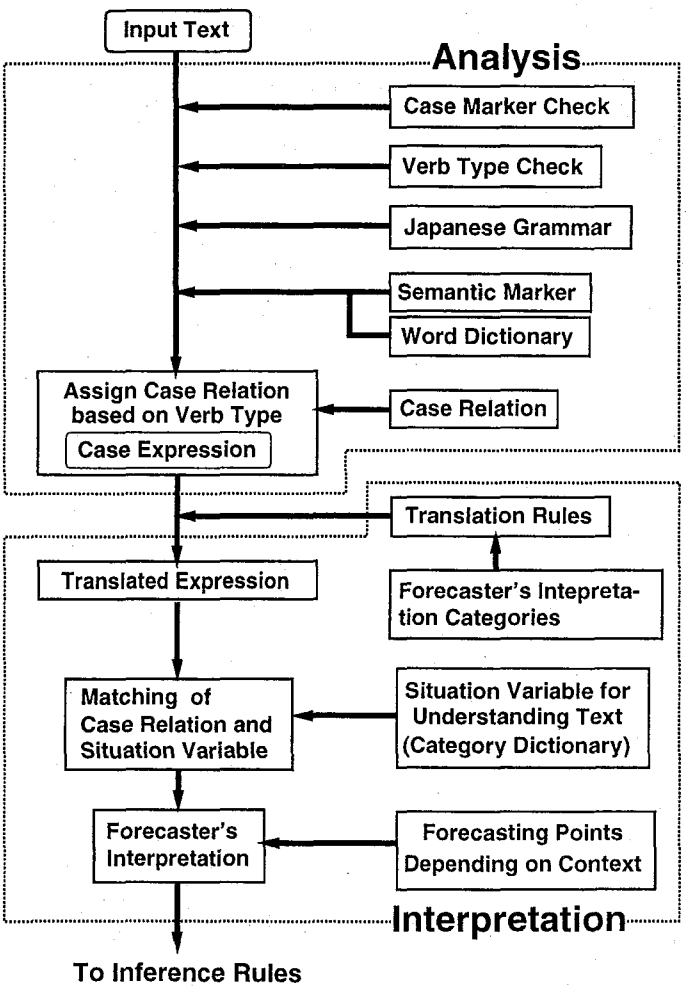

Figure 5.20: Overview of Natural Language Processing

5.5.1 Analysis Module

As input natural language information to the system, we use simple Japanese sentences whose morphological structures analyzed. Newspaper statements by VIPs are the source of natural language information. In this module, an input sentence is analyzed and translated into a Japanese case expression. Generally speaking, the meaning type of a verb plays a very important role in analyzing the structure of a sentence. In this work, we analyze Japanese case markers and the meaning type of each verb, thus, we can assign a case relation to each word in an input sentence, by respecting the semantics of each word and Japanese grammar.

Japanese Grammar

Japanese grammar is utilized when analyzing the structure of a sentence and assigning each word in the input sentence to a Japanese case expression. The system has some basic Japanese grammar [3] to analyze the structure of natural language information.

The basic Japanese grammar which the system has is as follows:

N.P.	C.M.	N.P.	C.M.	N.P.	C.M.	V.P. or AD.P. or ADV.P.	Period
~	*ga,ha*	~	*wo,ni*	~	*ni,wo*	*suru,sii,da*	.

where, N.P. : Noun Phrase
C.M. : Case Marker
V.P. : Verb Phrase
AD.P. : Adjectival Phrase
ADV.P. : Adjectival Verb Phrase (Keiyou-dousi, in Japanese)

Depending on this grammar, we show the basic types of sentences which can be input to the system.

- **Sentences which include one required case particle**

  ⌈ *ha* ⌋ or ⌈ *ga* ⌋

  Ex. *Keiki no kaifuku* ⌈ *ha* ⌋ *jyunchou da.*
  (The recovery of the business cycle has been making satisfactory progress.)
  Koyou toukei ⌈ *ga* ⌋ *sagatte iru.*
  (The employment ratio has been decreased.)

[3] Although there are many theories about Japanese grammar, we refer specifically to books [61] and [96].

- **Sentences which include two required case particles**

  ⌈ *ha* ⌋ + ⌈ *ni* ⌋

  ⌈ *ha* ⌋ + ⌈ *wo* ⌋

  ⌈ *ga* ⌋ + ⌈ *ni* ⌋

  ⌈ *ga* ⌋ + ⌈ *wo* ⌋

  Ex. *Tsuuka toukyoku* ⌈ *ha* ⌋ *genzai no endaka* ⌈ *wo* ⌋ *younin suru.*
  (The central bank allows the current state of the high yen rate.)
  Bei seifu ⌈ *ha* ⌋ *keiki no kaifuku* ⌈ *ni* ⌋ *cyuumoku suru.*
  (The U.S. government pays attention to the recovery of the U.S. business cycle.)
  Tsuuka toukyoku ⌈ *ga* ⌋ *kinyu hikisime* ⌈ *wo* ⌋ *jissi suru.*
  (The central bank tightens the money supply.)
  Bei seifu ⌈ *ga* ⌋ *FRB* ⌈ *ni* ⌋ *youkyuu suru.*
  (The U.S. requires the FRB to do something.)

- **Sentences which include three required case particles**

  ⌈ *ha* ⌋ + ⌈ *ni* ⌋ + ⌈ *wo* ⌋

  ⌈ *ha* ⌋ + ⌈ *wo* ⌋ + ⌈ *ni* ⌋

  ⌈ *ga* ⌋ + ⌈ *ni* ⌋ + ⌈ *wo* ⌋

  ⌈ *ga* ⌋ + ⌈ *wo* ⌋ + ⌈ *ni* ⌋

  Ex. *Kyuugekina kinri jyousyou* ⌈ *ha* ⌋ *sijyou* ⌈ *ni* ⌋ *ookina eikyou* ⌈ *wo* ⌋ *ataeru.*
  (A rapid change in money rate will have a big influence on the market.)
  Saikin no endaka ⌈ *ha* ⌋ *sijyou* ⌈ *wo* ⌋ *na-basu* ⌈ *ni* ⌋ *site iru.*
  (The recent high yen rate makes the market nervous.)
  Bei seifu ⌈ *ga* ⌋ *enyasu* ⌈ *ni* ⌋ *kenen* ⌈ *wo* ⌋ *hyoumei suru.*
  (The U.S. government expresses fear about the low yen rate.)
  Saikin no endaka ⌈ *ga* ⌋ *sijyou* ⌈ *wo* ⌋ *na-basu* ⌈ *ni* ⌋ *site iru.*
  (The recent high yen rate makes the market nervous.)

Noun Phrase and Verb Phrase

Basically, we deal with sentences which consist of case marker, noun phrase, and verb phrase, as the input natural language information. Here, we explain the grammatical character of the noun phrase and verb phrase in an input sentence.

- Noun Phrase

  There are various kinds of noun phrases. In this paper we deal with some basic noun phrase types as follows: (An noun phrase is expressed with ≪≫ .)

  1. The noun phrase consists of a noun.
     Ex. ≪ *hana* ≫ *ga saku.*
     (Flowers bloom.)
  2. The noun phrase consists of nouns with a conjunctive particle,
     ⌈ *no* ⌋.
     Ex. ≪ *kyou no jyoutai* ≫
     (Today's condition)
  3. The noun phrase consists of a quantifier and a noun with a conjunctive particle,
     ⌈ *no* ⌋.
     Ex. ≪ *takusan no hana* ≫
     (Many flowers)
  4. The noun phrase consists of an adjective and a noun.
     Ex. ≪ *kireina hana* ≫
     (Beautiful flowers)

- Verb Phrase

  Basically, a Japanese verb phrase consists of a verb and auxiliary verbs[4]. The system cannot deal with conjugation of verbs –that is, the system can only deal with the original dictionary form of verbs.

Classification based on Verb Meaning

When we analyze a natural language sentence, the meaning of the verb plays a very important role in this analysis. Verbs are classified into verb types based on their meaning[31][95]. In the case of Japanese grammar, each verb type has suitable case particles. By using this character, the coexistence of a verb and its case particles can be predicted, and this relation can be formalized[95]. In this paper, we refer to the book[61], and establish the following relation between a verb and its cases in the system as follows:

'(Verb, [(Case Expression$_1$, Case Marker$_1$) (Case Expression$_2$, Case Marker$_2$),...]).'

[4]There are five kinds of auxiliary verbs: aspect, modal, voice, tense, and polarity.

Ex. ('*Ataeru* (give)', [(target, '*wo*')(goal, '*ni*')]).
('*Chyuui wo harau* (pay attention to)', [(goal, '*ni*')]).

Dictionary

- **Word Dictionary**

  This dictionary is used for interpreting the words in an input natural language sentence by assigning a case relation to each word. Basically, this takes the following form:

  'word(A Part of Speech of the Word, Word, Semantic Marker).'

  Ex. word(noun, '*Keiki* (Economic Trends)', social_phenomenon).
  word(adj, '*Kyuugeki-na* (Rapid)', degree).

- **Category Dictionary**

  This dictionary is utilized when matching the meaning of a word in an input sentence to a recognized situation variable. Basically, this takes the following form:

  'sit_item(Situation Variable, Word).'

  Ex. sit_item(yen_dol_TREND, '*Yenyasu* (low yen rate)').
  sit_item(us_official_attitude_TREND, '*Bei tsuuka toukyoku no shisei* (FRB's policy)'

5.5.2 Understanding Module

This system understands of natural language based on the meaning type of main and auxiliary verbs. In other words, a VIP statement is understood by selecting an interpretation element from a forecaster's interpretation categories based on the meaning type of the sentence's main and auxiliary verbs. (We will explain this in detail later.) The forecaster's interpretation categories were extracted from newspapers by researching about fifty VIP statements. The understanding procedure in the system is as follows:

step1. Check the meaning of a verb type and use it to select an interpretation element from the forecaster's interpretation categories shown in Table 5.3.

step2. Check the correspondence between the content of the sentence and the situation variables which the system recognizes.

Here, we show an example of the result of steps 1 and 2 as follows:

Interpretation Element	:	*fear*
Situation Variable	:	Yen-Dollar Trend
State	:	Very Low (Yen against the U.S. dollar)

step3. Check the forecaster's view of economic conditions. This influences the result of understanding the input sentence. An example of a forecaster's view is as follows:

Forecaster's Concern	:	The Recovery of U.S. Economic Trends

step4. Determine the meaning of the input sentence. Select an interpretation element by considering the forecaster's view.

Each forecaster's view contains situation variables which should be considered when interpreting the input sentence. (We later present a table showing the relation between possible forecasters' views and situation variables.) An example of this is as follows:

Forecaster's Concern	:	The Recovery of U.S. Economic Trends
Situation Variables	:	Yen-Dollar Trend, Trade Balance

The system has rules which interpret the given state of the situation variables.(The rules can be found in Appendix E.) These rules interpret the given state, as shown below.

Forecaster's Concern	:	The Recovery of U.S. Economic Trends
State of Situation Variables	:	Yen-Dollar Trend(*very low*), Trade Balance(*very low*)
Interpretation	:	U.S. Economic Trends *will be delayed.*

The system also has rules which predict a forecaster's interpretation from the state of the situation variables shown above. An example of such a rule is as follows:

Interpretation	:	U.S. Economic Trends *will be delayed.*
Interpretation Element	:	*strong fear*

To summarize the examples mentioned above,

1. The forecaster's concern is the U.S. business recovery. (*forecaster's view*)
2. When forecasters are concerned about the U.S. business recovery, they consider the trend of the yen-dollar rate and the trend of the trade balance between the U.S. and Japan. (*situation recognition based on a forecaster's view*)

3. The future trend of the U.S. business recovery is predicted based on the trend of the yen-dollar rate and the trend of trade balances. (*prediction based on situation*)

4. Therefore, forecasters express *strong fear* for the current low yen rate. (*forecaster's interpretation*)

step5. Check the influence on the foreign exchange market by VIP statements, and by tenor and mode[5] information.

An example of this is shown below.

Tenor	:	Mr. Malford, the U.S. Treasury Undersecretary	:	rank A
Mode	:	The U.S. Congress	:	rank A

(We later show a table of social status ranks and the media which VIPs use.)
As the result of the interpretation procedure shown above, it is decided to what degree the statement by a VIP has an influence on the foreign exchange market, especially the yen-dollar rate. The degree of this influence is shown by selecting a suitable fuzzy relation expressing the future trend of the yen dollar rate. An example of this is as follows:

Interpretation Element	:	*strong fear*		
Tenor	:	Mr. Malford, the U.S. Treasury Undersecretary	:	rank A
Mode	:	The U.S. Congress	:	rank A
Future Trend	:	*Considerably higher*		

This result can be interpreted as Mr. Malford having a big influence on the foreign exchange market[6]. Because he spoke at the U.S. congress, his statement can be considered to be rather reliable. Therefore, as the result of considering natural language information, the future yen rate will be considerably higher than its current state.

[5]Here, tenor and mode do not correspond to tenor and mode in SFLT exactly. However, we use the term 'tenor' to show who speaks the statement, and use the term 'mode' to show which media the person utilizes.

[6]Rank A indicates the highest degree of status among social ranks. There are three levels of ranks: rankA, rankB, and rankC.

Forecasters' interpretation categories

VIPs make pronouncements about desirable market behavior. We believe that forecasters understand these statements according to a few categories. As the result of analyzing about fifty statements by VIPs in economic newspapers, we extracted five such interpretation categories shown in Table 5.3.

Table 5.3: Forecasters' interpretation categories

fear
admit
position & attitude
forecast
request

Forecasters' interpretation categories were equivalent for the views of both Central Banks and Governments. That is, 'fear' corresponds to 'Dissatisfaction', 'admit' corresponds to 'Approval', 'position & attitude' correspond to 'Wait and See, Attitude', 'forecast' corresponds to 'Prospect', and 'request' corresponds to 'Request'.

Equivalent translation based on the meaning type of a verb

As explained above, verbs are classified into some typical categories based on their meaning types. The category of a verb has a big influence on the meaning of the associated sentence. From this fact, in this paper, we realize an understanding of natural language by selecting a forecaster's interpretation element. An example of this is shown in Table 5.4.

Table 5.4: Example of the correspondence between a verb and a forecaster's interpretation category

Verb & Auxiliary	Category
take care of, pay attention to, etc.	fear
intent to, will	position, etc. & attitude
approve, accept, etc.	admit
will, may, think, etc.	forecast
hope, ask, etc.	request

Forecaster's View & Situation Variables Recognized

When forecasters interpret VIP statements, they take into account current economic conditions. Situation variables recognized by forecasters are determined by their view of economic conditions. The relation between a forecaster's view and situation variables recognized is shown in Table 5.5.

Table 5.5: The relation between a forecaster's view and situation variables recognized

U.S. Business Cycle	:	Trade Balance, Foreign Exchange Rate
U.S. Trade	:	Trade Balance, Financial Balance
U.S. Long Term Money Rate	:	Relative Balance of Long Term Money Rate
U.S. Short Term Money Rate	:	Relative Balance of Short Term Money Rate
U.S. Stock	:	Investment Trend of the U.S. and JPN Institutional Investors
U.S. Price	:	Official Attitude of the U.S. and JPN Central Bank
JPN Business Cycle	:	Trade Balance, Foreign Exchange Rate
JPN Trade	:	Trade Balance, Financial Balance
JPN Long Term Money Rate	:	Relative Balance of Long Term Money Rate
JPN Short Term Money Rate	:	Relative Balance of Short Term Money Rate
JPN Stock	:	Investment Trend of the U.S. and JPN Institutional Investors
JPN Price	:	Official Attitude of the U.S. and JPN Central Bank

Information of Tenor and Mode

When we interpret statements by VIPs, we also consider their social status and the media they use. The later are very important pieces of information for determining the reliability of a statement. Social status and media used by VIPs are shown in Table 5.6 and Table 5.7, respectively.

Table 5.6: Social status of VIPs

U.S.A.			**JPN.**		
U.S. President	:	rank A	JPN Prime Minister	:	rank C
U.S. Treasury Secretary	:	rank A	JPN Foreign Minister	:	rank C
U.S. Treasury Undersecretary	:	rank A	JPN Finance Minister	:	rank B
U.S. Trade Representative	:	rank B	Bank of JPN Chairman	:	rank A
FRB Chairman	:	rank A			
FOMC Committee Member	:	rank C			

Table 5.7: Media used by VIPs

U.S. Congress	:	rank A	JPN Congress	:	rank B
Summit	:	rank A	Financial Minister Interview	:	rank B
Financial Minister Conference	:	rank A	Foreign Minister Interview	:	rank B
Top-level Conference	:	rank A	Bank of JPN Biweekly Interview	:	rank C
Prime Minister Interview	:	rank C			

5.6 Inference

This part consists of three modules: **forecast model construction module**, **estimating module**, and **linguistic approximation module**. We will give detailed explanations of them, in turn.

5.6.1 Forecast Model Construction Module

In this module, a forecast model (i.e., a linguistic model) is constructed based on economic conditions. As explained above, first the system decides on a suitable economic condition type for the current economic conditions, and then recognizes more detailed economic conditions by following the limits of information references which the situation type provides. Through this process, both situation variables for the construction of a forecast model and the inference procedure are decided.

Determination of the Structure of a Forecast Model

A forecaster's knowledge for estimating FER changes is represented in the system by considering the relation between situation and knowledge. Situation types are organized hierarchically. The relation between a situation type and a piece of knowledge is decided by the level of attunement as explained in Chapter 3. This relation expresses the social semiotic aspect of FER forecasting, and it makes it possible for the system to realize the limit of information reference, and raise the efficiency of information processing by introducing knowledge inheritance among situation types. An example of a forecaster's knowledge for FER estimation is shown in Fig. 5.21.

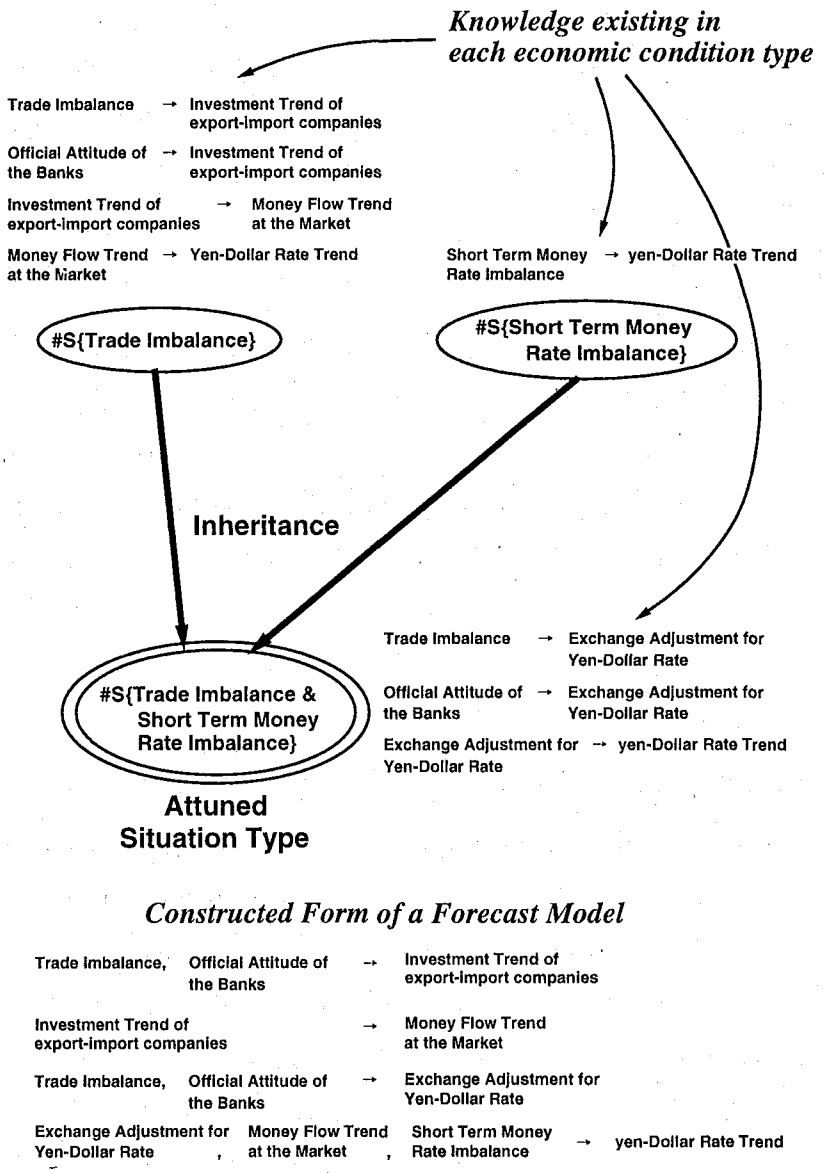

Figure 5.21: An example of forecaster's estimation knowledge

Each situation type has its own knowledge: structured knowledge and restricted knowledge. Here, structured knowledge represents the inference structure and the order of priority of knowledge for problem solving under a certain situation, and restricted knowledge represents specific knowledge –that is, the sense of values existing in a particular situation type. A lower situation type, if it is possible, inherits knowledge defined in upper situation types. Knowledge inheritance can raise the efficiency of information processing by saving memory, for example, it permits knowledge to be inherited by and applied to many subordinate situation types. Therefore, it is

natural to think that knowledge inheritance represents one functional aspect of common sense reasoning.

In Fig. 5.21, the knowledge existing in two situation types, #{**Trade Imbalance**} and #{**Short-Term Money Rate Imbalance**}, is inherited by the situation type, #{**Trade Imbalance & Short-Term Money Rate Imbalance**}, and combined as suitable estimating knowledge to construct a forecast model. In a forecasting process, (i) pieces of FER forecasting knowledge are gathered by inheritance from upper situation types (i.e., *inheritable knowledge*), (ii) the form of a forecast model is constructed (i.e., *structured knowledge*), and (iii) a FER forecast is performed by applying the gathered knowledge and existing knowledge (i.e., *restricted knowledge*) in an attuned situation type. (The relation between situation types and knowledge is explicated in Appendix F.)

From Fig. 5.21, we obtain the form of a forecast model shown below.

Trade imbal(t),	Off. Att.(t),		$\longrightarrow$	Ex-Im Comp.(t+1)
Trade imbal(t),	Off. Att.(t),		$\longrightarrow$	Ex. Adj.(t+1)
Ex-Im Comp.(t+1),			$\longrightarrow$	MF trend(t+1)
Ex. Adj.(t+1),	MF trend(t+1),	STM imbal(t)	$\longrightarrow$	YDR trend(t+1)

where,

Trade imbal(t)	:	Trade imbalance between JPN and U.S. at time t
Off. Att.(t)	:	Official Attitude of the central bank at time t
Ex-Im Comp.(t)	:	Investment trend of Export-Import companies at time t
Ex. Adj.(t)	:	Official Exchange Adjustment for yen-dollar rate at time t
MF trend(t)	:	Money Flow trend of the yen-dollar market at time t
STM imbal(t)	:	Short Term Money rate imbalance trend between JPN and U.S. at time t
YDR(t)	:	Yen-Dollar Rate trend at time t

The antecedents of the above causal relations indicate the causes for which the values of consequents change. This reflects the fact that the result of a forecast depends on which situation variables are established in rule antecedents. Here, we should notice that the above causal relationships are for selecting suitable fuzzy relations[7] to express the future trend of the consequent variables.

[7]Seven fuzzy relations are established in the system: *considerably higher, higher, somewhat higher, similar to, somewhat lower, lower, considerably lower.*

Thus, an above causal relationship is interpreted as the following rule.

$$If \;\; X(t) \;\; is \;\; \mathbf{F} \;\; and \;\; Y(t) \;\; is \;\; \mathbf{G} \;\; then \;\; \mathbf{f_R(Z(t+1),\ Z(t))} \;\; is \;\; R$$

where, f_R : Fuzzy relation function

R : An element of a fuzzy relation

Ex.

$$If \;\; \text{Trade imbal(t)} \;\; is \;\; \mathbf{very\ low} \;\; and \;\; \text{Off. Att.(t)} \;\; is \;\; \mathbf{medium} \;\; then$$
$$\mathbf{f_R(Ex\text{-}Im\ Comp.(t+1),\ Ex\text{-}Im\ Comp.(t))} \;\; is \;\; higher$$

(Here, the state value is expressed with one of five qualitative words: *very low, low, medium, high, very high.* We give a detailed explanation for this in Appendix D. Knowledge for selecting fuzzy relations is contained in Appendix G.)

Through the above process, a suitable forecast model for estimating FER changes is constructed. The knowledge needed for FER forecasting is extracted from books about foreign exchange forecasting[98, 97, 18, 90, 42, 17, 94, 67, 43, 20], interviews with economists and dealers, and articles from economic newspapers.

5.6.2 Estimating Module

This module executes the inferences for estimating the future trend of the FER.

The basic form of the inference is shown below.

$$\mathbf{Z(t+1)} \;\; is \;\; R \;\; than \;\; \mathbf{Z(t)}$$

where, R : A selected fuzzy relation

Ex.

$$\mathbf{Ex\text{-}Im(t+1)} \;\; is \;\; higher \;\; than \;\; \mathbf{Ex\text{-}Im(t)}$$

Fuzzy subsets and fuzzy relations in the system are represented with discrete expressions, and fuzzy inference is performed with matrix calculations –in this case, the max-min operation of fuzzy composition.

5.6.3 Linguistic Approximation Module

Since a forecast result will be produced in the form of fuzzy subset, we express it linguistically with fuzzy labels. It is expressed by selecting the most suitable expression from five fuzzy labels –*very high, high, medium, low, very low.*

5.6.4 Window Construction

The windows in the system are implemented with the library in SICStus Prolog. The system user selects items for input information. The user can see the graphical image of the trend of an economic index with X-graph, which can be executed by the system. An example of such an image is shown in Fig. 5.22.

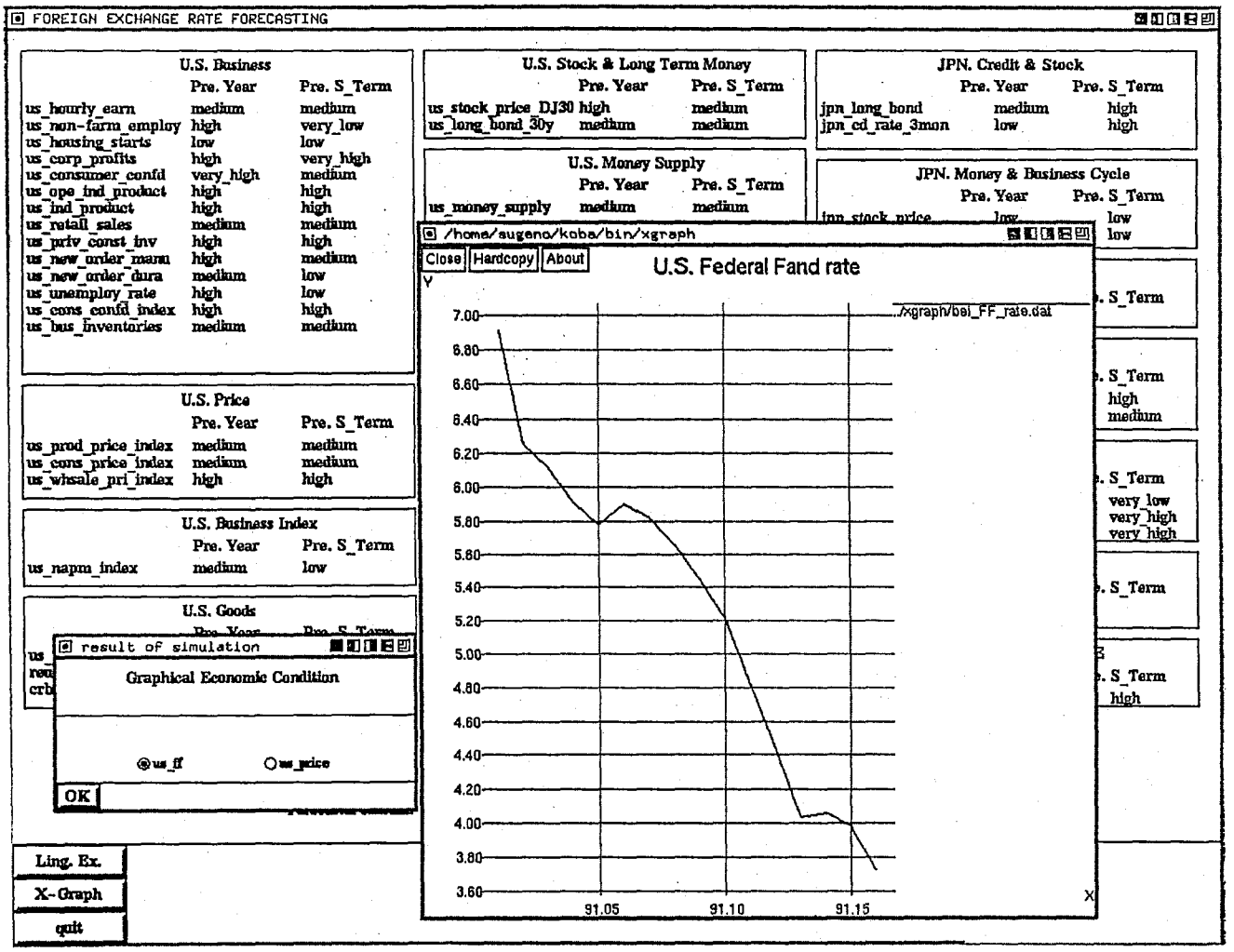

Figure 5.22: An example of a graphical image of an economic index

Chapter 6

Simulation Example

As an example of a simulation, we consider the situation in which the yen rate shot up due to the statement made by Mr. Malford, the U.S. Treasury Undersecretary, at the U.S. Congress on May 12, 1992. The content of his statement is as follows :

"We pay attention to an extreme low yen rate."

This statement had a strong effect on the FER. The trend of the yen exchange rate is shown in Fig.6.1.

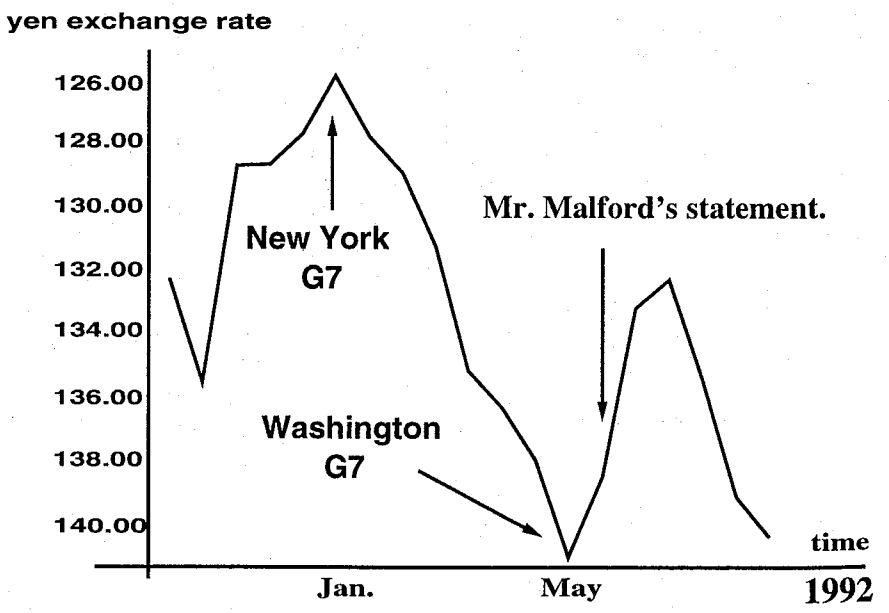

Figure 6.1: Trend of Exchange Rate of the Yen

An article about this event from a Japanese financial newspaper on May 14, 1992 is as follows:

> *"The yen shoot up by the statement by Mr. Malford, the U.S. Treasury Undersecretary hard expressing fear about the recent low yen rate at the Congress of the U.S. on May 12. This is because Bush government takes account of the continuous growth of U.S. economy. It is highly possible that the recent low yen rate makes U.S. domestic demand decrease. Recently Japanese current account balance is surplus of $ 90 billion and also long term capital income is surplus of $ 40 billion. If Japanese trade goes forward, U.S. domestic demand will decrease and the U.S. recovery will be delayed. But since it takes much time to correct the surplus of Japanese trade by the rising yen, only the exchange adjustment cannot wipe a fear that Japan will increase in black. Probably Japan will be requested to rise yen and increase domestic demand."* (*Nikkei Kinyuu Shinbun, May 14 1992*)

We will show an estimation process that depends on such facts for predicting the future trend of the yen-dollar rate in a simulation.

6.1 Simulation Process

We outline the simulation procedure of our FER forecast system as follows:

step 1. Start

step 2. Linguistic approximation of observed numerical data

step 3. Input situational information

step 4. Input a forecaster's economic variable of interest

step 5. Recognition of the state of twelve key economic variables

step 6. Input information about a VIP statement the social status of the VIP, and the place where the statement was made.

step 7. Understanding of the content of the statement by the VIP

step 8. Construction of a FER forecast model based on the observed economic conditions.

step 9. Estimation of the future trend of the yen-dollar rate.

step 10. End

An overview of the simulation process is illustrated in Fig.6.2

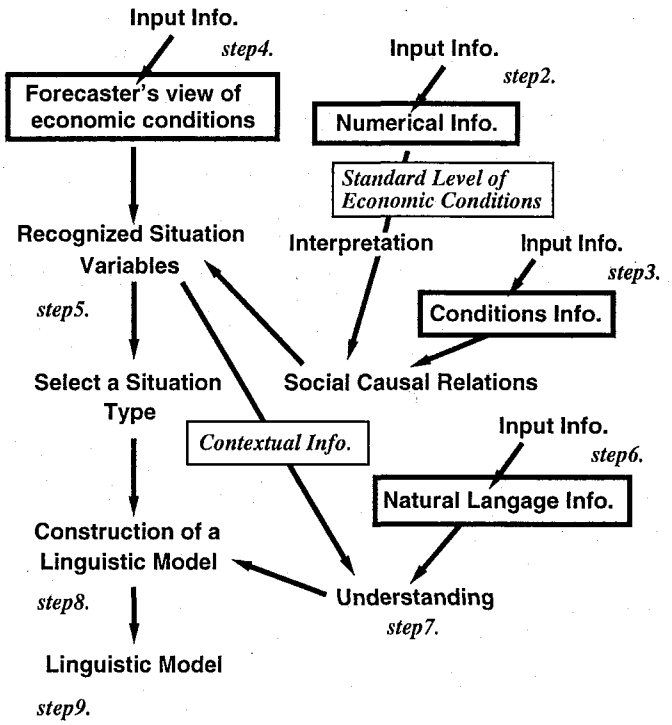

Figure 6.2: Overview of simulation process

We show an example simulation process of our FER forecast system by following the procedure shown above.

step 1. Start

The system starts to estimate the future trend of FER.

step 2. Linguistic approximation of the observed numerical data

We show an example of approximating the numerical value of an economic index.

Ex. U.S. Non-Farm Employment

	Change on Month	Change on Year
Standard level	0.0 %	1.0 %
Observed range	-0.3 $\sim$ 0.3 %	0.0 $\sim$ 2.0%
Observed value	+0.184%	+0.164%

After the linguistic approximation procedure, we obtain the result shown below.

Non-Farm Employment(change on month) is *very high*.

Non-Farm Employment(change on year) is *high*.

The results of linguistic approximation of the observed numerical data are shown in Table 6.1 and Table 6.2, Table 6.3. (Observed numerical data are placed in Appendix H.)

Table 6.1: Linguistic approximation of U.S. economic conditions

Economic Index	Pre. Year	Pre. Term	**Economic Index**	Pre. Year	Pre. Term
Average Hourly Earnings	medium	medium	Number of Non-farm Employment	high	very low
Housing Starts	low	low	Corporate Profits	high	very high
Consumer Confidence Index	very high	medium	Operating Ratio of Industrial Production	high	high
Index of Industrial Production	high	high	Retail Sales	medium	medium
GDP Private Construction Investment	high	high	New Orders for Manufactures	high	medium
New Orders for Durable Goods	medium	low	Unemployment Rate	high	low
Consumer Confidence Index	high	high	Business Inventories	medium	medium
Producer Price Index	medium	medium	Consumer Price Index	medium	medium
Wholesale Price Index	high	high	Purchasing Manager's Composite Diffusion Index	medium	low
Exports	medium	very low	Imports	high	high
Trade balance(Exports)	low	low	Trade balance(Imports)	very high	high
Financial Surplus	medium	high	Financial Deficit	medium	high
Government Expenditure	medium	medium	Official Discount Ratio	low	
FF rate	medium	medium	Treasury Bill Rates (3-Month)	very low	medium
Stock Price(D-J 30 Industrials Average)	high	medium	Long-Term Government Bonds(30-year)	medium	medium
Money Supply	medium	medium	Oil Price WTI	high	high
Reuter's Index	low	medium	CRB Index	low	medium

Table 6.2: Linguistic approximation of JPN economic conditions

Economic Index	Pre. Year	Pre. Term	**Economic Index**	Pre. Year	Pre. Term
Exports	high	low	Imports	very high	medium
Trade balance(Exports)	high	high	Trade balance(Imports)	very high	medium
Interest Rates on the Certificates of Deposit (3 Month)	low	high	Long-Term Government Bonds Yield	medium	high
The Nikkei Stock Average	low	low	Money Supply	medium	low
Financial Surplus	low	very high	Financial Deficit	low	very high
Sales of Department Stores	medium	high	Indexes of Operating Ratio	low	medium
GNP Growth Ratio	low	low	Official Discount Rate	high	
Consumer Price Index	high	high	Wholesale Price Index	medium	medium

Table 6.3: Linguistic approximation of GMN economic conditions

Economic Index	Pre. Year	Pre. Term	Economic	Pre. Year	Pre. Term
Interbank Rate	medium	high	Money Supply	high	medium
Long-Term Money Rate	high	medium	Official Discount Rate	very high	

The system window which displays the results of linguistic expressions of numerical data is shown in Fig.6.3.

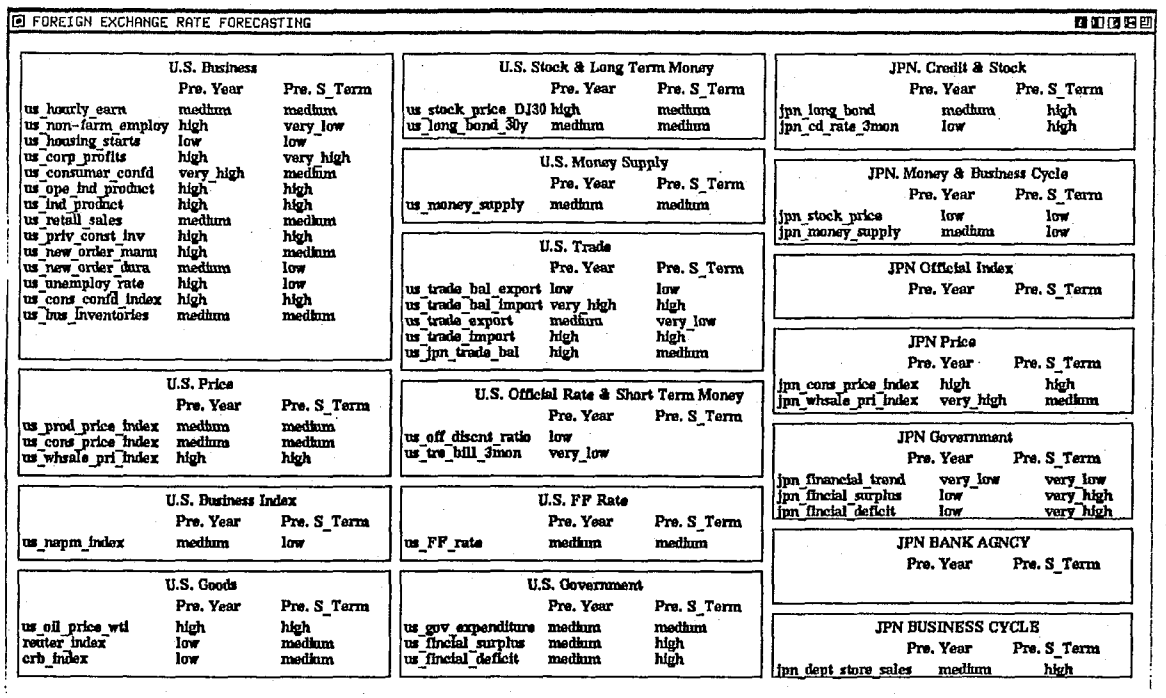

Figure 6.3: Result of Linguistic Expression of Numerical Data

step 3. Input situational information

Situational information input to the system is extracted from Japanese financial newspapers published from May 1 to May 12, 1992. The information input to the system is summarized in Table 6.4.

Table 6.4: Situational Information

Input Situation Variable	Trend
Investment trend of U.S. institutional investors	*yen-buy, dollar-sell*
Investment trend of JPN institutional investors	*yen-buy, dollar-sell*
Investment trend of U.S. export-import companies	*yen-buy, dollar-sell*
Official Attitude of FRB	*neutral*
Official Attitude of Bank of JPN	*neutral*

Situational Information Analysis

Situational information given to the system is expressed with either natural language or qualitative linguistic information. Qualitative linguistic information is input to the system exactly as it is (e.g., "Money flow trend of the yen-dollar market is *high*."). On the other hand, Japanese natural language needs to be analyzed before it is input to the system. That is, we use natural language information whose morphological structure has already been analyzed before it is input to the system. An example of the analysis of natural language in situational information is as follows:

'Wareware (FRB)','ha','chyuuritsugata no', 'kinyuu chyousetsu', 'wo', 'keizokusuru'. (FRB takes a neutral position.)

The analyzed form of the sentence is shown below.

[[subject(FRB)],[attrb(chyuritsugata no), goal(kinyuu chyousetsu)], [process(keizokusuru)]]

Situational information selects a situation variable in the system based on the *'subject'* and *'goal'* variables. In this case, from the subject **FRB** and goal **kinyuu chyousetsu**, the most suitable situation variable for expressing the content of the input information, **official attitude of FRB** is selected. The information the variable *'attrb'* expresses is that their monetary position is neutral. Then we get the result shown below.

Input Situation Variable	Trend
Official Attitude of FRB	*neutral*

An example of a situational information input window is shown in Fig.6.4.

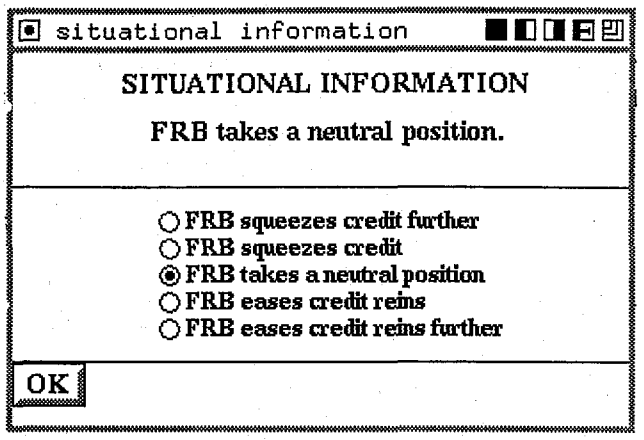

Figure 6.4: Example of situational information input window

step 4. Input a forecaster's economic variable of interest

Forecaster's economic variable of interest input to the system :

U.S. business cycle (the degree of recovery)

The input window for entering a forecaster's view is shown in Fig.6.5.

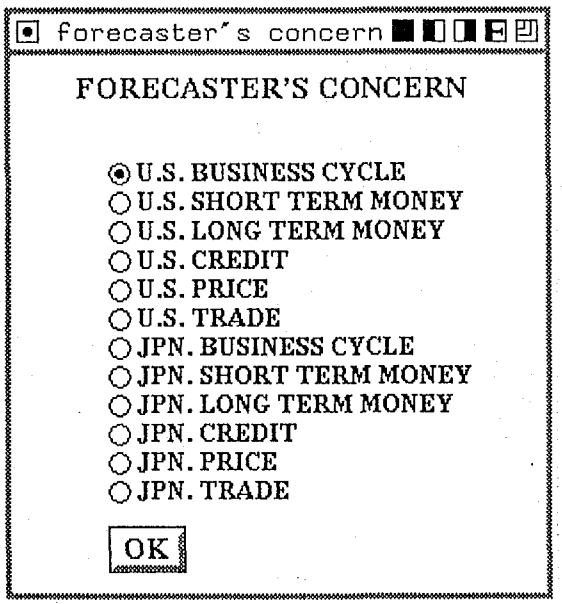

Figure 6.5: Forecaster's View Window

step 5. Recognition of the state of the 12 key economic variables

In this system, an economic condition type is decided from the difference between the standard level of an economic condition and the observed level of an economic condition. In this example,

an economic condition type is expressed by the state of the bold face situation variables in Table 6.5.

Table 6.5: Observed economic condition

U.S. business cycle	*low*	:	JPN business cycle	low
U.S. trade	**very low**	:	**JPN trade**	**very h**
U.S. long-term interest on money	*be stable*	:	JPN long-term interest on money	*high*
U.S. short-term interest on money	*be stable*	:	**JPN short-term interest on money**	**very h**
U.S. stock	*be stable*	:	JPN stock	*low*
U.S. price	*be stable*	:	JPN price	*high*

The system window which displays a situation type is shown in Fig.6.6.

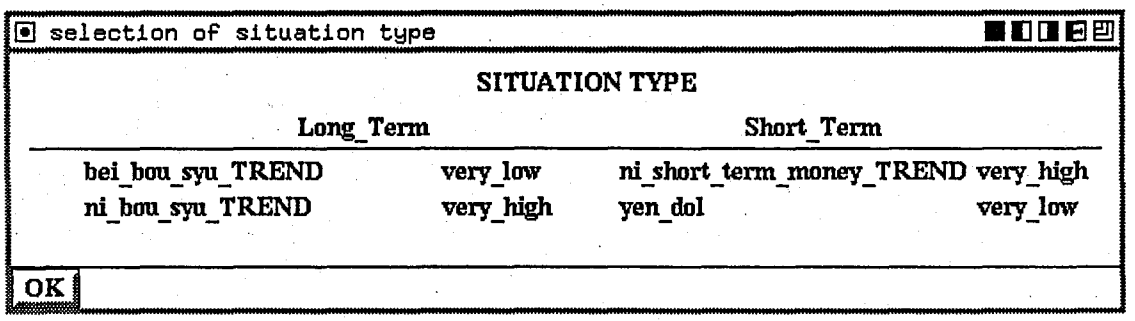

Figure 6.6: Attuned situation type

step 6. Input information about a statement by a VIP, the social status of that VIP, and the place where the statement was made.

As was explained in **step 3**, we use natural language information whose morphological structure has already been analyzed. The result of analyzing our example statement is shown below.

The statement by a VIP to the system:

'Wareware (U.S. seifu)','ha','kyokutan na', 'en yasu', 'ni', 'chyuui','wo', 'haratte iru'.

("We (U.S. government) pay attention to the extremely low yen rate.")

Table 6.6 shows the context of situation of the statement.

Table 6.6: Context of situation of the statement

Field:	The statement about the status of the yen- dollar trend
Tenor:	Mr. Malford, the U.S. Treasury Undersecretary
Mode:	the Congress of the U.S.

We show the natural language information input window in Fig.6.7.

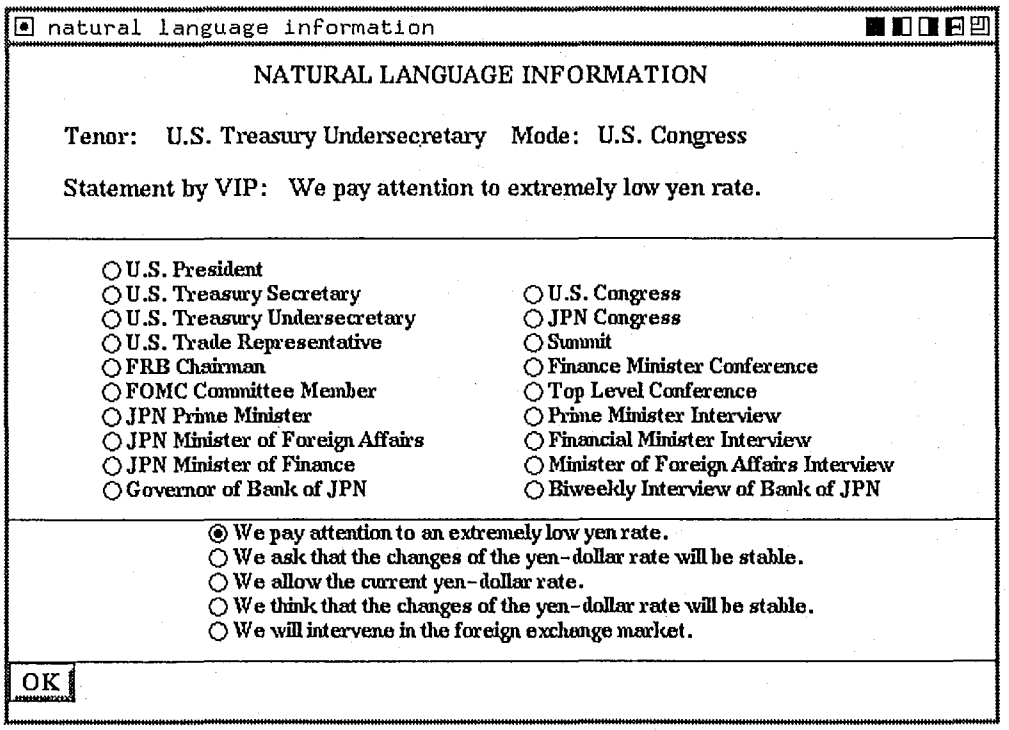

Figure 6.7: Natural language information input window

step 7. Understanding the content of the statement by a VIP

Natural Language Information Analysis

Natural language information is translated into Japanese case expressions in the system.

[[subject(U.S. seifu)],[attrb(kyokutan na), goal(en yasu)],

[process(chyuui wo harau), aspect(te iru)]]

Natural Language Information Understanding

step 1. **Select an interpretation element from a forecaster's interpretation categories depending on the meaning of the verb.**

Verb	**Interprt. elmt.**
chyuui wo harau	*fear*
(pay attention to)	

step 2. **Select one of the verb's case relations to be filled in later steps of the understanding process.**

Verb	**Case relation**
chyuui wo harau	*goal*
(pay attention to)	

step 3. **Select an economic variable which corresponds to the category of the word selected in step 2.**

Subject word	**Economic variable**
en yasu	*yen dollar trend*
(low yen rate)	

step 4. Decide on the meaning of the input sentence. That is, decide on an interpretation element by considering the forecaster's economic variable of interest. Forecaster's view given to the system :

U.S. business cycle (the degree of recovery)

The economic variables associated with a forecaster's economic variable of interest :

Yen dollar trend	:	*low*	(Yen against Dollar)
Trade imbalance between JPN and U.S.	:	*very high*	(against the U.S.)

According to the state of these variables, it is concluded that the VIP expresses

"*strong fear* for the low yen rate."

step 5. Check the statement's influence on the foreign exchange market by considering the content of the VIP's statement, the social status of the VIP, and the place where the statement was made.

Tenor	:	Mr. Malford,the U.S. Treasury Undersecretary	:	**rank A**
Mode	:	U.S. Congress	:	**rank A**
Field	:	**strong fear** for the low yen rate		

It is concluded that the observed information will have a big influence on the yen dollar rate.

step 8. Construction of a FER forecast model based on the observed economic conditions.

A forecast model is constructed based on a selected(i.e., attuned) situation type. In this simulation example, an selected situation type is

#S{(U.S. trade : very low)(JPN trade : very high)
(JPN short term interest on money : very low)
(yen dollar trend(against dollar) : very low)}.

The hierarchical relations, which an attuned situation type has, is shown in Fig. 6.8.

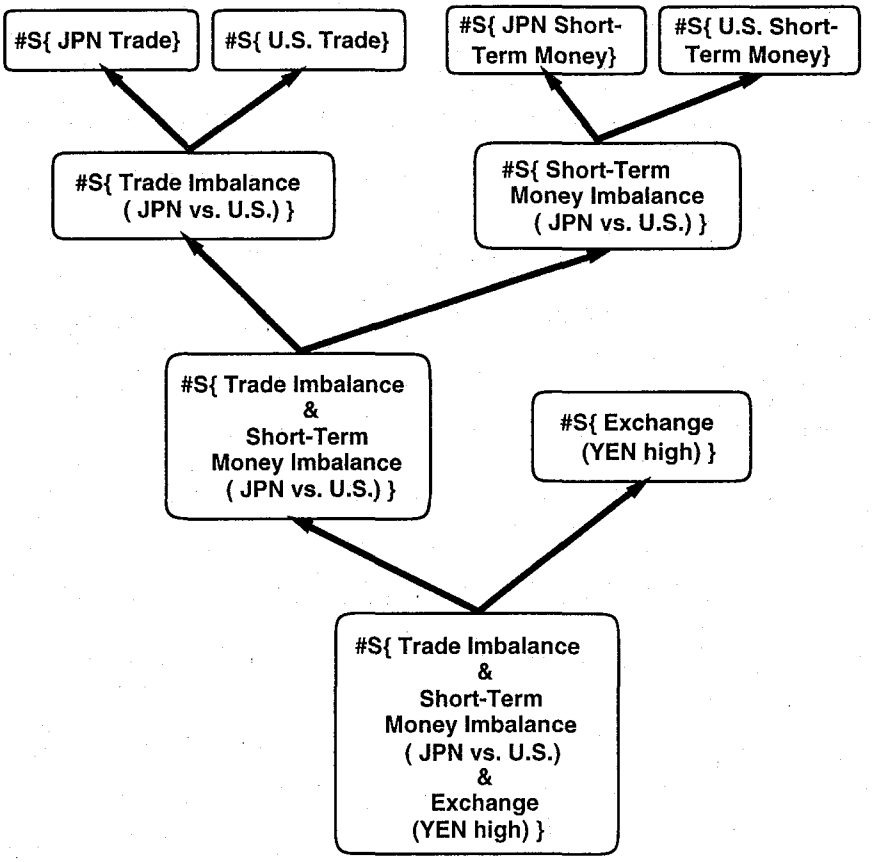

Figure 6.8: Hierarchical relations of an attuned situation type

Each situation type has the FER trend estimating knowledge shown below.

#S{yen-dollar-rate }		
Trend of yen-dollar rate	$\longrightarrow$	Official attitudes of the JPN and U.S. central banks
Official attitudes of the JPN and U.S. central banks	$\longrightarrow$	Investment trend of JPN and U.S. export-import companies
Investment trend of JPN and U.S. export-import companies	$\longrightarrow$	Money flow trend of the yen-dollar market
Money flow trend of the yen-dollar market	$\longrightarrow$	yen-dollar rate trend

#S{**Trade imbalance** }		
Recognize the trend of trade imbalance between JPN and U.S.		
Trade imbalance between JPN and U.S.	⟶	Investment trend of JPN and U.S. export-import companies
Official attitudes of the JPN and U.S. central banks	⟶	Investment trend of JPN and U.S. export-import companies
Investment trend of JPN and U.S. export-import companies	⟶	Money flow trend of the yen-dollar market
Money flow trend of the yen-dollar market	⟶	yen-dollar rate trend

#S{**Short term money rate imbalance** }		
Recognize the trend of short term money rate imbalance between JPN and U.S.		
Short term money rate imbalance trend between JPN and U.S.	⟶	yen-dollar rate trend

#S{**Trade imbalance & Short term money rate imbalance** }		
Trade imbalance between JPN and U.S.	⟶	Trend of exchange adjustment for yen-dollar rate by the JPN and U.S. central banks
Official attitude of the JPN and U.S. central banks	⟶	Trend of exchange adjustment for yen-dollar rate by the JPN and U.S. central banks

The knowledge existing in each situation type is (i) inherited through the hierarchy of situation types, (ii) gathered in the attuned situation, and (iii) reconstructed in a way that is suitable for estimating the FER trend at a particular time. A forecast model is built from the knowledge gathered through this process. We show a forecast model constructed in the attuned situation as follows:

YDR trend(t)			⟶	U.S. Off. Att.(t+1)
YDR trend(t)			⟶	JPN Off. Att.(t+1)
U.S. Off. Att.(t+1),	JPN Off. Att.(t+1),	Trade imbal.(t)	⟶	U.S. Ex-Im. Comp.(t+1)
U.S. Off. Att.(t+1),	JPN Off. Att.(t+1),	Trade imbal.(t)	⟶	JPN Ex-Im. Comp.(t+1)
U.S. Ex-Im. Comp.(t+1),	JPN Ex-Im. Comp.(t+1),		⟶	MF trend(t+1)
MF trend(t+1),	STM imbal.(t),	VIP Statement(t)	⟶	**YDR trend(t+1)**

where,

YDR trend(t)	:	yen-dollar rate trend at time t
U.S. Off. Att.(t)	:	Official attitude of the U.S. central bank (FRB) at time t
Trade imbal.(t)	:	Trade imbalance between JPN and U.S. at time t
U.S. Ex-Im. Comp.(t)	:	Investment trend of U.S. export-import companies at time t
JPN Ex-Im. Comp.(t)	:	Investment trend of JPN export-import companies at time t
MF trend(t)	:	Money flow trend of the yen-dollar market at time t
STM imbal.(t)	:	Short term money rate imbalance trend between JPN and U.S. at time t
VIP statement(t)	:	A statement by a VIP at time t

step 9. Estimation of the future trend of the yen-dollar rate.

The model forecast rules shown in **step 8.** were constructed with knowledge from each situation type. Inheritable knowledge was inherited through the hierarchy of situation types, and structured knowledge gave the order of rule construction. Finally, the FER forecast is performed by applying restricted knowledge existing in attuned situation types. This restricted knowledge gives a suitable fuzzy relation for estimating the FER trend.

A FER forecast model built in the attuned situation is shown as follows:

U.S. Off. Att.(t+1)	is	*considerably higher* than U.S. Off. Att.(t) if YDR trend(t) is *low*
JPN Off. Att.(t+1)	is	*considerably higher* than JPN Off. Att.(t) if YDR trend(t) is *low*
U.S. Ex-Im. Comp.(t+1)	is	*higher* U.S. Ex-Im. Comp.(t) if U.S. Off. Att.(t+1) is *very low*, JPN Off. Att.(t+1) is *medium*, and Trade imbal.(t) is *very low*
JPN Ex-Im. Comp.(t+1)	is	*higher* JPN Ex-Im. Comp.(t) if U.S. Off. Att.(t+1) is *very low*, JPN Off. Att.(t+1) is *medium*, and Trade imbal.(t) is *very low*
MF trend(t+1)	is	*somewhat higher* MF trend(t) if U.S. Ex-Im. Comp.(t+1) is *medium* and JPN Ex-Im. Comp.(t+1) is *medium*
YDR(t+1)	is	*considerably higher* YDR(t) if MF trend(t+1) is *medium*, STM imbal.(t) is *very high*, and VIP Statement(t) expresses *strong fear* for YDR(t)

The system window which shows a constructed model and the result of a forecast is shown in Fig.6.9.

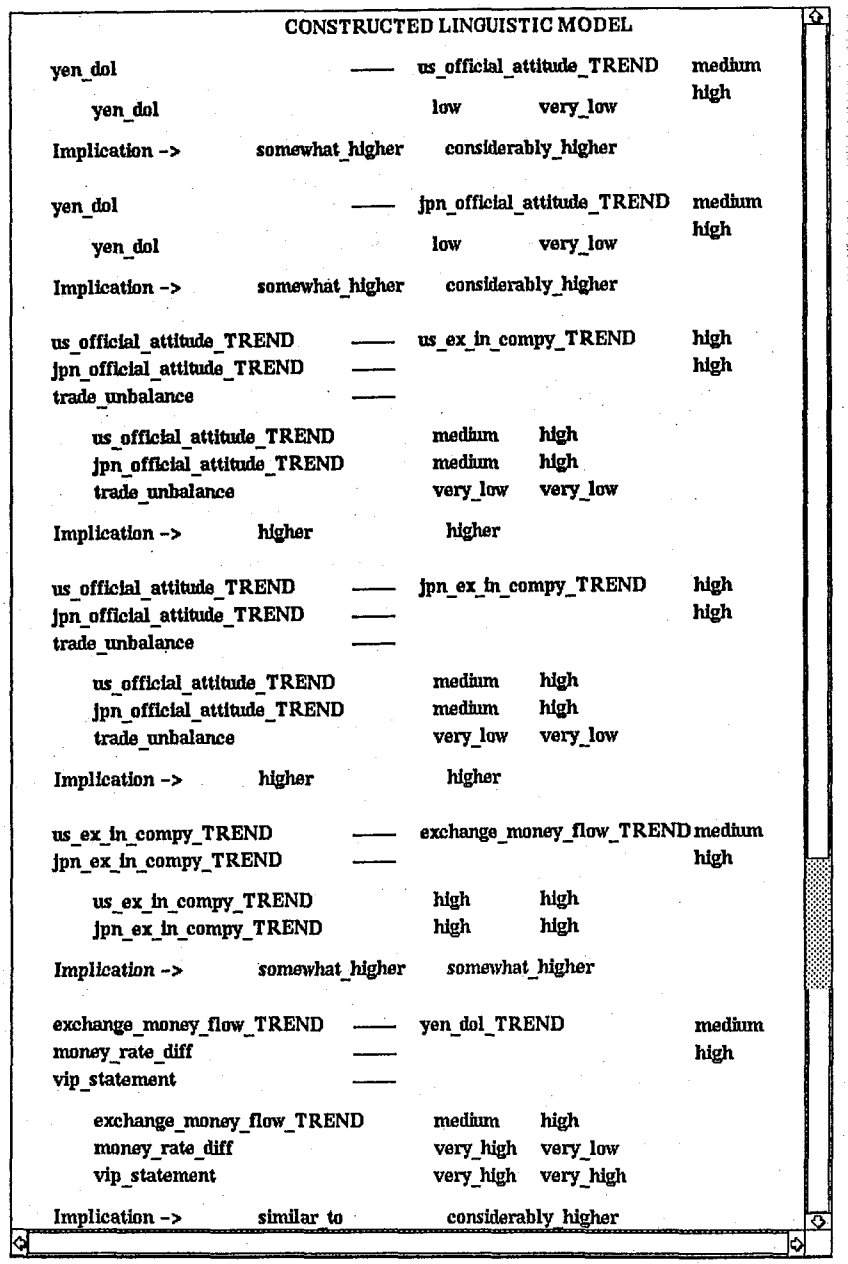

Figure 6.9: Constructed Model and Forecast Result

6.1.1 Discussion of Simulation Result

By using the causal relations represented in our foreign exchange simulation, the system recognized **short term money rate imbalance between the U.S. and Japan**, **trade imbalance between the U.S. and Japan**, and **low yen rate against the U.S. dollar**, as the current economic position. Since forecasters had been concerned about the recovery of the U.S. business cycle, and because the trade imbalance can be considered as an obstacle for U.S. economic recovery, they estimated the current low yen rate would cause easy-money operation by the Federal Reserve Bank (FRB), even though the FRB takes a neutral position at time t. They also assumed the U.S. and Japanese export-import companies would buy yen against the U.S. dollar. From these reasons, the yen rate was predicted to shoot up on the foreign exchange market. Moreover, the recent short-term money rate imbalance between the U.S. and Japan could also be considered as a cause of the yen's appreciation against the U.S. dollar. Under these economic conditions, at the U.S. Congress Mr. Malford [1] expressed strong fear for the current low yen rate. Since forecasters had been concerned about the recovery of the U.S. business cycle, both the current yen-dollar exchange level and the trade imbalance between the U.S. and Japan could be considered as obstacles to U.S. economic recovery. Therefore, Malford's statements could be interpreted as significantly influencing the foreign exchange market. From these factors, forecasters estimated that the future trend of the yen rate would be considerably higher than the current one.

[1] Because Mr. Malford is the U.S. Treasury Undersecretary (i.e., a VIP), he can have a big influence on the FER market.

6.1.2 Information Fusion in the System

An overview of an information fusion example in the system is illustrated in Fig.6.10.

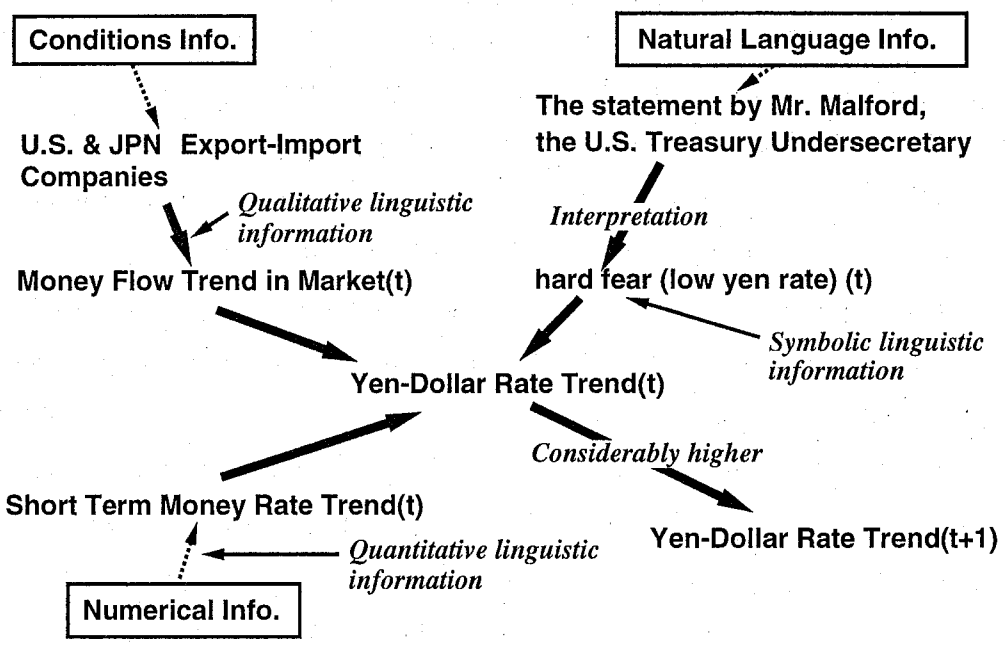

Figure 6.10: Overview of an Information Fusion Example

In the system, natural language information is translated into symbolic information, numerical data is translated into qualitative linguistic information, and situational information is translated into qualitative or symbolic information. Since all information is translated into linguistic form (based on current and standard economic conditions), they are all mutually comparable at the same level of abstraction in the system. This information is then used to estimate the future trends of other economic variables. These estimated values are also expressed linguistically and interpreted by contextual information. In general, information fusion based on language is performed by interpreting all information contextually.

Chapter 7

Conclusions

In this paper, we focused our attention on human intellectual information processing based on the uses of language and custom in a particular social group, and attempted to realize it in a computer. As background for proposing a new framework of information processing, we reviewed the ideas of linguistic philosophers such as Wittgenstein and Peirce. Then, we proposed a type of computing based on their philosophical investigations about the relation between human intellectual activity and the role of language. Wittgenstein gave us an rich philosophical investigation about the relation between human intellectual activity and the uses of language –that is, language is a tool for thinking, and human intellectual activities depend on the uses of language and custom in a particular social group. Moreover, Peirce insisted that the human thinking process is a semiotic process, and the function of this process is to allow humans to achieve intellectual activities.

Based on their philosophical investigations, we proposed a new type of computing called "intelligent computing." The basic concepts of intelligent computing are that language is the currency of information processing, information processing is based on custom. Intelligent computing was developed based on several ideas: (i) how to process information in a way that depends on custom, (ii) how to represent language in a computer, and (iii) how to represent a human thinking model with linguistic expressions. To realize information processing based on language, we had to understand how to represent and use language. Therefore, we introduced the concept of systemic functional linguistic theory (SFLT) into our proposing computing framework, because SFLT is a linguistic theory which discusses language from a social semiotic perspective. In addition, SFLT and the above linguistic philosophies have a common fundamental concept of language. SFLT gives us a fundamental concept of how language works in social

activities, how a linguistic system is constructed by reflecting its social context, and so on, all of which is based on the uses of language in social activities. According to this linguistic theory, we could learn how we should treat language, and how we should represent the environment in which semiotic systems exist.

Concerning (i), we proposed a method of processing information in a social semiotic sense. We believe that custom is represented by the social semiotic relation between situation and knowledge, in other words, it is represented by the relation between practical knowledge and common situation types in a particular social activity. To be concrete, in order to realize information processing based on custom in a particular social group, we considered how to represent custom by taking account of its functional aspects in our proposed relation between situations and knowledge. Moreover, we defined three types of situation-based knowledge (i.e., inheritable, structured, and restricted knowledge) for representing practical knowledge.

Concerning (ii), since we attempt to use language as processing information, we need to represent language in a computer. However, in fact, it is in principle impossible to express the real nature of language in a computer. Therefore, we focus on functional aspects of language, and we only express these features in linguistic processes in a computer. In particular, as a functional aspect of language, we proposed an information fusion technique based on language. By using this method, we can unify various kinds of information with language and use language as a common form of information in computational processes. We believe that this method can raise the efficiency of information processing.

Concerning (iii), we attempted to build a model of the human thinking process. This model is called a linguistic model. A linguistic model is expressed with linguistic expressions that reflect social context and involves some functional aspects of language to process information. It was applied to a social system as a simulation model.

An overview of our work is shown in Fig.7.1.

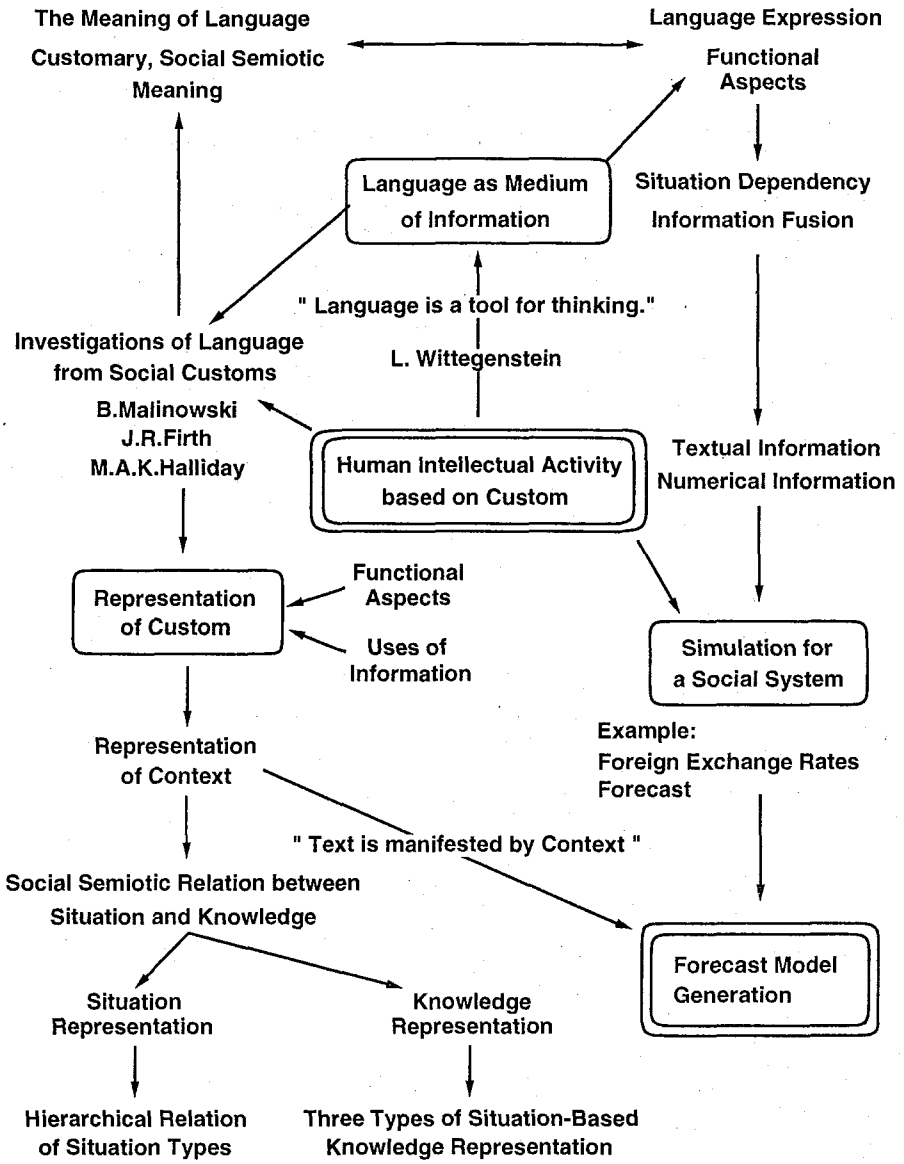

Figure 7.1: Overview of our work

In order to show an example of our proposed method and verify its validity, we considered an activity, estimation of future trends of FER changes, and represented a foreign exchange forecaster's estimation process with our proposed methods. In a simulation process, each kind of input information to the system is translated linguistically and unified by considering current economic conditions. Hence, a suitable forecast model for the economic conditions is constructed, and applied to estimating the trends of the FER. In this process, we introduced the methods

proposed above. The information used in a simulation process contains actual numerical data, situational information from newspapers, and statements by VIPs as natural language information. As an example of a simulation, we took up the fact that the yen rate shot up due to a statement by Mr. Malford (U.S. Treasury Undersecretary) at the U.S. Congress on May 12, 1992. As a simulation result, we could get a prediction for the future trends of yen-dollar exchange rate changes. We obtained a reasonable simulation result.

Generally speaking, when we simulate a social system, the result of that simulation depends on model structure, available information for the simulation, and so on. Therefore, it is not necessarily true that we can realize perfectly correct simulations. However, with regard to this, a simulation based on numerical information is no better than our proposed simulation based on linguistic information. In particular, the proposed simulation is realized based on a forecaster's estimating knowledge so that the validity of the result of a simulation depends on the knowledge (i.e., inference methods, algorithm for information reference, and so on) which is established in the system. However, although ordinary conventional social system simulation has been performed by using numerical information, the trends of a real social system cannot be determined with only numerical information. For the reason given above, our proposed method, which attempts to deal with various kinds of linguistic information, is required. Our proposed simulation is superior to a numerical simulation, because it can deal with various kinds of information, processes information on the assumption that it must also understand the meaning of information, and gets results similar to those produced by humans. We can, therefore, say that our method is the first attempt to introduce the concept of human information processing based on language into the field of social simulation engineering, and can also be evaluated as a new approach to social system simulation.

In the 1970's, growth of AI technologies unfortunately reached a dead end. At that time, expert system technologies provided us with a different method for developing human like intelligent systems. We extended this concept by regarding a human being as a large-scale expert system having an information processing system based on the customs of a particular social group. In so doing, we propose a different approach from conventional AI and a new type of information processing. The importance of introducing the uses of language and customs of a particular social group can be easily understood by observing the difference between a social group which uses Chinese characters and a social group which uses phonetic characters. Because, each Chinese character originates from a hieroglyphic character (i.e., a picture), it has its

own set of connotive meanings, and can remind us of associated meanings. On the other hand, meaning in an alphabetic language is determined by logically combining symbols. Therefore, it can be considered that language which originates from pictures is superior when expressing connotive meaning (e.g., sensory/perceptual features, feeling, etc.), and language which consists of symbols is superior when explaining something logically. We believe that this difference reflects the organization of human memory and the method of information processing. From this, we can say that human information processing differs in each social group, and semiotic systems, including language, plays a very important role to build up the national character.

In future work, we will further explore human intellectual activities based on custom and the uses of language, and improve existing and propose new functional aspects of language in information processing. Hence, we try to represent knowledge with natural language to further develop flexible and intelligent information processing systems. We will expand the quantity and quality of FER estimating knowledge in our simulation, and improve the system's general purpose natural language understanding capability.

Bibliography

[1] Sanjaya Addanki, editor. *A Fuzzy Simulation Model for a Socio-Economic System*, Toronto, 16-18,July 1979. Proceedings of the 1979 Summer Computer Simulation Conference.

[2] James Allen. *Natural Language Understanding.* The Benjamin/Cummings Publishing Company, Inc., 1987.

[3] Wanda M. Austin and Bechrokh Khoshnevis. Qualitative modeling using natural language: An application in system dynamics. In Paul A.Luker Paul A. Fishwick, editor, *Qualitative Simulation Modeling and Analysis*, chapter 11, pages 263–301. Springer-Verlag, 1991.

[4] J. Barwise and J. Perry. *Situation and Attitude.* MIT.Press, 1983.

[5] J. Bateman and L. Hang. The apprication of systemic-functional grammar to Japanese and Chinese for use in text generation. In *the International Conference on Computer Processing of Chinese and Oriental Languages*, pages 443–447, 1988.

[6] J. A. Bateman. The kyoto university systemic grammar developement facility: A user's guide. Technical report, Kyoto University, 1987.

[7] J. A. Bateman. From systemic-functional grammar to systemic-functional text generation: Escalating the exchange. In *WS88*, pages 123–132, 1988.

[8] J. A. Bateman. Uncovering textual meanings: A case study involving systemic-functional resources for the generation of japanese text. In C. L. Paris, W. R. Swartout, and W. C. Mann, editors, *NLGinAIandCL*, chapter 5, pages 125–153. Kluwer Academic Publishers, 1991.

[9] Howard W. Beck and Paul A. Fishwick. Incorporating natural language descriptions into modeling and simulation. *Simulation*, (3):102–109, March 1989.

[10] Howard W. Beck and Paul A. Fishwick. Natural language, cognitive models, and simulation. In Paul A.Luker Paul A. Fishwick, editor, *Qualitative Simulation Modeling and Analysis*, chapter 12, pages 302–325. Springer-Verlag, 1991.

[11] David Bloor (Kazuhisa Todayama translated). *Wittgenstein, A Social Theory of Knowledge.* Keisou Syobou, 1985.

[12] David Crystal(translated by Kiyozou Kazama and Kinsuke Hasegawa et al.). *The Cambridge Encyclopedia of Language (in Japanese translation: Gengogaku Hyakka Jiten).* Taisyuukan Syoten, 1992.

[13] N.A. Chomsky. *Syntactic Structures.* The Hague: Mouton, 1957.

[14] Bruce D'ambrosio. Extending the mathematics in qualitative process theory. In Lawrence E. Widman Kenneth A. Loparo Norman R. Nielsen, editor, *ARTIFICIAL INTELLIGENCE, SIMULATION, AND MODELING*, chapter 5, pages 133–158. A WILEY-INTER SCIENCE PUBLICATION, JHON WILEY&SONS, 1989.

[15] James D.Benson and William S.Greaves, editors. *SYSTEMIC PERSPECTIVES ON DISCOURSE, VOL.1,2.* Ablex Publishing Corpolation, 1985.

[16] Umbelt Echo (Yoshihiko Ikegami translated). *Semiotics I (in Japanese: Kigou ron I).* Iwanami Modern Selected Books. Iwanami Shyoten, 1983.

[17] Japanese Economic Newspaper Company Edited. *How to read Financial Articles in Japanese Economic Newspaper (in Japanese: Nikkei Kinyuu Men no Yomikata).* Japanese Economic Newspaper Company, 1986.

[18] Japanese Economic Newspaper Company Edited. *100 Commonsenses for Foreign Exchange (in Japanese: Gaikoku Kawase 100 no Jyousiki).* Japanese Economic Newspaper Company, 1989.

[19] Japanese Economic Newspaper Company Edited. *Financial English Dictionary (in Japanese: Kinyuu Syouken Eigo Jiten).* Japanese Economy Newspaper Company, 1990.

[20] Japanese Economic Newspaper Company Edited. *Easy Finance (in Japanese: Iyademo Wakaru Kinyuu).* Japanese Economic Newspaper Company, 1991.

[21] Davis Ernest. *Representations of Commonsense Knowledge.* Morgan Kaufmann Publishers, Inc., San Mateo, California, 1990.

[22] Robin P. Fawcett. *COGNITIVE LINGUISTICS AND SOCIAL INTERACTION.* Julius Groos Verlag, Heidelberg, 1980.

[23] Paul A. Fishwick. Qualitative methodology in simulation model engineering. *Simulation*, 52(3):95–101, 1989.

[24] Paul A. Fishwick. A study of terminology and issues in qualitative simulation. *Simulation*, (1):5–9, January 1989.

[25] Jay W. Forrester. *Industrial Dynamics.* The M.I.T Press,Cambrige,Massachusetts, 1961.

[26] Satoru Fukami. Foreign exchange trade support expert system. Technical report, Laboratory for International Fuzzy Engineering Research, 1990.

[27] Satoru Fukami Tatsuo Yagyu Hideo Yuize Minoru Yoneda Michel Grabisch. Report on life decision support system project (in japanese). Technical report, Laboratory for International Fuzzy Engineering Research, 1991.

[28] Hajime Fukuchi. The effect of functional grammar and its purpose (in japanese : Kinou bunpou no chikara to sono nerai). *Language*, October 1988. Monthly Publication.

[29] Gerald Gazdar and Chris Mellish. *Natural Language Processing in Prolog.* Addison-Wesley Publishin Company, 1989.

[30] M.A.K. Halliday. *Language as social semiotic.* Edward Arnold, London, 1978.

[31] M.A.K. Halliday. *An Introduction to Functional Grammar.* Edward Arnold, London, 1985.

[32] M.A.K. Halliday, editor. *NEW DEVELOPMENT IN SYSTEMIC LINGUISTICS volume1:Theory and Description.* Frances Printer, London and New York, 1987.

[33] M.A.K. Halliday. Towards probabilistic interpretations. In *paper given at the Sixteeth International Systemic Congress*, Finland, June 12-16 1989.

[34] M.A.K. Halliday. How do you mean? In *paper given at the Seventeeth International Systemic Congress.* University of Stirling, July 1990.

[35] M.A.K. Halliday and Ruqaiya Hasan. *Language,context,and text: Aspect of language in a social-semiotic perspective (in Japanese translation).* Deakin University Press, Australia, 1985.

[36] M.A.K. Halliday and J.R. Martin. *Readings in Systemic Linguistics.* Batsford Academic and Educational Ltd., 1981.

[37] M.A.K. Halliday and C. Matthiessen. *Construing Experience through Meaning: a language-based approach to cognition.* de Gruyter, Berlin, forthc.

[38] Daisaburo Hashidume. *Language game and a Social Theory, Wittgenstein,Hart,Ruman (in Japanese: Gengo ge-mu to Syakai Riron, Wittgenstein,Hart,Ruman).* Keisou Syobou, 1985.

[39] Shinichi Honida and Teruhisa Ichikawa. *Fandamental Techniques for Building an Expert System (in Japanese: Ekisupa-to Sisutemu Kiso Gijyutsu).* Ohmu Shya, 1989.

[40] Shin Iwamoto and Akira Ishikawa. What is situation semantic theory. *Language*, 1986, Feburary. Monthly Publication, vol.15, No.2.

[41] Roman Jakobson. *"Closing Statement: Linguistics and Poetics," in Style in Language.* John wiley & Sons, New York, 1960.

[42] Souichi Kadokawa. *Dictionary for Reading Articles about Finance,Economy (in Japanese: Keizai kiji wo Yomikonasu Jiten).* Asuka Syuppan, 1989.

[43] Hisao Kanamori and Seiichi Toshida. *How to Interpret The Economic Trends (in Japanese: Keiki Saikuru no Yomikata).* Yuubi kaku, 1988.

[44] Yasuhiro Katagiri. Situation semantics and discourse understanding. *Journal of Japanese Society for Artificial Intelligence, vol.7 No.3*, 1992, May.

[45] W.J.M. Kickert. An example of linguistic modeling:the case of murder's theory of power. In Guputa et al., editor, *Advance in Fuzzy Set Theory and Applications.* NORTH HOLLAND, 1979.

[46] Ichiro Kobayashi and Michio Sugeno. An approach to interpretation of linguistic model based on functional linguistic theory. In *Proceedings of eighth Fuzzy System Symposium*, pages 589–592. Japan Society for Fuzzy Theory and Systems, May 1992.

[47] Ichiro Kobayashi and Michio Sugeno. A study on understanding of natural language based on knowledge base using fuzzy theory. In *Proceedins of seventh Fuzzy System Symposium*, pages 573–576. Japan Society for Fuzzy Theory and Systems, June 1992. Nagoya.

[48] Tokumi Kodama. *Structure of Language (in Japanese: Gengo no Sikumi).* Taisyuukan Syoten, 1991.

[49] Youichi Kodama. *An Introduction to System Dynamics (in Japanese: Sisutem Dainamikusu Nyuumon).* Koudanshya, 1983.

[50] Takao Komine. *Introduction to the U.S. Economic Indices (America Keizai Sihyou Nyuumon, in Japanese).* Touyou Keizai Sinpou Sya, 1990. (in Japanese).

[51] Bronislaw Malinowski. The problem of meaning in primitive languages. In Ogden and Richers, editors, *Meaning in Meaning (in Japanse translation).* 1967.

[52] J.R. Martin. *Process and Text:Two Aspect of Human Semiosis*, pages pp. 248–274. Ablex Publishing Corpolation, 1985.

[53] J.R. Martin. *English text:system and structure.* Amsterdam:Benjamins, 1992.

[54] J.R. Martin and C. Matthiessen. Systemic typology and topology, 1990.

[55] C. Matthiessen. Semantic for a systemic grammar: The chooser and inquery framework. Technical Report ISI/RS-87-189, Information Science Institute, University of Southern California, 1987.

[56] C. Matthiessen. Lexico(grammatical) choice in text generation. In *NLGinAIandCL*, chapter 10, pages 249–292. Kluwer Academic Publishers, 1991.

[57] C. Matthiessen. Register in the round:diverrsity in a unified theory of register analysis. In Mohsen Ghadessy, editor, *Register analysis:theory into practice.* Pinter, London, 1992.

[58] C. Matthiessen and J. Bateman. *Text Generation and Systemic-Functional Linguistics: Experiences from English and Japanese.* Pinter, London, 1991.

[59] Colin McGinn. *Wittgenstein on Meaning -An Interpretation and Evaluation.* Japanese translation rights arranged with Basil Blackwell Ltd. through English Agency (Japan) Ltd., 1984.

[60] Peter Milling, editor. *Fuzzy Variables in Computer Simulation Modelling*, Boston, 8-10,October 1980. Proceedings of the International Conference on Cybernetics and Society, IEEE.

[61] Sizuo Mizutani. *Grammar and Semantics I (in Japanese: Bunpou to Imi I)*, volume I. Asakura Syoten (Asakura Publisher), 1983.

[62] Hideyuki Nakashima. Inference about situations. *Journal for Japanese Society for Artificial Intelligence, vol.5 No.5*, 1990, September.

[63] Hideyuki Nakashima. Inference with situations. *Journal of Japanese Society for Artificial Intelligence, vol.7 No.3*, 1992, May.

[64] Hideyuki Nakashima and Syun Tutiya. Inferring in a situation about situation. In Jon Barwise Jean Mark Gawron Gordon Plotlin and Syun Tutiya, editors, *Situation Theory and Its Applications, Volume2*, pages 215–228. Center for the Study of Language and Information Leland Stanford Junior University, 1991.

[65] Minoru Nakau. Consideration of halliday's functional grammar (in japanese: Halliday no kinou bunpou wo kangaeru). *Language*, October 1988. Monthly Publication.

[66] Hirosato Nomura. *Natural Language Processing and Machine Translation (in Japanese: Gengo Syori to Kikai Honyaku).* Koudanshya Scientific, 1991.

[67] Nobuhiro Nomura. *How to Interpret The Business Cycle (in Japanese: Keiki Saikuru no Yomikata).* JIyuu Kokumin Business, 1988.

[68] Akihiro Nozaki. Prblems ahead of development of human like computer (in japanese: Computer ni tachihadakaru kabe). *Language*, October, vol.21, No.11 1992. Monthly Publication.

[69] Society of Fuzzy Systems and Theory. *Fuzzy Expert System.* Nikkan Kougyou Shinbun Sya, 93.

[70] Yamaichi Research Institute of Securities and Economisc Inc. *Monthly Digest of Statistics.* Yamaichi Research Institute of Securities and Economisc Inc., 1993, January.

[71] Makoto Ohsima. *A Study on Discourse Grammar.* Liber Press, 1992.

[72] Setsuo Ohsuga. *An Introduction to Data Base and Knowledge Be-su —Toward New Information System— (in Japancese: Data Base to Chisiki Be-su Nyuumon —Atarashii Jyouhou Sisutemu wo Mezasite—).* Ohmu Shya, 1989.

[73] Setuso Ohsuga. *An Introduction to Knowledge Base (in Japanese:Chisiki Be-su Nyumon).* Ohmu Sya, 1986.

[74] Terry Patten. *Systemic text generation as problem solving.* Cambridge University Press, Cambridge, 1988.

[75] Raman Rajagopalan, editor. *Qualitative modeling and simulation: A survey.* AI APPLIED TO SIMULATION, Feb. 25-28 1985. Proceedings of the European Conference at the University of Ghent.

[76] Wendy B. Rauch-Hindin. *ARTIFICIAL INTELLIGENCE IN BUSINESS, SCIENCE, AND INDUSTRY*, volume I. Prentice-Hall, A Division of Simon and Schuster, Inc., 1986.

[77] Wendy B. Rauch-Hindin. *ARTIFICIAL INTELLIGENCE IN BUSINESS, SCIENCE, AND INDUSTRY*, volume II. Prentice-Hall, A Division of Simon and Schuster, Inc., 1986.

[78] Roger C. Schank. *Dynamic Memory.* Cambridge University Press, 1982.

[79] Roger C. Schank. *Explanation Patterns.* Lawrence erlbaum associates publishers, 1986.

[80] Roger C. Schank and R. Abelson. *Scripts, Plans, Goals and Understanding.* Lawrence Erlbaum Associates, Hillsdale, New Jersey, 1982.

[81] R. Shannon, R.E. Mayer and H.H. Adelsberger. Expert systems and simulation. *Simulation*, 44:275-284, 1985.

[82] Hidetoshi Shirai. From the viewpoint of situation semantic theory(in japanese: Jyoukyou imi ron no tachiba kara). *Information Processing, Vol.27,No.8*, 1986, August.

[83] Kenichiro Shirai. *Semantic Theory in Natural Language — The Developement from Montague Semantics to Situation Semantics (In Japanease: Sizengengo no Imiron —- Montagyu karu Jyoukyou heno Tenkai).* Sangyo Tosho, 1991.

[84] Society for Computer Simulation. *Model Development Revisited*, San Diego,CA, 1984. Proceedings of the 1984 Winter Simulation Conference, Dallas,Texas, pp.217-229.

[85] John.F. Sowa. *Conceptual Structures.* Addison-Wesley Publishing Company, 1984.

[86] John.F. Sowa. Toward the expressive power of natural language. In John.F. Sowa, editor, *Principle of Semantic Networks.* Morgran Kaufuman Publishers,Inc., 1991.

[87] Michio Sugeno. *Development of Fuzzy Theory: The Recovery of Subjectivity in the Field of Science (in Japanese: Fajii Riron no Tenkai : Kagaku ni Okeru Syukansei no Kaifuku).* Science Publisher, 1989.

[88] Michio Sugeno and Ichiro Kobayashi. Social system simulation based on systemic functional linguistic theory. In *Proceedings of the Fifth International Fuzzy Systems Association World Congress*, pages 679–682, July 1993. Korea.

[89] Michio Sugeno and Ichiro Kobayashi. An approach to social system simulation based on linguistic information —an application on the forecast of foreign exchange rate changes—. *Journal of Japan Society for Fuzzy Theory and Systems*, 6(4):81-101, August 1994.

[90] Investment Research Group Sumitomo Trust Bank. *Basic Text for Finance (in Japanese: Kinyuu no Kiso Tekisuto).* Nippon Nouritsu Kyoukai, 1991.

[91] Hiroyuki Suzuki. Basic ideas of situation theory. *Journal of Japanese Society for Artificial Intelligence, vol.7 No.3*, 1992, May.

[92] Atsushi Tabuchi. Construction of systemic grammar for japanese sentences generation (in japanese: Nihongo bunsyou sakusei no tame no sisutemic bunpou no sakusei). Technical report, Kyoto University, 1986.

[93] Atsushi Tabuchi. Japanese sentences generation system which cares about the point of an argument (in japanese: Ronsi no tenkai wo kouryo sita nihongo bunsyou no seisei sisutem), 1988.

[94] Yukio Takahashi. *A Book for Foreign Exchange written by a Top Dealer (in Japanese: Toppu Di-ra ga Kaita Kawase no Hon).* Jiji Tususin Sya, 1989.

[95] Takamatsu. *Linguistic Information Processing(in Japanese: Gengo Jyouhou Syori).* Corona Publisher, 1981.

[96] Yukinori Takubo Takashi Masuoka. *Basic Japanese Grammar (in Japanese: Kiso Nihongo Bunpou).* Kuroshio Publisher, 1992.

[97] Taisuke Tanaka. *Estimating Rates is an Intelligent Sport Combative–Introduction to Forecasting Money Market (in Japanese: Souba ha Chiteki Kakutougi dearu –Kinyuu Ma-ketto Yosoku Nyuumon).* Koudan Publisher (in Japanese: Koudan Sya), 1991.

[98] Taisuke Tanaka. *Introduction to Forecasting Money Market (in Japanese: Kinyu Ma-ketto Yosoku Nyuumon).* Oriental Economic Publisher (in Japanese: Touyou Keizai Sinpou Sya), 1992.

[99] Kouji Terasawa. *Elementary Lessons for Financial English.* Japanese Economy Newspaper Company, 1978.

[100] Haruki Ueno and Mitsuru Ishizuka. *Knowledge Representation and Utilization (in Japanese: Chisiki no Hyougen to Riyou).* Ohum Shya, 1987.

[101] Eija Ventola. Text analysis in operation:a multilevel approach. In M.A.K. Halliday, editor, *NEW DEVELOPMENT IN SYSTEMIC LINGUISTICS volume2: Theory and Description.* Frances Printer, London and New York, 1987.

[102] Hideo Watanabe. Analysis of conjuctive structure of sentence with editorials in newspapers as its target (in japanese: Shinbun syasetsu wo taisyou to sita bunsyou no motsu setsuzoku kouzou no kaiseki). Master's thesis, Kyoto University, 1986.

[103] Fred Wenstop. Deductive verbal models of organizations. *Int.J.Man-Manchine Studies,* Vol.8:293–311, 1976.

[104] Fred Wenstop. Fuzzy set simulation models in a systems dynamics perspective. *Kybernetes,* 6:209–218, 1976.

[105] Fred Wenstop. Exploring linguistic conseqences of assertons in social sciences. In R.R.Yager M.M.Gupta, R.K.Ragade, editor, *ADVANCES IN FUZZY SET THEORY AND APPLICATIONS*, pages 501–518. North-Holland, 1979.

[106] Fred Wenstop. Quantitative analysis with linguistic values. *Fuzzy Sets and Systems,* Vol.4:99–115, 1980.

[107] Lawrence E. Widman. Artificail intelligence, simulation, and modeling: A critical survey. In Norman R.Nielsen Lawrence E.Widman, Kenneth A.Loparo, editor, *ARTIFICIAL INTELLIGENCE, SIMULATION, AND MODELING*, chapter 1, pages 1–44. A WILEY-INTER SCIENCE PUBLICATION, JHON WILEY&SONS, 1989.

[108] Terry Winograd. *UNDERSTANDING NATURAL LANGUAGE.* Academic Press Inc, Edinburgh University Press, 1972.

[109] Terry Winograd. *LANGUAGE AS A COGNITIVE PROCESS.* Addidon-Wesley, Reading,Massachusetts, 1983.

[110] Ludwig Wittgenstein. *Tractatus Logico-Philosophicus (in Japanese: Ronri Tetsugaku Ronkou).* The International Library of Psychology Philosophy and Scientific Method, 1918.

[111] Ludwig Wittgenstein. *Philosophical Investigations.* Basil Blackwell Ltd, 1953.

[112] Tatsuo Yagyu. Rules for foreign exchange trade system. Laboratory for International Fuzzy Engineering Research, 1989.

[113] Tatsuo Yagyu. Decision support system for foreign exchange dealing. Technical report, Laboratory for International Fuzzy Engineering Research, 1990.

[114] Noboru Yamaguchi. Systemic functional theory of grammar(the first part)-an interpretation of halliday's linguistic theory-. Technical Report Fukushima University Department of Pedagogy Articles No.40 (Cultural Science Section), Fukushima University, 1986,November.

[115] Noboru Yamaguchi. Functionalism and the genealogy of studies on language (in japanese: Gengo kenkyu ni okeru kinou syugi to sono keifu). *Language*, October 1988. Monthly Publication.

[116] Noboru Yamaguchi. Halliday's theory main technical terms (in japanese: Halide-riron syuyou jyutsugo syuu). *Language*, April 1991. Monthly Publication.

[117] Noboru Yamaguchi. Text and context. In Minoru Yasui, editor, *Development of Mordern English (in Japanese: Gendai Eigogaku no Ayumi).* Kaitaku shya, 1991.

[118] Kazuhiko Yamamoto and Hitoshi Matsubara. On the frame problem. *Journal of Japanese Society for Artificial Intelligence, Vol.2,No.3*, 1987, September.

[119] Toshio Yokoi. A very large-scale knowledge base based on the amalgamation of knowledge processing and natural language processing –from electronic dictionaries to knowledge archives—. *Journal of Japanese Society for Artificial Intelligence*, 8(3):286–296, 1993.

[120] Minoru Yoneda. Decision support system based on intellectual information processing. Technical report, Laboratory for International Fuzzy Engineering Research, 1990.

[121] Yuuji Yonemori. *Peirce's Semiotics(in Japanese: Pa-su no Kigougaku).* Keisou Syobou, 1981.

[122] Yuuji Yonemori. About common sense (in japanese: Jyousiki ni tsuite). A Section Meeting for Knowledge Engineering, August 1989.

[123] Hideo Yuize. Function and implementation of foreign exchange dealing support expert system. Technical report, Laboratory for International Fuzzy Engineering Research, 1991.

[124] Hideo Yuize Tatuso Yagyu Minoru Yoneda Yasunori Katoh Shun'ichi Tano Michel Grabisch Satoru Fukami. Decision support system for foreign exchange trading –practical implementation–. In *Fuzzy Engineering toward Human Friendly Systems*, pages 971–982, Yokohama, JAPAN, November 13-15 1991. Laboratory for International Fuzzy Engineering Research.

[125] Lotfi A. Zadeh. Fuzzy sets. *Information and Control*, 8:338–353, 1965.

[126] Lotfi A. Zadeh. Outline of a new approach to the analysis of complex systems and decision processes. *IEEE Transactions on Systems Man and Cybarnetics,vol.SMC-3*, pages 28–44, 1973.

[127] Lotfi A. Zadeh. Syllogistic reasoning in fuzzy logic and its applications to usuality and reasoning wiht dispositions. *IEEE Transactions on Systems Man and Cybarnetics,SMC-15*, pages 754–763, 1985.

[128] Lotfi A. Zadeh. *Fuzzy sets and applications: selected papers by L.A.Zadeh.* A Wiley-Interscience, 1987.

Appendix

A Main Causes of FER Changes

A.1 Fiscal Policy of the Government

The fiscal policy of the government is shown in Fig.1.

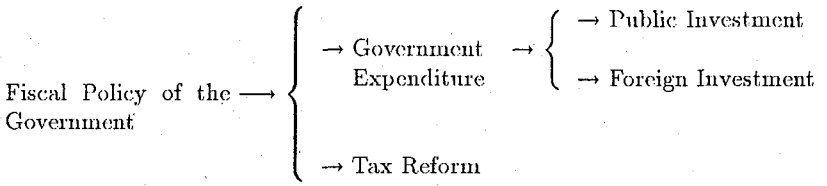

Figure 1: Fiscal Policy of the Government

A.2 Monetary Policy of the Central Banks

The monetary policy of the central banks is shown in Fig.2.

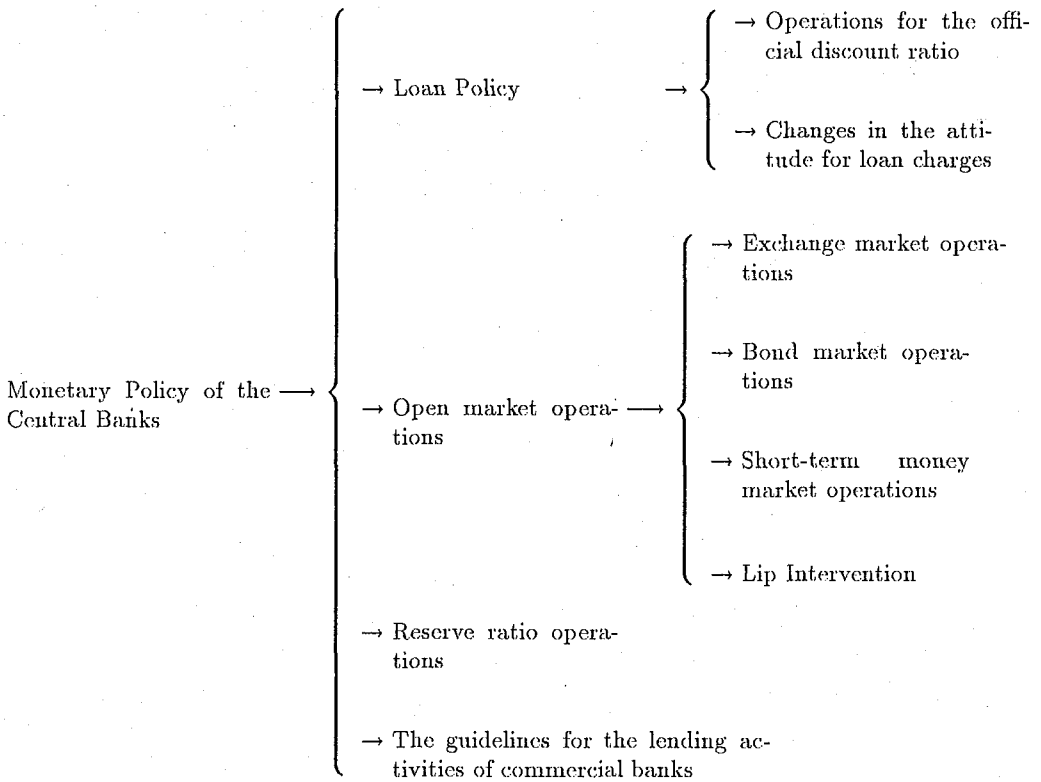

Figure 2: Monetary Policy of the Central Banks

A.3 State of the Market

The tendencies of economic conditions, market consciousness, and so on, can be thought of as main causes of foreign exchange rate changes. We show the terms which can be considered to express market consciousness and the trends of the market in Fig.3 and Fig.4, respectively.

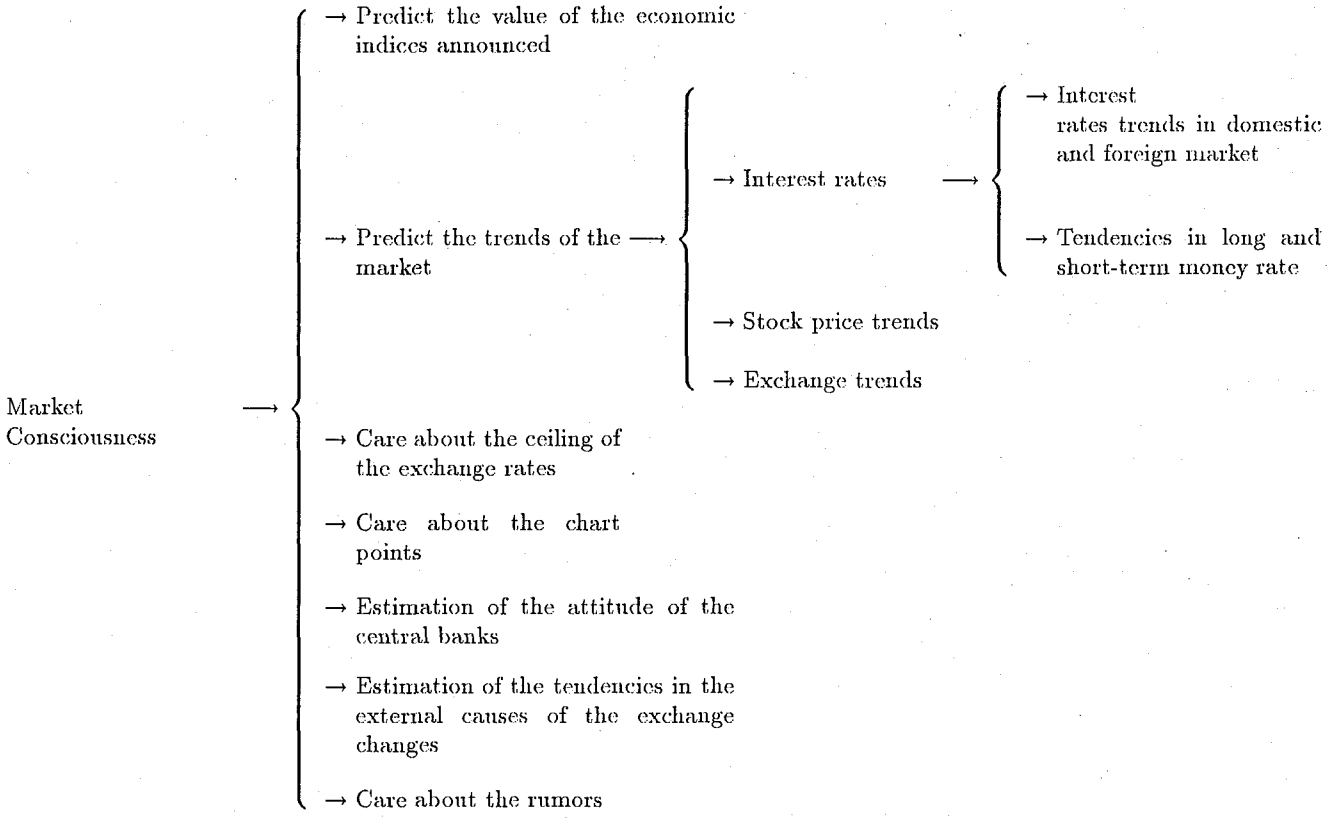

Figure 3: Market Consciousness

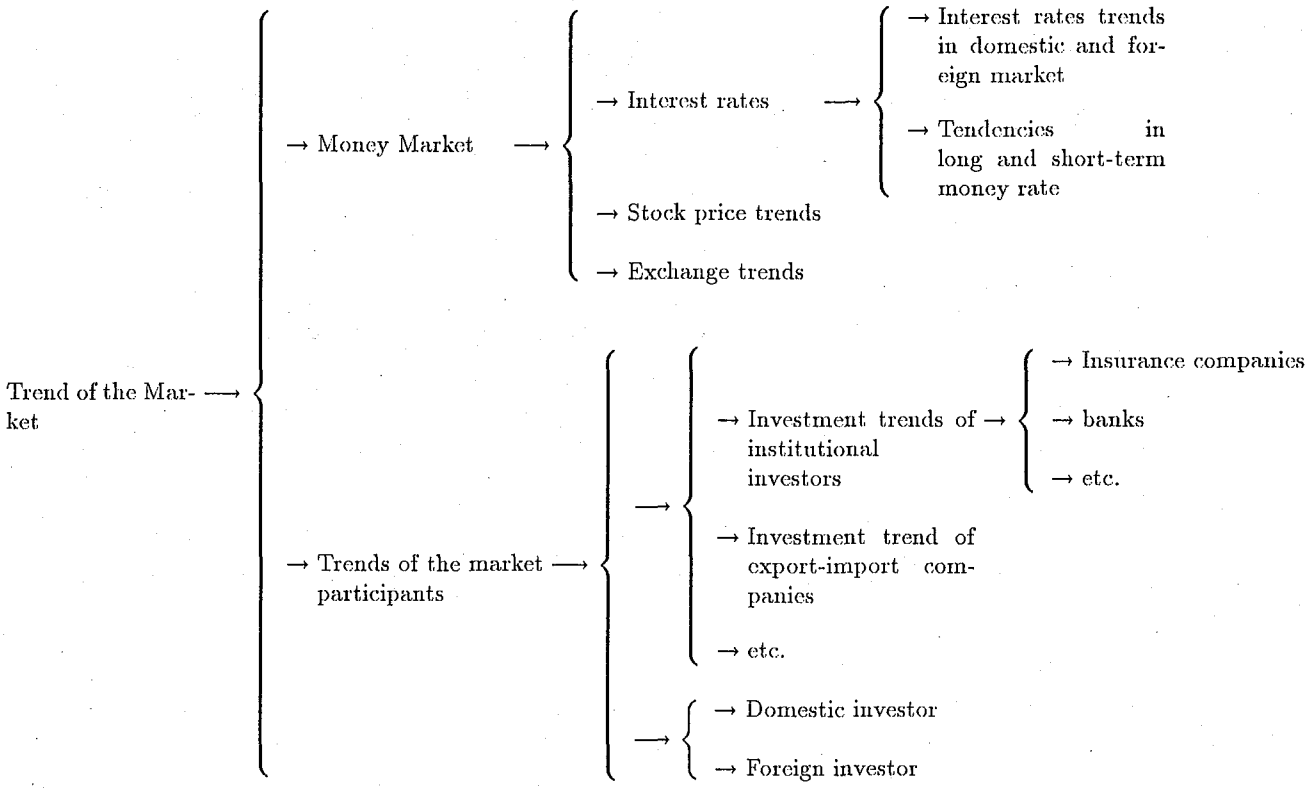

Figure 4: Trend of the Market

A.4 External causes of the exchange changes

The external causes of the exchange changes is shown in Fig.5.

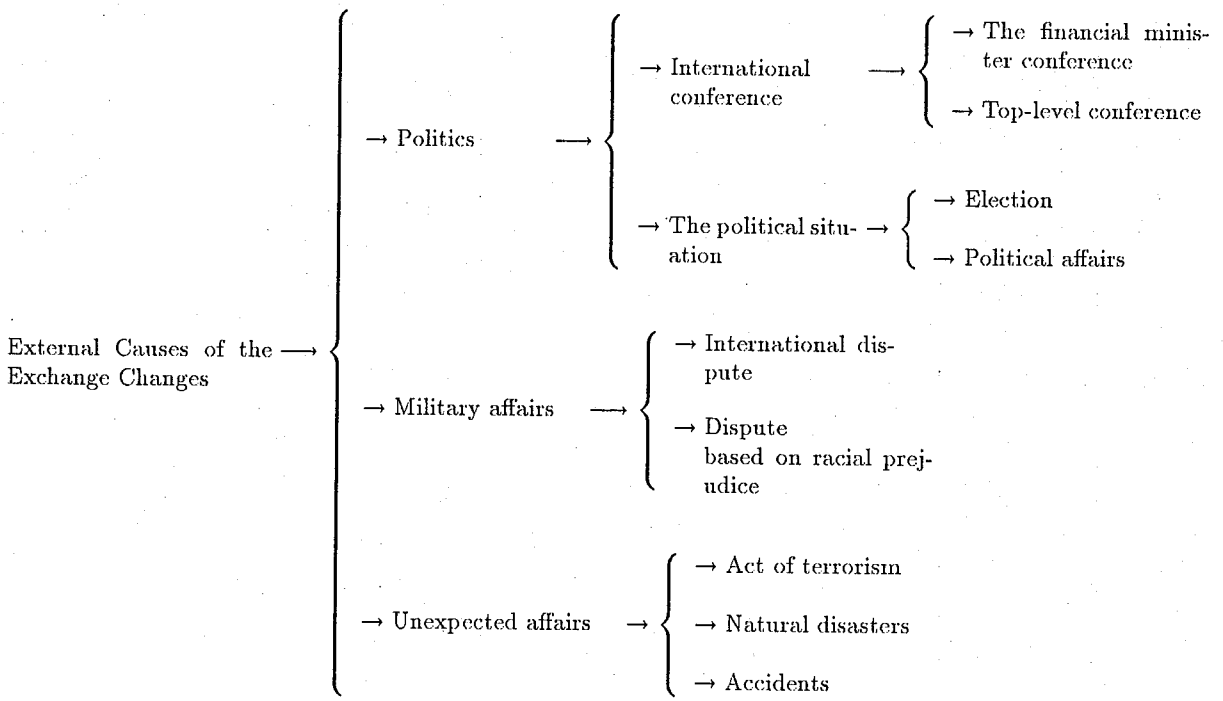

Figure 5: External Causes of the Exchange Changes

B Economic Indices Data

We show the economic indices data of U.S., Japan, and German, which are from Jan. 1991 to April 1992.

B.1 U.S. Economic Indices Data

Economic Indices	Average Hourly Earnings	Average Hourly Earnings (Pre. Mon.)	Average Hourly Earnings (Pre. Year)	Number of Non-farm Employment	Number of Non-farm Employment (Pre. Mon.)	Housing Starts	Housing Starts (Pre. Mon.)	Housing Starts (Pre. Year)
91.1	$ 10.18	0.2%	3.7%	108845thou.	-256thou.	84.4	-12.3%	-47.1%
2	10.20	0.2	3.1	108557	-288	100.8	19.4	-31.1
3	10.24	0.3	3.2	108344	-213	91.8	-8.9	-30.1
4	10.28	0.3	3.3	108178	-166	97.8	6.5	-19.6
5	10.32	0.4	3.4	108265	87	98.3	0.5	-19.5
6	10.37	0.5	3.5	108227	-38	103.6	5.4	-11.1
7	10.36	-0.1	3.1	108190	-37	105.3	1.6	-8.9
8	10.40	0.4	3.3	108267	77	105.3	0.0	-6.6
9	10.41	0.1	3.1	108293	26	102.0	-3.1	-8.3
10	10.40	-0.1	3.0	108285	-8	108.5	6.4	7.3
11	10.44	0.4	3.1	108139	-146	108.5	0.0	-4.1
12	10.48	0.4	3.0	108154	15	111.8	3.0	16.2
92.1	10.47	-0.1	2.8	108100	-54	118.0	5.5	39.8
2	10.51	0.4	3.0	108142	42	125.7	6.5	24.7
3	10.55	0.4	3.0	108200	58	134.4	6.9	46.4
4	10.54	-0.1	2.5	108377	177	111.5	-17.0	14.0

Economic Indices	Corporate Profits(a.f. season)	Corporate Profits (Pre. Year)	Consumer Confidence Index (Pre. Term)	Consumer Confidence Index (Pre. Year)	Index of Industrial Production	Index of Industrial Production (Pre. Year)	Index of Industrial Production (Pre. Term)
91.1	302.1	-11.2			106.6	-0.8%	-0.6
2	302.1	-11.2			105.7	-2.6	-0.8
3	302.1	-11.2	1.0%	0.4%	105.0	-3.6	-0.7
4	303.5	-10.7	-0.9	-0.4	105.5	-3.0	0.5
5	303.5	-10.7	0.4	0.1	106.4	-2.7	0.9
6	303.5	-10.7	0.3	-0.3	107.3	-2.5	0.8
7	306.1	2.1	0.3	-0.3	108.1	-2.1	0.7
8	306.1	2.1	-0.2	-0.3	108.0	-2.3	-0.1
9	306.1	2.1	0.2	-0.3	108.4	-2.0	0.4
10	315.6	6.6	-0.4	0.2	108.4	-1.4	0.0
11	315.6	6.6	0.5	0.9	108.1	-0.2	-0.3
12	315.6	6.6	-0.1	0.7	107.4	0.2	-0.6
92.1	347.0	14.9	1.1	3.0	106.6	0.0	-0.7
2	347.0	14.9	0.4	2.7	107.2	1.4	0.6
3	347.0	14.9	-0.5	1.2	107.6	2.5	0.4
4	347.0	14.9	0.1	2.2	108.1	2.5	0.5

Economic Indices	Retail Sales (Pre.Mon.)	Retail Sales (Pre.Year)	Private Construction Investment	Private Construction Investment (Pre.Term)	Private Construction Investment (Pre.Year)	New Orders for Manufactures	New Orders for Manufactures (Pre.Year)	New Orders for Durable Goods
91.1	-1.7	-1.6	5191	-17.4	-5.7	2344.6	-0.2	1177.9
2	2.0	0.6	5191	-17.4	-5.7	2331.3	-1.2	1175.5
3	0.7	1.3	5191	-17.4	-5.7	2264.3	-8.1	1121.2
4	-0.3	1.5	5148	-3.3	-5.4	2312.3	-3.8	1161.4
5	0.9	2.7	5148	-3.3	-5.4	2365.4	-3.6	1184.3
6	0.0	1.7	5148	-3.3	-5.4	2337.3	-3.6	1171.3
7	0.4	1.8	5100	-3.7	-8.2	2480.9	1.2	1308.3
8	-0.7	0.8	5100	-3.7	-8.2	2431.6	-3.0	1254.8
9	0.3	0.5	5100	-3.7	-8.2	2376.2	-4.6	1200.9
10	-0.1	0.3	5056	-3.4	-7.1	2422.3	-5.0	1233.3
11	0.0	-0.1	5056	-3.4	-7.1	2431.4	1.6	1240.5
12	0.0	1.5	5056	-3.4	-7.1	2341.0	-1.7	1177.9
92.1	2.1	5.5	5077	1.7	-2.2	2351.9	0.3	1205.7
2	1.6	4.9	5077	1.7	-2.2	2369.4	1.6	1208.6
3	-1.0	3.2	5077	1.7	-2.2	2408.0	6.3	1236.1

Economic Indices	New Orders for Durabls Goods	Unemployment Rate	Consumer Confidence Index	Business Inventories	Business Inventories (Pre.Year)	Consumer Price Index	Consumer Price Index (Pre.Year)
91.1	-3.0	6.2	55.1	8303.3	2.4	134.7	5.6
2	-4.0	6.5	59.4	8275.9	2.2	134.9	5.3
3	-14.4	6.7	81.1	8185.3	0.9	135.1	5.0
4	-7.5	6.6	79.4	8168.9	0.5	135.4	5.0
5	-8.9	6.8	76.4	8117.1	-0.6	135.7	5.0
6	-7.8	6.9	78.0	8071.1	-0.7	136.1	4.7
7	1.1	6.8	77.7	8068.0	-1.5	136.2	4.3
8	-2.7	6.8	76.1	8066.5	-1.9	136.6	3.7
9	-5.4	6.8	72.9	8097.9	-2.0	137.1	3.4
10	-5.8	6.9	60.1	8130.2	-1.9	137.4	2.9
11	6.8	6.9	52.7	8139.0	-2.0	137.9	3.1
12	-2.0	7.1	52.5	8166.8	-1.1	138.2	3.0
92.1	2.4	7.1	50.2	8129.9	-2.1	138.3	2.7
2	2.8	7.3	47.3	8131.8	-1.7	138.7	2.8
3	10.3	7.3	56.5	8162.6	-0.3	139.4	3.2
4	8.0	7.2	65.1	8286.3	0.0	139.7	3.2

Economic Indices	Producer Price Index	Wholesale Price Index	Wholesale Price Index (Pre.Year)	Exports (Pre.Term)	Exports (Pre.Year)	Imports (Pre.Term)	Imports (Pre.Year)
91.1	113.2	1449.0	-2.3	1.1	7.6	4.3	-3.5
2	104.4	1439.0	-3.0	-1.4	5.3	-3.2	-1.6
3	100.7	1428.6	-4.2	1.7	2.4	-0.5	-8.8
4	100.4	1450.2	-1.7	3.8	10.1	4.1	-1.5
5	100.9	1449.3	-2.4	-0.8	7.9	1.0	-3.3
6	99.3	1452.2	-3.1	-0.7	2.8	-0.9	-4.8
7	99.3	1476.4	-0.6	1.9	9.5	4.2	-2.2
8	99.1	1455.2	-4.1	-1.7	7.1	0.5	1.1
9	98.4	1460.0	-2.6	2.1	10.5	1.2	7.4
10	100.5	1453.7	-3.5	4.1	8.5	1.5	4.4
11	100.4	1447.7	-2.2	1.2	13.1	-3.0	3.2
12	98.3	1442.0	-2.8	-2.9	8.7	1.3	10.7
92.1	97.7	1451.4	0.2	-1.3	6.2	-0.3	5.8
2	99.4	1455.7	1.2	5.8	13.8	-0.9	8.3
3	97.9	1474.4	3.2	-2.0	9.7	4.9	14.2
4	98.4						

Economic Indices	Trade Balance (Exports) (s.a.)	Trade Balance (Imports) (s.a.)	Trade balance By Japan (s.a.)	Treasury Bill Rates(3-Month)	FF Rate	Oil Price(WTI)	CRB Index
91.1	34292	41190	-3462	6.22	6.91	24.70	220
2	33657	38962	-3159	5.94	6.25	20.54	215
3	34156	38501	-3575	5.91	6.12	19.88	222
4	35461	39744	-3347	5.65	5.91	20.82	218
5	35019	40000	-2432	5.46	5.78	21.24	212
6	34715	39384	-3231	5.57	5.90	20.20	215
7	35190	40823	-3797	5.58	5.82	21.43	218
8	34464	41078	-3737	5.33	5.66	21.68	217
9	35283	41757	-4183	5.22	5.45	21.85	214
10	36842	42712	-4638	4.99	5.21	23.23	213
11	37269	41382	-3413	4.56	4.81	22.43	212
12	36053	41675	-4462	4.07	4.43	19.53	213
92.1	35467	41266	-3817	3.80	4.03	18.82	214
2	37654	40948	-2967	3.84	4.06	19.01	215
3	37085	42668	-3986	4.04	3.98	18.97	204
4	36406	43469	-4210	3.75	3.73	20.31	207

Economic Indices	Reuter's Index	Financial Surplus	Financial Deficit	Government Expenditure	Government Expenditure (Pre.Term)	Government Expenditure (Pre.Year)	Purchasing Manager's Composite Diffusion Index
91.1	1732.3	1007	991	9445	2.8	2.3	38.7
2	1732.3	677	938	9445	2.8	2.3	39.1
3	1732.3	648	1060	9445	2.8	2.3	40.4
4	1778.5	1404	1104	9443	-0.1	1.7	42.1
5	1778.5	636	1169	9443	-0.1	1.7	45.0
6	1778.5	1034	1060	9443	-0.1	1.7	50.0
7	1755.5	786	1194	9361	-3.4	0.9	51.1
8	1700.8	764	1201	9361	-3.4	0.9	53.5
9	1671.6	1093	1162	9361	-3.4	0.9	54.3
10	1683.4	781	1147	9233	-5.4	-1.6	53.2
11	1650.6	732	1179	9233	-5.4	-1.6	50.3
12	1642.3	1037	1062	9233	-5.4	-1.6	47.4
92.1	1611.4	1041	1197	9304	3.1	-1.5	47.4
2	1609.2	621	1112	9304	3.1	-1.5	52.4
3	1625.4	729	1236	9304	3.1	-1.5	54.1
4	1635.9	1384	1238	9327	1.0	-1.2	51.3

Economic Indices	Money Supply (billion)	Money Supply (Pre.3Mon.)	Money Supply (Pre.Year)	Exports (0.1 bil.dol.)	Imports (0.1 bil.dol.)		
91.1	3344.0	1.1%	3.2%	315.4	366.1		
2	3369.4	4.4	3.4	311.1	354.5		
3	3386.9	5.9	3.5	316.5	352.9		
4	3394.8	6.2	3.5	328.6	367.2		
5	3405.6	4.4	3.7	326.0	370.9		
6	3411.8	3.0	3.6	323.8	367.7		
7	3407.5	1.5	3.3	330.0	383.2		
8	3409.7	0.5	2.8	324.4	385.1		
9	3411.9	0.0	2.4	331.4	389.6		
10	3417.9	1.2	2.5	345.0	395.5		
11	3431.6	2.6	2.9	349.2	383.7		
12	3439.8	3.3	3.0	339.1	388.7		
92.1	3447.5	3.5	3.1	334.9	387.4		
2	3474.4	5.1	3.1	354.1	384.0		
3	3475.7	4.2	2.6	347.2	402.9		
4	3471.5	2.8	2.3				

Economic Indices	New Orders for Manufactures (Pre.Term)	New Orders for Durable Goods (Pre.Term)	Business Inventories (Pre.Term)	Consumer Price Index (Pre.Term)	Wholesales Price Index (Pre.Term)	Consumer Price	Retail Sales
91.1	-1.6	-2.0	0.6	0.4	-2.3	3791.8	149481
2	-0.6	-0.2	-0.3	0.1	-0.7	3814.3	152410
3	-2.9	-4.6	-1.1	0.1	-0.7	3858.9	153622
4	2.1	3.6	-0.2	0.2	1.5	3845.5	153009
5	2.3	2.0	-0.6	0.2	-0.1	3877.2	154686
6	-1.2	-1.1	-0.6	0.3	0.2	3893.1	154669
7	6.1	11.7	0.0	0.1	1.7	3907.4	154660
8	-2.0	-4.1	0.0	0.3	-1.4	3906.6	153767
9	-2.3	-4.3	0.4	0.4	0.3	3928.7	154071
10	1.9	2.7	0.4	0.2	-0.4	3920.8	154464
11	0.4	0.6	0.1	0.4	-0.4	3946.6	153974
12	-3.7	-5.0	0.3	0.2	-0.4	3961.5	154280
92.1	0.5	2.4	-0.5	0.1	0.7	4007.8	157808
2	0.7	0.2	0.0	0.3	0.3	4030.3	159753
3	1.6	2.3	0.4	0.5	1.3	4030.3	157873
4		1.4	0.3	0.2		4039.9	158385

B.2 JPN Economic Indices Data

Economic Indices	Imports	Exports	Trade Balance	Trade Balance (Imports) (s.a.)	Trade Balance (Exports) (s.a.)	Interest Rates on CD 3Mons.	Long-Term Government Bonds Yield
91.1	20902	21813	3104	18585	25551	8.184	6.523
2	19916	24979	7084	18203	25535	8.014	6.539
3	21051	29546	10541	18349	26061	8.098	6.645
4	17793	24107	8591	14869	23061	7.954	6.650
5	20296	24459	5470	17492	25218	7.811	6.612
6	18194	25426	9291	16871	25064	7.791	6.725
7	20008	26609	8264	16666	25092	7.554	6.636
8	19102	24806	8269	16310	25647	7.306	6.444
9	17987	27650	10852	16962	26428	6.703	6.208
10	21257	28459	10127	16702	26370	6.413	6.015
11	20678	27091	8460	16990	26247	6.217	6.009
12	19552	29581	12631	15582	26350	6.022	5.769
92.1	20151	23984	5960	17401	27744	5.177	5.533
2	17889	28102	12438	15583	27392	5.193	5.586
3	19389	30358	12970	16243	26980	4.969	5.512
4	20056	27248	10096	16652	26085	4.721	5.696

Economic Indices	Financial Surplus	Financial Deficit	Sales of Department Stores (Pre.Year)	Indexes of Operating Ratio(s.a.)	GNP Growth Ratio(s.a.)	Money Supply	Money Supply (Pre.Year)
91.1			7.1%	106.7	6.4	497.9	7.4
2			5.1	106.2	6.4	492.6	5.5
3			5.1	104.0	6.4	497.0	5.1
4	7372	7703	5.1	105.5	4.5	498.6	3.8
5	3844	2009	4.6	106.1	4.5	496.3	3.6
6	9690	4524	6.9	103.4	4.5	498.4	3.7
7	5286	2654	2.7	106.3	4.1	504.0	3.4
8	4302	1224	5.6	103.1	4.1	502.1	2.7
9	3581	4028	2.3	103.0	4.1	504.1	2.2
10	3061	2763	2.5	103.0	3.0	503.2	2.1
11	3370	3910	4.4	101.9	3.0	501.9	2.4
12	8678	4664	0.3	100.3	3.0	512.2	2.0
92.1	4987	1392	1.5	100.4	2.4	507.0	1.8
2	2807	1532	3.1	99.3	2.4	500.5	1.6
3	4420	4666	2.9	96.9	2.4	505.8	1.8
4	7500	7836	1.5	97.1	1.4	506.3	1.6

Economic Indices	Exports (Pre.Term)	Exports (Pre.Year)	Imports (Pre.Term)	Imports (Pre.Year)	Real Number of Sales of Department Stores	Wholesale Price Index	Wholesale Price Index (Pre.Term)
91.1	2.0%	$ 16.8	-4.7%	$ 13.8	8924		
2	-0.9	13.5	-1.6	16.9	7557		
3	5.6	13.5	-1.1	10.8	10648		
4	-13.2	10.0	-13.9	-3.3	9287		
5	10.1	13.5	14.5	10.0	9114	96.5	
6	-1.7	7.0	-4.2	6.4	9408	96.5	
7	2.1	11.3	4.9	7.7	12570	96.5	0.0
8	1.1	10.6	-3.4	0.5	8000	96.5	0.0
9	-0.1	7.0	-2.3	-5.1	8543	96.3	0.2
10	3.0	6.5	6.2	-9.5	10046	96.2	0.1
11	-0.3	5.3	-4.1	-12.0	10161	96.1	0.0
12	-1.3	4.3	-3.5	-14.7	16608	96.1	0.1
92.1	7.1	10.0	7.9	-3.6	9308	95.1	0.2
2	1.4	12.5	-8.2	-10.2	9323	95.9	0.0
3	-3.6	2.7	1.3	-7.9	9306	95.9	0.0
4	-4.3	13.0	5.7	12.7	12462	95.8	0.1

Economic Indices	Wholesale Price Index Pre.Year						
91.1							
2							
3							
4							
5							
6							
7	1.7						
8	1.5						
9	0.7						
10	0.3						
11	0.1						
12	0.2						
92.1	0.6						
2	0.6						
3	0.6						
4	0.8						

B.3 GMN Economic Indices Data

Economic Indices	Call Rate	Interbank Rate	Official Discount Rate	Long-Term Money Rate	Money Supply	Money Supply Pre.Year	
91.1	8.48	9.27	6.0	9.1	1468.0	19.9	
2	8.68	8.96	6.5	8.6	1475.3	19.9	
3	8.72	8.98	6.5	8.5	1462.0	20.6	
4	8.81	9.09	6.5	8.5	1459.3	19.9	
5	8.55	8.98	6.5	8.5	1469.3	20.2	
6	8.76	8.96	6.5	8.5	1473.1	4.8	
7	8.82	9.06	6.5	8.8	1469.4	4.4	
8	8.84	9.22	7.5	8.8	1483.1	4.6	
9	9.01	9.17	7.5	8.6	1486.5	4.5	
10	8.64	9.28	7.5	8.6	1494.4	4.8	
11	8.99	9.32	7.5	8.6	1534.9	5.7	
12	9.12	9.46	8.0	8.5	1597.6	6.3	
92.1	9.47	9.44	8.0	8.1	1566.4	6.7	
2	9.55	9.50	8.0	8.1	1574.3	6.7	
3	9.60	9.58	8.0	8.2	1568.7	7.3	
4	9.50	9.63	8.0	8.2	1577.9	8.1	

C Standard Levels of Indices Appropriate for May, 1992 Economic Conditions

C.1 U.S.

Economic Indices	Standard Level	Observation Range
Average Hourly Earnings(Pre.Mon.)	about 3.0%	0.0~6.0%
Average Hourly Earnings(Pre.Year)	about 0.0%	-2.0~2.0%
Number of Non-farm Employment(Pre.Mon.)	about 0.1%	0.0 ~ 0.2%
Number of Non-farm Employment(Pre.Year)	about 0%	-0.3 ~0.3 %
Housing Starts(Pre.Mon.)	about 0%	-25 ~ 25%
Housing Starts(Pre.Year)	about 25%	0 ~ 50%
Corporate Profits(Pre.Term)	about 3.0%	-6.0 ~ 12.0%
Corporate Profits(Pre.Year)	about 10%	2 ~ 18%
Consumer Confidence Index(Pre.Term)	about 0.0 %	-1.0 ~ 1.0 %
Consumer Confidence Index(Pre.Year)	about 3.0 %	1.0 ~ 5.0 %
Operating Ratio of Industrial Production(Pre.Term)	about -2.0%	-10.0 ~ 6.0%
Operating Ratio of Industrial Production(Pre.Year)	about -1.0 %	-3.0 ~ 1.0 %
Index of Industrial Production(Pre.Term)	about 0 %	-0.8 ~ 0.8%
Index of Industrial Production(Pre.Term)	about 1.5 %	0 ~ 3.0 %
Retail Sales(Pre.Mon.)	about 1.0 %	-2.0 ~ 4.0%
Retail Sales(Pre.Year)	about 3.0 %	0 ~ 6.0 %
Private Construction Investment(Pre.Mon.)	about -4.0%	-14.0 ~ 6.0 %
Private Construction Investment(Pre.Year)	about -3.5 %	-7.0 ~ 0.0 %
New Orders for Manufactures(Pre.Term)	about 1.0 %	-4.0 ~ 6.0%
New Orders for Manufactures(Pre.Year)	about 3.0 %	-2.0 ~ 8.0 %
New Orders for Durable Goods(Pre.Term)	about 2.5 %	0.0 ~ 5.0%
New Orders for Durable Goods(Pre.Year)	about 8.0 %	3.0 ~ 13.0 %
Business Inventories(Pre.Term)	about 0.0 %	-2.0 ~ 2.0%
Business Inventories(Pre.Year)	about 0.0 %	-2.0 ~ 2.0 %
Consumer Price Index(Pre.Term)	about 0.0 %	-2.0 ~ 2.0%
Consumer Price Index(Pre.Year)	about 3.0 %	0.0 ~ 6.0 %
Producer Price Index(Pre.Term)	about 0%	-2.0 ~ 2.0%
Producer Price Index(Pre.Year)	about -2.0%	-7.0 ~ 3.0%
Wholesale Price Index(Pre.Term)	about 0.0%	-2.0 ~ 2.0%
Wholesale Price Index(Pre.Year)	about 0.0 %	-5.0 ~ 5.0 %
Exports(Pre.Term)	about 1.5%	-3.0 ~ 6.0%
Exports(Pre.Year)	about 10.0 %	6.0 ~ 14.0 %
Imports(Pre.Term)	about 1.0 %	-5.0 ~ 7.0 %
Imports(Pre.Year)	about 4.0 %	-10.0 ~ 18.0 %
Trade Balance(Exports)(Pre.Term)	about 2.0%	-5.0 ~ 9.0 %
Trade Balance(Exports)(Pre.Year)	about 8.0%	0.0 ~ 16.0%
Trade Balance(Imports)(Pre.Term)	about 0.0%	-5.0 ~5.0 %
Trade Balance(Imports)(Pre.Year)	about 7.0%	4.0 ~ 10.0 %
Trade balance By Japan(Pre.Term)	about 0.0 %	-35 ~ 35%
Trade balance By Japan(Pre.Year)	about 0.0 %	-80~ 80%

Economic Indices	Standard Level	Observation Range
Unemployment Rate(Pre.Mon.)	about 0.0 %	-5.0 ~ 5.0%
Unemployment Rate(Pre.Year)	about 8.0 %	4.0~ 12.0%
Consumer Confidence Index(Pre.Term)	about 6.0 %	-14.0 ~ 26.0%
Consumer Confidence Index(Pre.Year)	about -25.0 %	-50.0~ 0.0%
Treasury Bill Rates(3-Month)(Pre.Term)	about 0.0%	-10.0 ~ 10.0%
Treasury Bill Rates(3-Month)(Pre.Year)	about 0.0%	-50~50 %
Long-Term Government Bonds(Pre.Mon.)	about 0.0%	-5.0 ~ 5.0%
Long-Term Government Bonds(Pre.Year)	about -4.0%	-8.0~ 0.0 %
FF Rate(Pre.Mon.)	about -6.0%	-12.0 ~0.0 %
FF Rate(Pre.Year)	about -35.0%	-45.0~-25.0 %
Oil Price(WTI)(Pre.Term)	about 0.0%	-8.0 ~ 8.0%
Oil Price(WTI)(Pre.Year)	about -6.5%	-13.0 ~ 0.0 %
CRB Index(Pre.Term)	about -2.0%	-8.0 ~ 4.0 %
CRB Index(Pre.Year)	about 0.0%	-6.0~ 6.0 %
Reuter's Index(Pre.Term)	about 0.0%	-4.0 ~ 4.0%
Reuter's Index(Pre.Year)	about -7.0%	-10.0~-4.0 %
Financial Surplus(Pre.Term)	about 0.0%	-100.0~100.0%
Financial Surplus(Pre.Year)	about 0.0%	-200.0~200.0 %
Financial Deficit(Pre.Term)	about 0.0 %	-200.0 ~200.0 %
Financial Deficit(Pre.Year)	about 0.0 %	-500.0 ~500.0 %
Government Expenditure(Pre.Term)	about 0 %	-6.0 ~ 6.0 %
Government Expenditure(Pre.Year)	about -1.5 %	-3.0~0.0 %
Purchasing Manager's Composite Diffusion Index (Pre.Term)	about 5.0 %	0.0 ~ 10.0%
Purchasing Manager's Composite Diffusion Index (Pre.Year)	about 20.0%	5.0 ~ 35.0%
Money Supply(Pre.Term)	about 3.0%	0 ~ 6.0%
Money Supply(Pre.Year)	about 2.0 %	1.0 ~ 3.0%
D-J 30 Industrial Average(Pre.Mon.)	about 2.0%	0.0 ~ 4.0%
D-J 30 Industrial Average(Pre.Year)	about 10.5 %	8.0 ~ 13.0%

C.2 JPN

Economic Indices	Standard Level	Observation Range
Imports(Pre.Mon.)	about 0%	-14.0 ~ 14.0%
Imports(Pre.Year)	about 0%	-16.0 ~ 16.0%
Exports(Pre.Mon.)	about 0%	-10.0~ 10.0%
Exports(Pre.Year)	about 8.0%	0.0~ 16.0%
Trade Balance(Pre.Term)	about 0.0%	-100 ~100%
Trade Balance(Pre.Year)	about 0.0 %	-100 ~ 100%
Trade Balance(Imports)(Pre.Term)	about 2.0%	-11.0 ~ 15.0%
Trade Balance(Imports)(Pre.Year)	about -2.0 %	-20.0 ~16.0 %
Trade Balance(Exports)(Pre.Term)	about 0.0%	-7.0 ~7.0 %
Trade Balance(Exports)(Pre.Year)	about 9.0 %	0.0 ~18.0 %
Interest Rates on CD 3Mons.(Pre.Term)	about -8.0%	-18.0 ~2.0 %
Interest Rates on CD 3Mons.(Pre.Year)	about -35.0%	-45.0 ~-25.0 %
Long-Term Government Bonds Yield(10year) (Pre.Term)	about 0.0%	-6.0 ~6.0%
Long-Term Government Bonds Yield(10year) (Pre.Year)	about -15.0%	-18.0 ~-12.0 %
Financial Balance(Pre.Term)	about -40%	-80.0 ~0.0 %
Financial Balance(Pre.Year)	about 0.0%	-100.0~100.0 %
Financial Surplus(Pre.Term)	about -50.0%	-100 ~ 0.0 %
Financial Surplus(Pre.Year)	about -50.0%	-100.0 ~100.0 %
Financial Deficit(Pre.Term)	about 0.0%	-200~200%
Financial Deficit(Pre.Year)	about 0.0%	-200 ~ 200%
Wholesale Price Index(Pre.Term)	about 0.0%	-1.0 ~1.0 %
Wholesale Price Index(Pre.Year)	about 0.0%	-3.0 ~3.0 %
Consumer Price Index(Pre.Term)	about -20.0%	-70.0 ~ 30.0%
Consumer Price Index(Pre.Year)	about -40.0%	-70.0 ~-10.0%
Sales of Department Stores(Pre.Term)	about 20.0%	-20 ~ 60 %
Sales of Department Stores(Pre.Year)	about 25.0%	-25.0 ~ 75.0%
Indexes of Operating Ratio(Pre.Term)	about 0.0%	-2.5 ~ 2.5 %
Indexes of Operating Ratio(Pre.Year)	about -7.0 %	-10.0~-4.0 %
GNP Growth Ratio(Pre.Term)	about -25.0%	-70.0 ~ 20.0%
GNP Growth Ratio(Pre.Year)	about -60.0 %	-85.0 ~ -35.0%
Money Supply(Pre.Term)	about 0.0%	-20.0 ~ 20.0%
Money Supply(Pre.Year)	about -60.0%	-80.0 ~-40.0 %
The Nikkei Stock Average(Pre.Term)	about 0.0%	-5.0 ~ 5.0%
The Nikkei Stock Average(Pre.Year)	about -25%	-40.0 ~-10.0%

C.3 GMN

Economic Indices	Standard Level	Observation Range
Call Rate(Pre.Term)	about 2.0%	-3.0 ~7.0 %
Call Rate(Pre.Year)	about 10.0%	8.0~ 12.0%
Interbank Rate(Pre.Term)	about 0.0%	-1.0 ~1.0 %
Interbank Rate(Pre.Year)	about 6.0%	4.0 ~ 8.0 %
Long-Term Money Rate(Pre.Term)	about 0.0%	-8.0 ~ 8.0%
Long-Term Money Rate(Pre.Year)	about -5.0%	-2.0 ~ -8.0 %
Money Supply(Pre.Term)	about 0.0%	-5.0 ~ 5.0%
Money Supply(Pre.Year)	about 7.0%	4.0 ~ 10.0%

D Linguistic Rules for Recognizing Economic Conditions

In this section, we show the linguistic rules for recognizing economic conditions. The system has some typical rule types[1], and each causal relation shares the rules for saving computer memories. We show the relation between rule types and causal relations below.

D.1 U.S. Economic Trend

Rule_1

U.S Trade

- **Reuter's Index** ⟶ **World Commodity Market Trend(Materials)**
- **CRB Index** ⟶ **World Commodity Market Trend(Foods)**

U.S Product

- **U.S. GDP Private Construction Investment** ⟶ **U.S. Construction Investment Trend**

U.S Short Term Money Rate Trend

- **U.S. Treasury Bill Rate(3-Months)** ⟶ **U.S. Market Operation Trend**

U.S. Market Operation Trend is "*high/low*" means that the possibility of intervention to the market by U.S. FRB is "*high/low*".

- **U.S. Market Operation Trend** ⟶ **U.S. FF Rate Change Pressure**
- **U.S. Market Operation Trend** ⟶ **U.S. FRB Monetary Policy Trend**

U.S. FRB Monetary Policy Trend is "*high*" means that the possibility of easing money rate by U.S. FRB is "*high*", and "*low*" means that the possibility of tightening money rate by U.S. FRB is "*high*".

FRB Attitude

- **U.S. FRB Monetary Policy Trend** ⟶ **U.S. FRB Intervent Trend on Bond Market**

U.S. FRB Intervent Trend on Bond Market is "*high*" means that the possibility of FRB's buying operation is "*high*", and "*low*" means that the possibility of FRB's selling operation is "*high*".

A ⟶ X	
Premise(Antecedent)	Consequents
A	X
very high	very high
high	high
medium	medium
low	low
very low	very low

[1]The system has eleven rule types: Rule_1, Rule_1_sp1, Rule_2, Rule_2_sp1, Rule_2_sp2, Rule_3, Rule_3_sp1, Rule_3_sp2, Rule_3_sp3, Rule_state_n3, Rule_FRB_policy, and Rule_Relative_money.

Rule_1_sp1

U.S Stock & Bond

- U.S. Financial Trend ⟶ U.S. Bond Publishment Trend

A ⟶ X	
Antecedents	Consequents
A	X
very high	very low
high	low
medium	medium
low	high
very low	very high

Rule_2

U.S Trade

- U.S. Exports, U.S. Trade Balance(Exports) ⟶ U.S. Exports Trend
- U.S. Imports, U.S. Trade Balance(Imports) ⟶ U.S. Imports Trend
- World Commodity Market Trend(Materials), World Commodity Market Trend(Foods) ⟶ World Commodity Market Trend

U.S Product

- U.S. Corporate Profits, U.S. Wholesale Price Index ⟶ U.S. Corporate Profits Trend
- U.S. Industrial Production Trend, U.S. Corporate Profits Trend ⟶ U.S. Production Trend
- U.S. Personal Consumption Index, U.S. Wholesale Price Index ⟶ U.S. Personal Consumption Trend

U.S Long Term Money Rate

- U.S. Housing Investment Trend, U.S. Construction Investment Trend ⟶ U.S. Domestic Funds Demand Trend
- U.S. Housing Construction Trend, U.S. Unemployment Rate Trend ⟶ U.S. Consumption Trend

U.S Price

- U.S. Money Supply, U.S. Stock Price Trend ⟶ U.S. Money Supply Trend
- U.S. Industrial Capacity Utilization, U.S. Industial Production Trend ⟶ U.S. Industrial Capacity Utilization Trend
- U.S. Consumer Price Index, U.S. Industrial Capacity Utilization Trend ⟶ U.S. Consumer Price Trend
- U.S. Produce Price Trend, U.S. Consumer Price Trend ⟶ U.S. Price Trend

FRB Attitude

- **U.S. Long-Term Money Rate Trend, ⟶ U.S. Long-Term Money Rate Trend for FRB Policy**
  U.S. FF Rate Trend

U.S. Long-Term Money Rate Trend for FRB Policy is "*high*" means that the possibility of easing long-term money rate by U.S. FRB is "*high*", and "*low*" means that the possibility of tightening long-term money rate by U.S. FRB is "*high*".

A, B ⟶ X			
Antecedents			Consequents
A		B	X
very high	and	very high	very high
very high	and	high	very high
very high	and	-	high
very low	and	very high	medium
very low	and	high	low
very low	and	-	very low
low	and	very high	high
low	and	high	medium
high	and	high	very high
high	and	low	medium
low	and	low	very low
-	and	high	high
-	and	very high	very high
-	and	very low	very low
low	and	-	low
-	and	low	low
-	and	very low	very low
medium	and	low	low
high	and	medium	high

Rule_2_sp1

U.S Trade

- **U.S. Trade Balance(Exports), U.S. Trade Balance(Imports)** ⟶ **U.S. Trade Balance**
- **U.S. Stock Price(D-J Average), U.S. Oil Price(WTI) Trend** ⟶ **U.S. Stock Price Trend**

U.S Product

- **U.S. Unemployment Rate, U.S. Number of Non-Farm Employment** ⟶ **U.S. Unemployment Trend**
- **U.S. Wage Trend, U.S. Unemployment Trend** ⟶ **U.S. Employment Trend**

U.S. Stock & Bond

- **U.S. Financial Surplus, U.S. Financial Deficit** ⟶ **U.S. Financial Trend**

U.S Short Term Money Rate Trend

- **U.S. FF Rate Trend, U.S. Official Discount Rate** ⟶ **U.S. Short-Term Money Rate Trend**

A, B ⟶ X			
Antecedents(rule_2_sp1)			Consequents
A		B	X
very high	and	very low	very high
very high	and	low	very high
very high	and	-	high
very low	and	very low	medium
very low	and	low	low
very low	and	-	very low
low	and	very low	high
low	and	low	medium
high	and	low	very high
high	and	high	medium
low	and	high	very low
-	and	low	high
-	and	very low	very high
-	and	very high	very low
low	and	-	low
-	and	high	low
-	and	very high	very low
medium	and	high	low
high	and	medium	high

Rule_3

U.S Long Term Money Rate

- **U.S. Long-Term Government Bonds(30years), U.S. Bond Market Trend, U.S. Domestic Funds Demand Trend** **⟶ U.S. Long-Term Money Rate Trend**

A, B, C ⟶ X					
Antecedents(rule_3)					Consequents
A		B		C	X
very high	and	very high	and	-	very high
very high	and	-	and	very high	very high
-	and	very high	and	very high	very high
very high	and	high	and	-	high
very high	and	-	and	high	high
-	and	very high	and	high	high
high	and	very high	and	-	high
high	and	-	and	very high	high
-	and	high	and	very high	high
high	and	high	and	-	high
high	and	-	and	high	high
-	and	high	and	high	high
high	and	high	and	-	high
high	and	-	and	high	high
-	and	high	and	high	high
very low	and	very low	and	-	very low
very low	and	-	and	very low	very low
-	and	very low	and	very low	very low
very low	and	low	and	-	low
very low	and	-	and	low	low
-	and	very low	and	low	low
low	and	very low	and	-	low
low	and	-	and	very low	low
-	and	low	and	very low	low
low	and	low	and	-	low
low	and	-	and	low	low
-	and	low	and	low	low
low	and	low	and	-	low
low	and	-	and	low	low
-	and	low	and	low	low
-	and	-	and	-	medium

Rule_3_sp1

U.S Trade

- **U.S. Trade Balance,**
  U.S. Imports Trend ,
  U.S. Exports Trend

⟶ U.S. Total Domestic Demand Trend

A, B, C ⟶ X					
Antecedents(rule_3_sp1)					Consequents
A		B		C	X
very low	and	very high	and	-	very low
very low	and	-	and	very low	very low
-	and	very high	and	very low	very low
very low	and	high	and	-	low
very low	and	-	and	low	low
-	and	very high	and	low	low
low	and	very high	and	-	low
-	and	high	and	very low	low
low	and	-	and	very low	low
very high	and	very low	and	-	very high
very high	and	-	and	very high	very high
-	and	very low	and	very high	very high
very high	and	low	and	-	high
very high	and	-	and	high	high
-	and	very low	and	high	high
high	and	very low	and	-	high
-	and	low	and	very high	high
high	and	-	and	very high	high
low	and	high	and	-	low
low	and	-	and	low	low
-	and	high	and	low	low
low	and	high	and	-	low
-	and	high	and	low	low
low	and	-	and	low	low
high	and	low	and	-	high
high	and	-	and	high	high
-	and	low	and	high	high
high	and	low	and	-	high
-	and	low	and	high	high
high	and	-	and	high	high
-	and	-	and	-	medium

Rule_3_sp2

U.S Stock & Bond

- **U.S. Bond Publishment Trend,**
  Investment Trend of the U.S. Institutional Investors,
  Investment Trend of JPN Institutional Investors
  ⟶ U.S. Bond Supply and Demand Trend

Investment Trend of the U.S./JPN Institutinal Investors is "*high*" means that they buy yen, and "*low*" means that they buy dollar.
U.S. Bond Supply and Demand Trend is "*high*" means that bond demand is highly requested, and "*low*" means that bond supply is highly requested.

A, B, C ⟶ X					
Antecedents(rule_3_sp2)					Consequents
A		B		C	X
very low	and	very high	and	-	very high
very low	and	-	and	very high	very high
-	and	very high	and	very high	very high
very low	and	high	and	-	high
very low	and	-	and	high	high
-	and	very high	and	high	high
low	and	very high	and	-	high
low	and	-	and	very high	high
-	and	high	and	very high	high
low	and	high	and	-	high
low	and	-	and	high	high
-	and	high	and	high	high
low	and	high	and	-	high
low	and	-	and	high	high
-	and	high	and	high	high
very high	and	very low	and	-	very low
very high	and	-	and	very low	very low
-	and	very low	and	very low	very low
very high	and	low	and	-	low
very high	and	-	and	low	low
-	and	very low	and	low	low
high	and	very low	and	-	low
high	and	-	and	very low	low
-	and	low	and	very low	low
high	and	low	and	-	low
high	and	-	and	low	low
-	and	low	and	low	low
high	and	low	and	-	low
high	and	-	and	low	low
-	and	low	and	low	low
-	and	-	and	-	medium

Rule_3_sp3

U.S Product

- U.S. NAPM Index,
  U.S. Unemployment Trend,
  U.S. Industrial Production Trend
  ⟶ U.S. Economic Trends

U.S Price

- U.S. Production Price Index,
  U.S. Business Inventories Trend,
  U.S. Wage Level Trend
  ⟶ U.S. Production Price Trend
- U.S. Production Price Trend,
  U.S. Consumer Price Trend,
  U.S. Money Supply Trend
  ⟶ U.S. Inflation Trend

FRB Attitude

- U.S. Production Price Trend,
  U.S. Consumer Price Trend,
  U.S. Money Supply Trend
  ⟶ U.S. Inflation Trend
- U.S. Bond Supply and Demand Trend,
  U.S. Stock Price Trend,
  U.S. FRB Bond Market Operations Trend
  ⟶ Bond Market Trend

U.S. FRB Bond Market Operations Trend is "*high*" means that the possibility of FRB's buying operation is "*high*", and "*low*" means that the possibility of FRB's selling operation is "*high*".

A, B, C ⟶ X					
Antecedents(rule_3_sp3)					Consequents
A		B		C	X
very high	and	very low	and	-	very high
very high	and	-	and	very high	very high
-	and	very low	and	very high	very high
very high	and	low	and	-	high
very high	and	-	and	high	high
-	and	very low	and	high	high
high	and	very low	and	-	high
-	and	low	and	very high	high
high	and	-	and	very high	high
very low	and	very high	and	-	very low
very low	and	-	and	very low	very low
-	and	very high	and	very low	very low
very low	and	high	and	-	low
very low	and	-	and	low	low
-	and	very high	and	low	low
low	and	very high	and	-	low
-	and	high	and	very low	low
low	and	-	and	very low	low
high	and	low	and	-	high
high	and	-	and	high	high
-	and	very low	and	high	high
high	and	very low	and	-	high
-	and	low	and	high	high
high	and	-	and	high	high
low	and	high	and	-	low
low	and	-	and	low	low
-	and	very high	and	low	low
low	and	very high	and	-	low
-	and	high	and	low	low
low	and	-	and	low	low
-	and	-	and	-	medium

Rule_state_n3

U.S Trade

- **U.S. Government Expenditure,**
  U.S. New Orders for Manufactures,
  U.S. New Orders for Durable Goods
  ⟶ U.S. Total Domestic Demand Trend

A, B, C ⟶ X					
Antecedents(rule_state_n3)					Consequents
A		B		C	X
very high	and	-	and	very high	very high
very high	and	very high	and	-	very high
-	and	very high	and	very high	very high
very high	and	high	and	-	high
very high	and	-	and	high	high
-	and	very high	and	high	high
high	and	very high	and	-	high
-	and	high	and	very high	high
high	and	-	and	very high	high
very low	and	-	and	very low	very low
very low	and	very low	and	-	very low
-	and	very low	and	very low	very low
very low	and	low	and	-	low
very low	and	-	and	low	low
-	and	very low	and	low	low
low	and	very low	and	-	low
-	and	low	and	very low	low
low	and	-	and	very low	low
high	and	high	and	-	high
high	and	-	and	high	high
-	and	high	and	high	high
high	and	high	and	-	high
-	and	high	and	high	high
high	and	-	and	high	high
low	and	low	and	-	low
low	and	-	and	low	low
-	and	low	and	low	low
low	and	low	and	-	low
-	and	low	and	low	low
low	and	-	and	low	low
-	and	-	and	-	medium

Rule_FRB_policy

FRB Attitude

- **U.S. Government Expenditure,**
  U.S. Unemployment Trend,
  U.S. Price Trend
  ⟶ U.S. FRB Basic Monetary Policy

U.S. FRB Monetary Policy is "high" means that FRB regards the recovery of business cycle as important, and "*low*" means that FRB regards the stability of price trend as important.

A, B, C ⟶ X					
Antecedents(rule_FRB_policy)					Consequents
A		B		C	X
very low	and	very high	and	-	very high
low	and	very high	and	medium	very high
very low	and	high	and	medium	very high
low	and	high	and	medium	high
very low	and	very low	and	medium	high
very low	and	low	and	medium	very high
very high	and	very high	and	medium	medium
high	and	high	and	medium	medium
high	and	low	and	medium	medium
-	and	-	and	very high	very low
-	and	-	and	high	low
-	and	-	and	-	medium

D.2 Japan's Economic Trend

Rule_1

JPN Money Rate - Economic Trends

- **JPN Governmental Bond(10years) ⟶ JPN Long-Term Money Rate Trend**
- **JPN The Nikkei Stock Average ⟶ JPN Stock Price Trend**

Rule_1_sp1

JPN Stock & Trend

- **JPN Financial Trend ⟶ JPN Bond Publishment Trend**

JPN Money Rate - Economic Trends

- **JPN Money Supply Trend ⟶ Monetary Policy of Bank of Japan**

Monetary Policy of Bank of Japan is "*high*" means that Monetary Policy of Bank of Japan is "high" means that Bank of Japan regards the recovery of business cycle as important, and "*low*" means that Bank of Japan regards the stability of price trend as important.

Rule_2

JPN Stock & Trend

- **JPN Money Supply Trend,JPN Price Trend ⟶ JPN Inflation Trend**

JPN Trade

- **JPN Exports,JPN Trade Balance(Exports) ⟶ JPN Exports Trend**
- **JPN Imports,JPN Trade Balance(Imports) ⟶ JPN Imports Trend**

Rule_2_sp1

JPN Stock & Trend

- **JPN CD Rate(3Months),JPN Official Discount Rate ⟶ JPN Short-Term Money Rate Trend**
- **JPN Bond Publishment Trend, JPN Bond Institutional Investors Investment Trend ⟶ JPN Bond Supply and Demand Trend**

JPN Bond Institutional Investors Investment Trend is "*high*" means that they they buy Japanese bond, and "*low*" means that they buy U.S. bond.
JPN Bond Supply and Demand Trend is "*high*" means that "*high*" means that bond supply is highly requested, and "*low*" means that bond demand is highly requested.

Rule_3

JPN Money Rate - Economic Trends

- **JPN Sales of Department Stores, Indexes of Operating Ratio, JPN GNP Growth Ratio ⟶ JPN Economic Trends**

Rule_3_sp1

JPN Trade

- **JPN Trade Balance,**
  JPN Exports Trend,
  JPN Imports Trend
  ⟶ JPN Trade Balance Trend

Rule_3_sp3

JPN Stock & Trend

- **JPN Financial Index,**
  JPN Financial Deficit,
  JPN Financial Surplus
  ⟶ JPN Financial Trend
- **Oil Price Trend,**
  JPN Consumer Price Index,
  JPN Wholesale Price Index
  ⟶ JPN Price Trend

D.3 German's Economic Trend

Rule_1

- **GMN Money Supply ⟶ Monetary Policy of GMN Central Bank**

Monetary Policy of GMN Central Bank is "high" means that GMN Central Bank regards the recovery of business cycle as important, and "*low*" means that GMN Central Bank regards the stability of price trend as important.

Rule_2

- **GMN Inter-Bank Money Rate,**
  GMN Official Discount Ratio
  ⟶ GMN Short-Term Money Rate Trend
- **GMN Short-Term Money Rate Trend,**
  GMN Long-Term Money Rate Trend
  ⟶ GMN Money Rate Trend

D.4 Rule_Relative_money

- **U.S. Short-Term Money Rate Trend,**
  JPN Short-Term Money Rate Trend,
  GMN Short-Term Money Rate Trend ⟶ **Relative U.S. Short-Term Money Rate Trend**

Relative U.S. Short-Term Money Rate Trend is "*high*" means that U.S. short-term money rate is relatively higher that the other country's short-term money rate, and "*low*" means that U.S. short-term money rate is relatively lower than the other country's short-term money rate.

A, B, C ⟶ X					
Antecedents					Consequents
A		B		C	X
very high	and	very low	and	-	medium
very high	and	-	and	very high	medium
very high	and	-	and	high	high
very high	and	high	and	-	high
very high	and	-	and	-	very high
high	and	very high	and	-	low
high	and	-	and	very high	low
high	and	high	and	-	medium
high	and	-	and	high	medium
high	and	very low	and	very low	very high
high	and	low	and	low	very high
high	and	low	and	low	very high
high	and	-	and	-	high
very low	and	very low	and	-	medium
very low	and	-	and	very low	medium
very low	and	-	and	low	low
very low	and	low	and	-	low
very low	and	-	and	-	very low
low	and	very low	and	-	high
low	and	-	and	very low	high
low	and	low	and	-	medium
low	and	-	and	low	medium
low	and	very high	and	very high	very low
low	and	high	and	high	very low
low	and	low	and	low	very low
low	and	-	and	-	low
-	and	-	and	-	medium

E Rules for Situation Variables related to Forecaster's View

Rule_1

- **Relative Blance of Long Term Money Rate** —→ **U.S. Long Term Money Rate**
- **Relative Balance of Short Term Money Rate** —→ **U.S. Short Term Money Rate**
- **Official Attitude of the U.S. FRB** —→ **U.S. Price**
- **Relative Balance of Long Term Money Rate** —→ **JPN Long Term Money Rate**
- **Official Attitude of the Bank of Japan** —→ **JPN Price**

A —→ X	
Antecedents	Consequents
A	X
very high	very high
high	high
medium	medium
low	low
very low	very low

Rule_2

- **Trande Blance , Financial Blance** —→ **U.S. Trade**
- **Domestic Demand, Foreign Exchange Rate** —→ **JPN Business Cycle**
- **Trade Blance, Financial Blance** —→ **JPN Trade**
- **Investment Trend of the U.S. Institutional Investors, Investment Trend of JPN Institutional Investors** —→ **JPN stock**

A,B —→ X			
Antecedents			Consequents
A		B	X
very high	and	very high	very high
very high	and	high	very high
very high	and	-	high
very low	and	very high	medium
very low	and	high	low
very low	and	-	very low
low	and	very high	high
low	and	high	medium
high	and	high	very high
high	and	low	medium
low	and	low	very low
-	and	high	high
-	and	very high	very high
-	and	very low	very low
low	and	-	low
-	and	low	low
-	and	very low	very low
medium	and	low	low
high	and	medium	high

Rule_2_sp1

- **Investment Trend of the U.S. Institutional Investors, Investment Trend of JPN Institutional Investors** ⟶ **U.S. Stock**

A,B ⟶ X			
Antecedents			Consequents
A		B	X
very high	and	very high	very low
very high	and	high	very low
very high	and	-	low
very low	and	very high	medium
very low	and	high	high
very low	and	-	very high
low	and	very high	low
low	and	high	medium
high	and	high	very low
high	and	low	medium
low	and	low	very high
-	and	high	low
-	and	very high	very low
-	and	very low	very high
low	and	-	high
-	and	low	high
-	and	very low	very high
medium	and	low	high
high	and	medium	low

Rule_3

- **Trade Balance, Foreign Exchange Rate** ⟶ **U.S. Business Cycle**

Trade Balance,Foreign Exchange Rate ⟶ U.S. Business Cycle			
Antecedents			Consequents
Trade Balance		Foreign Exchange Rate	U.S. Business Cycle
very high	and	very high	medium
very high	and	high	high
very high	and	-	very high
very low	and	very low	medium
very low	and	low	low
very low	and	-	very low
low	and	very low	high
low	and	low	medium
high	and	low	very high
high	and	high	medium
medium	and	low	high
-	and	very high	very low
-	and	very low	very high
low	and	medium	low
medium	and	high	low
high	and	medium	high

F The Relation between Situation Types and Knowledge

The knowledge which the system has is related to the position of business recession.

#S{Short term money rate imbalance}		
Long-Term Trend	Short-Term Trend	Basic Forecasting Pattern
-	JPN *high*	• JPN short term money rate trend, U.S. short term money rate trend ⟶ Short term money rate imbalance trend • Short term money rate imbalance trend ⟶ Yen-Dollar rate trend
-	JPN *low*	• JPN short term money rate trend, U.S. short term money rate trend ⟶ Short term money rate imbalance trend • Short term money rate imbalance trend ⟶ Yen-Dollar rate trend
-	U.S. *high*	• JPN short term money rate trend, U.S. short term money rate trend ⟶ Short term money rate imbalance trend • Short term money rate imbalance trend ⟶ Yen-Dollar rate trend
-	U.S. *low*	• JPN short term money rate trend, U.S. short term money rate trend ⟶ Short term money rate imbalance trend • Short term money rate imbalance trend ⟶ Yen-Dollar rate trend

#S{Stock Fluctuation}		
Long-Term Trend	Short-Term Trend	Basic Forecasting Pattern
JPN *low*	JPN *low*	• JPN stock trend, Investment trend of U.S. institutional investor ⟶ JPN long-term money trend(↓) • Investment trend of U.S. institutional investor ⟶ Trend of Yen-Dollar rate
U.S. *low*	U.S. *low*	• U.S. stock trend, Investment trend of JPN institutional investor ⟶ U.S. long-term money trend(↓) • Investment trend of U.S. institutional investor ⟶ Trend of Yen-Dollar rate
-	JPN *low*	• JPN stock trend ⟶ JPN long-term money trend(bond rate(↑) • JPN stock trend ⟶ Investment trend of JPN institutional investor • JPN stock trend ⟶ Yen-Dollar trend
-	U.S. *low*	• U.S. stock trend ⟶ U.S. long-term money trend(bond rate(↑) • U.S. stock trend ⟶ Investment trend of U.S. institutional investor • U.S. stock trend ⟶ Yen-Dollar trend

#S{Trade Imbalance}		
Long-Term Trend	Short-Term Trend	Basic Forecasting Pattern
-	JPN *Surplus*	• JPN Trade Balance, U.S. Trade Balance ⟶ Trade Balance(b.w. JPN&U.S.) • Trade Balance(JPN&U.S.), Financial Balance(JPN&U.S.) ⟶ Official attitudes of JPN and U.S. central banks • Trade Balance(JPN&U.S.), Official attitudes of JPN and the U.S. central banks ⟶ Investment trend of JPN and U.S. export-import companies • Investment trend of JPN and U.S. export-import companies ⟶ Yen-Dollar rate trend
-	JPN *Deficit*	• JPN Trade Balance, U.S. Trade Balance ⟶ Trade Balance(b.w. JPN&U.S.) • Trade Balance(JPN&U.S.), Financial Balance(JPN&U.S.) ⟶ Official attitudes of JPN and U.S. central banks • Trade Balance(JPN&U.S.), Official attitudes of JPN and the U.S. central banks ⟶ Investment trend of JPN and U.S. export-import companies • Investment trend of JPN and U.S. export-import companies ⟶ Yen-Dollar rate trend
-	U.S. *Surplus*	• JPN Trade Balance, U.S. Trade Balance ⟶ Trade Balance(b.w. JPN&U.S.) • Trade Balance(JPN&U.S.), Financial Balance(JPN&U.S.) ⟶ Official attitudes of JPN and U.S. central banks • Trade Balance(JPN&U.S.), Official attitudes of JPN and the U.S. central banks ⟶ Investment trend of JPN and U.S. export-import companies • Investment trend of JPN and U.S. export-import companies ⟶ Yen-Dollar rate trend
-	U.S. *Deficit*	• JPN Trade Balance, U.S. Trade Balance ⟶ Trade Balance(b.w. JPN&U.S.) • Trade Balance(JPN&U.S.), Financial Balance(JPN&U.S.) ⟶ Official attitudes of JPN and U.S. central banks • Trade Balance(JPN&U.S.), Official attitudes of JPN and the U.S. central banks ⟶ Investment trend of JPN and U.S. export-import companies • Investment trend of JPN and U.S. export-import companies ⟶ Yen-Dollar rate trend

#S{Business Cycle Recovery}		
Long-Term Trend	Short-Term Trend	Basic Forecasting Pattern
U.S. *low*	-	• U.S. money supply trend ⟶ U.S. easy-money policy trend • U.S. easy-money policy trend ⟶ Yen-Dollar trend
JPN *low*	-	• JPN money supply trend ⟶ JPN easy-money policy trend • JPN easy-money policy trend ⟶ Yen-Dollar trend
U.S. *very low*	-	• U.S. business recovery trend ⟶ U.S. bond publishment trend • U.S. bond publishment trend ⟶ U.S. long-term money trend • U.S. business cycle trend ⟶ JPN domestic deman enlargement • U.S. money supply trend ⟶ U.S. easy-money policy trend • U.S. easy-money policy trend, U.S. long-term money trend ⟶ Yen-Dollar trend
JPN *very low*	-	• JPN business recovery trend ⟶ JPN bond publishment trend • JPN bond publishment trend ⟶ JPN long-term money trend • JPN money supply trend ⟶ JPN easy-money policy trend • JPN easy-money policy trend, JPN long-term money trend ⟶ Yen-Dollar trend

#S{Exchange Trend Imbalance}		
Long-Term Trend	Short-Term Trend	Basic Forecasting Pattern
-	-	• Yen-Dollar trend ⟶ Official attitudes of JPN and U.S. central banks • Official attitudes of JPN and U.S. central banks ⟶ Investment trend of JPN and U.S. export-import companies • Investment trend of JPN and U.S. export-import companies ⟶ Yen-Dollar trend

#S{Long-Term Money Imbalance}		
Long-Term Trend	Short-Term Trend	Basic Forecasting Pattern
-	-	• Relative balance of long-term money rate(U.S., JPN, GMN), U.S. inflation trend ⟶ Investment trend of U.S. institutional investor, Investment trend of JPN institutional investor • Investment trend of U.S. instiurional investor, Invetment trend of JPN institutional investor ⟶ Yen-Dollar trend

#{Price Flctuation}		
Long-Term Trend	Short-Term Trend	Basic Forecasting Pattern
-	U.S. *low or high*	• U.S. price trend, Official attitude of U.S. central bank ⟶ U.S. easy-money policy trend • Investment trend of U.S. institutional investor, U.S. easy-money policy trend ⟶ Yen-Dollar trend
-	JPN *low or high*	• JPN price trend, Official attitude of JPN central bank ⟶ JPN easy-money policy trend • Investment trend of JPN institutional investor, JPN easy-money policy trend ⟶ Yen-Dollar trend

#S{Short-Term Money Imbalance&Trade Imbalance }		
Long-Term Trend	Short-Term Trend	Basic Forecasting Pattern
JPN *high* & U.S.*low*	JPN *high* & U.S.*low*	• Trade imbalance(b.w. JPN and U.S.) ⟶ Trend of exchange adjustment for Yen-Dollar rate by JPN and U.S. central banks • Official attitude of JPN and U.S. central banks ⟶ Trend of exchange adjustment for Yen-Dollar rate by JPN and U.S. central banks • Short-term money rate unbalnace trend ⟶ Yen-Dollar rate trend • Trend of exchange adjustment for Yen-Dollar rate by JPN and U.S. central banks ⟶ Yen-Dollar rate trend
-	-	• Trade imbalance ⟶ Trend of exchange adjustment for Yen-Dollar rate by JPN and U.S. central banks ⟶ Yen-Dollar rate trend • Official attitude of JPN and U.S. central banks ⟶ Trend of exchange adjustment for Yen-Dollar rate by JPN and U.S. central banks ⟶ Yen-Dollar rate trend • Short term money imbalance trend ⟶ Yen-Dollar rate trend • Trend of exchange adjustment for Yen-Dollar rate by JPN and U.S. central banks ⟶ Yen-Dollar rate trend ⟶ Yen-Dollar rate trend

#S{Trade Imbalance & Business cycle Recovery}		
Long-Term Trend	Short-Term Trend	Basic Forecasting Pattern
JPN *high* & U.S.*low*	U.S. *low*	• Trade Imbalance ⟶ Trend of exchange adjustment for Yen-Dollar rate by JPN and U.S. central banks ⟶ Yen-Dollar rate trend • Official attitude of JPN and U.S. central banks ⟶ Trend of exchange adjustment for Yen-Dollar rate by JPN and U.S. central banks ⟶ Yen-Dollar rate trend • U.S. business cycle recovery trend ⟶ JPN domestic demand enlargement • Trend of exchange adjustment for Yen-Dollar rate by JPN and U.S. central banks ⟶ Yen-Dollar rate trend ⟶ Yen-Dollar rate trend
-	-	• Trade imbalance ⟶ Trend of exchange adjustment for Yen-Dollar rate by JPN and U.S. central banks • Official attitude of JPN and U.S. central banks ⟶ Trend of exchange adjustment for Yen-Dollar rate by JPN and U.S. central banks • Trend of exchange adjustment for Yen-Dollar rate by JPN and U.S. central banks ⟶ Yen-Dollar rate trend

#S{Short-Term Money Imbalance & Business Cycle Recovery}		
Long-Term Trend	Short-Term Trend	Basic Forecasting Pattern
JPN *low* & U.S. *low*	JPN *high* & U.S.*low*	• Short term money rate trend, Official attitude of U.S. central bank ⟶ Yen-Dollar rate trend
	JPN *low* & U.S.*high*	• Short term money rate trend, Official attitude of JPN central bank ⟶ Yen-Dollar rate trend

G Linguistic Rules for Estimating FER Changes

Rule_ex_db1

Short Term Money Rate Imbalance

- **Short term money rate imbalance trend ⟶ Yen-dollar rate trend(yen agst. dollar)**

Business Cycle Recovery

- **U.S. bond publishment trend ⟶ U.S. long-term money rate trend**
- **JPN bond publishment trend ⟶ JPN long-term money rate trend**

A ⟶ X	
Antecedents	Consequents
A	X
very high	considerably higher
high	somewhat higher
meidum	similar to
low	somewhat lower
very low	considerably lower

Rule_ex_db1_sp1

Business Cycle Recovery

- **U.S. money supply trend ⟶ U.S. easy-money policy trend**
- **JPN money supply trend ⟶ JPN easy-money policy trend**
- **U.S. business recovery trend ⟶ U.S. bond publishment trend**
- **U.S. business recovery trend ⟶ JPN domestic demand enlargement trend**
- **JPN business recovery trend ⟶ JPN bond publishment trend**
- **JPN money supply trend ⟶ JPN easy-money policy trend**

A ⟶ X	
Antecedents	Consequents
A	X
very high	considerably lower
high	somewhat lower
medium	similar to
low	somewhat higher
very low	considerably higher

Rule_ex_db2

Short-Term Money Rate Imbalance

- **U.S. short-term money rate trend, JPN short-term money rate trend ⟶ Short-term money rate imbalance trend (dollar agst. yen)**

Trade Imbalance

- **U.S. trade trend, JPN trade trend ⟶ Trade balance(b.w. JPN&U.S.)**

Business Cycle Recovery

- **JPN long-term money rate trend, JPN easy-money policy trend ⟶ Yen-Dollar rate trend**

Short Trem Money Imbalance & Business Cycle Recovery

- **Official attitude of the U.S. central bank, Short term money rate trend ⟶ Yen-Dollar rate trend**

A, B ⟶ X			
Antecedents			Consequents
A		B	X
very high	and	very high	similar to
very high	and	high	slightly higher
very high	and	medium	somewhat higher
very high	and	low	higher
very high	and	very low	considerably higher
high	and	very high	slightly lower
high	and	high	similar to
high	and	medium	slightly higher
high	and	low	somewhat higher
high	and	very low	higher
medium	and	very high	somewhat lower
medium	and	high	slightly lower
medium	and	medium	similar to
medium	and	low	slightly higher
medium	and	very low	somewhat higher
low	and	very high	lower
low	and	high	somewhat lower
low	and	medium	slightly lower
low	and	low	similar to
low	and	very low	slightly higher
very low	and	very high	considerably lower
very low	and	high	lower
very low	and	medium	somewhat lower
very low	and	low	slightly higher
very low	and	very low	similar to

Rule_ex_db2_sp1

Business Cycle Recovery

- **Investment trend of U.S. export-import companies, Investment trend of JPN export-import companies ⟶ Money flow trend of the yen-dollar market(yen agst. dollar)**

A, B ⟶ B			
Antecedents			Consequents
A		B	X
very high	and	very high	considerably higher
very high	and	high	higher
very high	and	medium	somewhat higher
very high	and	low	slightly higher
very high	and	very low	similar to
high	and	very high	higher
high	and	high	somewhat higher
high	and	medium	slightly higher
high	and	low	similar to
high	and	very low	slightly higher
medium	and	very high	somewhat higher
medium	and	high	slightly higher
medium	and	medium	similar to
medium	and	low	slightly lower
medium	and	very low	somewhat lower
low	and	very high	slightly higher
low	and	high	similar to
low	and	medium	slightly lower
low	and	low	somewhat lower
low	and	very low	lower
very low	and	very high	similar to
very low	and	high	slightly lower
very low	and	medium	somewhat lower
very low	and	low	lower
very low	and	very low	considerably lower

Rule_ex_db2_sp2

Business Cycle Recovery

- **U.S. long-term money rate trend, U.S. easy-money policy trend ⟶ Yen-dollar trend**

A、B ⟶ X			
Antecedents			Consequents
A		B	X
very high	and	very high	similar to
very high	and	high	slightly lower
very high	and	medium	somewhat lower
very high	and	low	lower
very high	and	very low	considerably lower
high	and	very high	slightly higher
high	and	high	similar to
high	and	medium	slightly lower
high	and	low	somewhat lower
high	and	very low	lower
medium	and	very high	somewhat higher
medium	and	high	slightly higher
medium	and	medium	similar to
medium	and	low	slightly lower
medium	and	very low	somewhat lower
low	and	very high	higher
low	and	high	somewhat higher
low	and	medium	slightly higher
low	and	low	similar to
low	and	very low	slightly lower
very low	and	very high	considerably higher
very low	and	high	higher
very low	and	medium	somewhat higher
very low	and	low	slightly higher
very low	and	very low	similar to

Rule_ex_db2_sp3

Short Money Rate Imbalance & Business Cycle Recovery

- **Short-term monery imbalance trend, Official attitude of JPN central bank ⟶ Yen-Dollar trend**

A、B ⟶ X			
Antecedents			Consequents
A		B	X
very high	and	very high	considerably lower
very high	and	high	lower
very high	and	medium	somewhat lower
very high	and	low	slightly lower
very high	and	very low	similar to
high	and	very high	lower
high	and	high	somewhat low
high	and	medium	slightly lower
high	and	low	similar to
high	and	very low	slightly higher
medium	and	very high	somewhat low
medium	and	high	slightly lower
medium	and	medium	similar to
medium	and	low	slightly higher
medium	and	very low	somewhat higher
low	and	very high	slightly lower
low	and	high	similar to
low	and	medium	slightly higher
low	and	low	somewhat higher
low	and	very low	higher
very low	and	very high	similar to
very low	and	high	slightly higher
very low	and	medium	somewhat higher
very low	and	low	higher
very low	and	very low	considerably higher

Rule_ex_db3_sp1

Trade Imbalance

- **Official attitude of U.S. central bank, Official attitude of JPN central bank, Trade imbalance trend(b.w. JPN & U.S.)⟶ Investment trend of U.S. export-import companies**

A、B、C ⟶ X					
Antecedents					Consequents
A		B		C	X
very high	and	very high	and	-	considerably lower
very high	and	-	and	very high	considerably lower
-	and	very high	and	very high	considerably lower
very high	and	high	and	-	lower
very high	and	-	and	high	lower
-	and	very high	and	high	lower
high	and	very high	and	-	lower
-	and	high	and	very high	lower
high	and	-	and	very high	lower
very low	and	very low	and	-	considerably higher
very low	and	-	and	very low	considerably higher
-	and	very low	and	very low	considerably higher
very low	and	low	and	-	higher
very low	and	-	and	low	higher
-	and	very low	and	low	higher
low	and	very low	and	-	higher
-	and	low	and	very low	higher
low	and	-	and	very low	higher
high	and	high	and	-	somewhat lower
high	and	-	and	high	somewhat lower
-	and	high	and	high	somewhat lower
high	and	high	and	-	somewhat lower
-	and	high	and	high	somewhat lower
high	and	-	and	high	somewhat lower
low	and	low	and	-	somewhat higher
low	and	-	and	low	somewhat higher
-	and	low	and	low	somewhat higher
low	and	low	and	-	somewhat higher
-	and	low	and	low	somewhat higher
low	and	-	and	low	somewhat higher
-	and	-	and	-	similar to

Rule_ex_db3_sp2

Short-term money rate imbalance & Trade imbalance

- **Trend of exchange adjustment for the yen dollar rate by JPN and U.S. central banks, Money flow trend of the yen-dollar market, Short-term money imbalance trend(b.w. JPN& U.S.)⟶ Yen-Dollar rate trend**

A、B、C ⟶ X					
Antecedents					Consequents
A		B		C	X
very high	and	very high	and	-	considerably higher
very high	and	-	and	very low	considerably higher
-	and	very high	and	very low	considerably higher
very high	and	high	and	-	higher
very high	and	-	and	low	higher
-	and	very high	and	low	higher
high	and	very high	and	-	higher
-	and	high	and	very low	high
high	and	-	and	very low	higher
very low	and	very low	and	-	considerably lower
very low	and	-	and	very high	considerably lower
-	and	very low	and	very high	considerably lower
very low	and	low	and	-	lower
very low	and	-	and	high	lower
-	and	very low	and	high	lower
low	and	very low	and	-	lower
-	and	low	and	very high	lower
low	and	-	and	very high	lower
high	and	high	and	-	somewhat higher
high	and	-	and	low	somewhat higher
-	and	high	and	low	somewhat higher
high	and	high	and	-	somewhat higher
-	and	high	and	low	somewhat higher
high	and	-	and	low	somewhat higher
low	and	low	and	-	somewhat lower
low	and	-	and	high	somewhat lower
-	and	low	and	high	somewhat lower
low	and	low	and	-	somewhat lower
-	and	low	and	high	somewhat lower
low	and	-	and	high	somewhat lower
-	and	-	and	-	similar to

Rule_ex_db3_sp3

Short-Term Money Rate Imbalance & Trade Imbalance

- **Official attitude of U.S. central bank, Official attitude of JPN central bank, Trade imbalance trend(b.w. JPN & U.S.)⟶ Yen-Dollar rate trend**

A、B、C ⟶ X					
Antecedents					Consequents
A		B		C	X
-	and	very high	and	very high	considerably higher
very low	and	very high	and	-	considerably higher
very low	and	-	and	very high	considerably higher
-	and	high	and	very high	higher
low	and	very high	and	-	higher
low	and	-	and	very high	higher
-	and	high	and	very high	higher
very low	and	-	and	high	higher
very low	and	high	and	-	higher
-	and	very low	and	very low	considerably lower
very high	and	very low	and	-	considerably lower
very high	and	-	and	very low	considerably lower
-	and	very low	and	low	lower
high	and	very low	and	-	lower
high	and	-	and	very low	lower
-	and	low	and	very low	lower
very high	and	-	and	low	lower
very high	and	low	and	-	lower
-	and	high	and	high	somewhat higher
low	and	high	and	-	somewhat higher
low	and	-	and	high	somewhat higher
-	and	high	and	high	somewhat higher
low	and	-	and	high	somewhat higher
low	and	high	and	-	somewhat higher
-	and	low	and	low	somewhat lower
high	and	low	and	-	somewhat lower
high	and	-	and	low	somewhat lower
-	and	low	and	low	somewhat lower
high	and	-	and	low	somewhat lower
high	and	low	and	-	somewhat lower
-	and	-	and	-	similar to

H Observed Numerical Data of Economic Indices

Observed Numerical Data of U.S. Economic Indices

Economic Index	Pre. Year	Pre. Term	Economic Index	Pre. Year	Pre. Term
Average Hourly Earnings	2.53%	-0.1%	Number of Non-farm Employment	0.184%	0.164%
Housing Starts	14.0	-17.0	Corporate Profits	14.86	9.95
Consumer Confidence Index	5.06	0.24	Operating Ratio of Industrial Production	0.13	0.38
Index of Industrial Production	2.46	0.46	Retail Sales	3.51	0.32
GDP Private Construc tion Investment	-2.19	0.42	New Orders for Manufactures	6.35	1.63
New Orders for Durable Goods	7.96	1.43	Unemployment Rate	9.09	-1.37
Consumer Confidence Index	-18.0	15.22	Business Inventories	-0.28	0.38
Producer Price Index	-1.99	0.51	Consumer Price Index	3.18	0.22
Wholesale Price Index	3.20	1.28	Purchasing Manager's Composite Diffusion Index	21.85	-5.18
Exports	9.70	-1.95	Imports	14.17	4.92
Trade balance(Exports)	2.66	1.83	Trade balance(Imports)	9.37	1.88
Financial Surplus	-20.59	69.68	Financial Deficit	-17.04	67.94
Government Expenditure	-1.49	0.0	Official Discount Ratio	-45.45	-14.29
FF rate	-36.89	-6.28	Treasury Bill Rates (3-Month)	-31.32	-7.18
Stock Price(D-J 30 Industrials Average)	12.05	2.32	Long-Term Government Bonds(30-year)	-3.05	0.13
Money Supply	2.26	-0.12	Oil Price WTI	-2.45	7.06
Reuter's Index	-8.02	0.65	CRB Index	-5.05	1.47

Observed Numerical Data of JPN Economic Indices

Economic Index	Pre. Year	Pre. Term	**Economic Index**	Pre. Year	Pre. Term
Exports	13.03%	-10.24%	Imports	12.72%	3.44%
Trade balance(Exports)	13.11	-3.32	Trade balance(Imports)	11.99	2.52
Interest Rates on the Certificates of Deposit (3 Month)	-40.65	-4.99	Long-Term Government Bonds Yield	-14.35	3.34
The Nikkei Stock Average	-33.53	-13.55	Money Supply	-57.89	-11.11
Financial Surplus	-66.96	-3.12	Financial Deficit	-44.96	208.00
Sales of Department Stores	34.19	33.91	Indexes of Operating Ratio	-8.28	-0.41
GNP Growth Ratio	-68.89	-41.67	Official Discount Rate	-40.91	-13.33
Consumer Price Index	-29.41	20.00	Wholesale Price Index	-0.73	-0.104

Observed Numerical Data of GMN Economic Indices

Economic Index	Pre. Year	Pre. Term	Economic	Pre. Year	Pre. Term
Interbank Rate	5.94%	0.52%	Money Supply	8.13%	0.59%
Long-Term Money Rate	-3.53	0.0	Official Discount Rate	23.08	0.0