Main TOC

SOME TRENDS IN THE STUDIES ON METASYNTHESIS*

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ABSTRACT

In recent ten years the metasynthesis methods or synthesis and integration has attracted a lot of attention in the fields of environment, social and economic problems, industry, health and education etc. In this paper some new trends for the development of metasynthesis will be introduced. We wish describe some progress carried out in the large key project supported by National Science Foundation of China. This project is titled in "Metasynthesis systems with combination between man and machine for decision support of macroeconomics" (1999-2003). We had developed some methods and software for running metasynthesis approach

Keywords: Metasynthesis, System, Synthesis, Integration, Macroeconomics

INTRODUCTION

From July of 1999 we carried out a project titled in "Metasynthesis systems with combination between man and machine for decision support of macroeconomics" (1999-2003). This is a large key project supported by National Natural Science Foundation of China (NSFC). In this project the metasynthesis system approach plays a main role. Prof. Qian, Yu and Dai originated Metasynthesis system approach in 1990 for solving so-called open, complex, giant systems. Here we wish give a short description

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of open complex giant system. The openness denotes energy, information, or material exchange with the outside world. The number of subsystems is extremely large. The complexity of such system can be outlined as thus: (1) between the subsystems there are many modes of communication; (2) subsystems are of many varieties; (3) the subsystems have different ways of expressing and acquiring knowledge;(4) the structure of the subsystems change with evolution, so the structure of the system is in a state of flux. They gave several examples for the open, giant complex systems, such as geographical systems, including the earth system, environmental system; social and economic system; military system and human body system [Qian et.al, 1993]. In this paper we will introduce this metasynthesis system approach and other similar studies in other countries.

METASYNTHESIS SYSTEM APPROACH

The meta-synthesis method, called as metasynthesis from qualitative to quantitative approach is *to unite organically* the expert group, data, all sorts of information, and the computer technology, and *to unite* scientific theory of various disciplines and human experience and knowledge. The open, giant complex systems involve biology, noetic science, medical science, geoscience, astronomy and social science theories. So this system is really giant field for scientific research. It is worth to point out that these related theories of disciplines originally distributed in different branches of science and even in different scientific and technological domains [Qian et.al, 1993]. Now in China the fields of applications of this system approach have covered like social –economic system, military system, sustainable development and system recognition etc., its theory has been consolidated. To run the mentioned large key project is one of efforts contributed to realization of this approach.

SIMILAR METASNTHESIS RESEARCH IN ABROAD AND CHINA

Some examples of researches and projects

Example 1.1 Global Change and environmental problem

E1.1.1 ***System Integration; Synthesis***

In report “Scientific Design for the Common Module of the Global Ocean Observing System (GOOS) and the Global Climate Observing System (GCOS): An Ocean Observing System for Climate” the

section VIII is named as ***System Integration; Synthesis*** [Ocean observing system development panel,1996]

E1.1.2 ***Synthesis and integration***

In International Geosphere-Biosphere Programme (IGBP) the transect approach are proposed as tools for synthesis and integration of research. They assume that the transect approach promoted collaboration among different disciplines through sharing of common research facilities and sites, also data bases. ***Synthesis and integration*** activities are essential for both the practical application of transects research to management issues and for the delivery of regional-level understanding and modeling expertise to Earth system science [Steffen W.L. et al.1999]. More practical example can be seen in the Romanovsky's paper: "***Synthesis and Integration of environmental data*** along the East Siberian Transect and Comparison of active layer and Permafrost conditions with an Alaskan Transect" [Romanovsky,1998]

E1.1.3 ***Integration and Synthesis Project***

In ***IGAC*** (International Global Atmospheric Chemistry) ***Integration and Synthesis Project*** they organized workshop and published book mentioning the integration and synthesis [IGAC]

E1.1.4 ***model integration***

In Rizzoli and Young's paper "Software tools and techniques to model environmental systems: a review" they mentioned the requirements of an Environmental Decision Support System (EDSS) is ***knowledge acquisition and representation, model integration and reuse,*** spatial data management, planning and management and optimization, problem definition and solving and ***expert help.*** [Rizzoli, Young, 1996]

E1.1.5. ***Data integration, synthesis***

Regional Analysis by Intelligent Systems ON Computer (***RAISON)*** is a decision support shell which can include Expert Systems, knowledge Tools, GIS and Databases. It developed by Environment Canada. RAISON for Windows Version 1.0 is a powerful environmental information system used for data ***integration*** and management, and for data analysis***, synthesis*** and display. It integrates database (data, text, images, maps), spreadsheet, statistics, graphing, contouring, geo-referencing, spatial visualization, and expert system modules through a common graphical user interface, and is particularly suitable for applications which involve point and layer data. [Environment Canada, 1999; NWRI, 2001]

E1.1.6. ***Research Integration Project***

The Center for Environmental Applied Hydrology (CEAH) is a research center within the Departments of Civil and Environmental Engineering and Geography and Environmental

Studies at the University of Melbourne. The CEAH has run a ***Research Integration Project*** started from 1996 till 2001, supported by LWRRDC (Land and Water Resources Research and Development Corporation). The principal objective of the investigation is the improvement of catchments management through improvements in both the integration of land and water research activities and the delivery and feedback mechanisms operating at catchments and property scales. This project wishes to identify and develop methods and tools, which can be used to improve integration of land and water research activities at all, scales of catchments and management. As far as possible, a generic approach will be further developed and improved through application to further case studies within a range of available data. [CEAH, 2000]

Example 1.2 Social problem and Enterprises management

E1.2.1 ***Metasynthesis Corporation***

In Russia there is a ***Metasynthesis Corporation*** who takes charge of consulting the social-economic systems, company activities and information technologies problems. They mentioned an important methodology used often-methodology of conceptual analysis and design of organizational control system, which permits to analyze the complex objects from different views and to synthesize procedures for getting the solutions reduced to new strategies. [Metasynthesis Corporation, 2002]

Example 1.3 Physical system

E1.3.1 ***Model Integration***

Workshop on ***Model Integration*** for complex system. The workshop addressed several topics; two of them are integrating partial-system models, integrating views of multiple facets. They wish to run the Model Integration for Complex Systems (MICS). [Hook, Kieburtz, 1997]

E1.3.2 ***Stanford Olympus Synthesis System***

Stanford Olympus ***Synthesis*** System is an experimental research tool for specification and design of digital circuits developed by the ***synthesis group*** at Stanford. [Synthesis group at Stanford, 1991]

E1.3.3 ***physically knowledgeable synthesis***

Envisia ***synthesis*** with ***physically knowledgeable synthesis*** (PKS) technology was developed by Cadence Design Systems in 1999. [Cadence Design Systems, 1999]

*E1.3.4.****Science of Synthesis***

Japan Society for Promotion of Sciences (JSPS) had organized a new research field titled in "**Science of Synthesis"**(1997-2001) as research for the future program. For this field

Osaka University, Kyoto University etc. had organized a project titled in “A methodology of collaborative synthesis by artificial intelligence”. The main applications put into the design and production of industrial product. They use the ontology engineering to let the knowledge to be systemized for synthesis. Project provides intelligent information processing platform for cooperative synthesis [Final Report for Future Program, 2002]

Example 1.4 Health and educationE1.4.1 ***Qualitative Metasynthesis***
Analytic Techniques for ***Qualitative Metasynthesis*** is a research project studied by Sandelowski and Barroso in School of Nursing, University of North Carolina at Chapel Hill (2000-2005). This study aims to develop the analytic and interpretive techniques to conduct qualitative metasynthesis projects. [Sandelowski , Barroso J. 2001]

OTHER SYNTHESIS AND INTEGRATION METHODS

There are some other synthesis and integration methods similar with metasynthesis system approach. We just introduce some of them.

Synthesis of distributed expert system (DES)

Zhang and Zhang had started their systematic research work on synthesis of distributed expert system (DES) from 1992.They had summarized systematically the potential synthesis cases, methodologies and strategies of synthesis of solution in DES. They identified four potential synthesis cases in DES: conflict synthesis case, inclusion synthesis case, overlap synthesis case and disjoint synthesis case, and defined four types of DES: homogeneous DES, partially homogeneous DES, partially heterogeneous DES and heterogeneous DES. The necessary conditions of synthesis strategies in different synthesis cases are recognized. They gave the measurements for synthesis strategies.
Two methodologies had proposed by them for designing synthesis strategies in DESs: analysis method and induction methods. Their work is really systematic and solid in mathematics, but the objects are a little bit narrow [Zhang and Zhang, 1999]

Comprehensive research synthesis

Research reviews play an important role in the dissemination of knowledge. The study on the methodology of research synthesis is crucial. The history of development of research

synthesis is similar with the reason for developing the metasynthesis systems approach. At first people used the qualitative approach-traditional narrative reviews, then the quantitative approach-meta-analysis was proposed. ***Meta-analysis*** is a statistical method of research integration, which can quantitatively integrate and analyze the findings from all the empirical studies relevant to an issue and amenable to quantitative aggregation. Meta-analysis has several advantages over traditional narrative review. It not only shows the direction of the effect of treatment, but also quantifies the effect and identifies the moderator variables. In a meta-analysis, findings from different studies are expressed in terms of a common metric called the effect size. However meta-analysis gives more weight to studies with multiple results and ignore studies for which the effect size cannot be computed. To overcome the limitations of the two mentioned methods Slavin proposed the method of "***best-evidence synthesis***" which in theory draw the strengths of two methods. It does not prescribe a rigid set of criteria for selecting the empirical studies. This method does not exclude all the studies for which computation of the effect size is not possible. In this method, statistical analysis is supplemented with a rich literature review, which explains any discrepancies observed, and summarizes the results, which cannot be quantified [Slavin, 1986].

The fourth kind of research synthesis is interpretive synthesis, including such as ***reciprocal translational synthesis*** [Jensen & Allen, 1996], ***refutational synthesis*** and ***lines of argument synthesis*** [Nobit & Hare, 1988]. The main idea of such kind of methods assumes that synthesis of qualitative research should be interpretive rather than aggregative. They consider the findings of individual studies. The purpose of these methods is not to generate predictive theories, but to facilitate a fuller understanding of the phenomenon, context or culture under consideration. Finally Suri argues that each of these four methods has their own strengths and weakness, so he suggests that a ***comprehensive research synthesis*** should include quantitative as well as qualitative research findings. The process of synthesizing research should be inductive and interpretive rather than a rigid set of procedures and techniques [Suri, 2000]

Metasynthesis System Reconstruction

Klir proposed reconstructability analysis (RA) in 1976. The purpose of RA is to deal with the various problems that emerge from the relationship between systems perceived as whole and their various subsystems. RA is thus connected with the issues of wholeness. RA involves two problems: identification problem and reconstruction problem. The first problem concerns with a given structure whose elements are viewed as subsystems of an

unknown overall system. The aim is to make meaningful inferences about the overall system from information in the subsystem and possibly, some additional background information. The second problem deals with a given overall system. The aim is to break the system into subsystems as small as possible, that are adequate to reconstruct the overall system, to an acceptable degree of approximation, solely from the information contained in the subsystems. Shu combines this analysis with metasynthesis and proposed ***metasynthesis reconstructabilty analysis***, which can integrate the data, information, models and knowledge. Recently Shu used it to forecast the growth rate of GDP in China in recent ten years. Especially after including the knowledge from experts the exactness of forecasting is much better than without including the knowledge [Shu, 2000,2001]

Integration in Probability Risk Assessment (PRA)

PRA proposed by NASA in the 50s is a set of methods, also as a methodology for assessing the safety of large complex systems, such as space program and nuclear power station. In the earlier time the study on the safety of mentioned systems were based on the qualitative analysis on the possible risk factors, such as FMEA, HA, then moved to the quantitative analysis methods, such as FTA. The PRA included both quantitative and qualitative analysis methods. It is an integrtion of FMEA, FTA and other techniques to assess the potential for failure and to help find ways to reduce risk [NASA, 2000]. But in 1960 since the poor estimation of risk by using the Probabilistic Risk Assessment for the Apollo Space Program NASA stopped to use PRA. But in the field of nuclear safety the PRA had developed. Only after the accident of Space Shuttle 'Challenge' in 1986 the NASA had attracted attention to use the PRA again. And the PRA itself also had got much progress. According to author's view PRA is really similar with a metasynthesis from qualitative to quantitative, its analysis is based on the data, information, knowledge and model, finally the expert opinions will be collected [Zhao 2000, Zhao and Gu, 2000, NASA, 1995]. In Zhao's doctoral dissertation three types of methods for collecting the expert's opinions had illustrated [Zhao 2000]. The important reason for using the metasynthesis in risk assessment for space program is that it is quite not enough the number of test data available in space program to run the usual statistical risk analysis. As a usual we have got just a few of real data tested by space program under study, then we have to use some substitute data, e.g. from the tested data in whole system but in incomplete conditions, data in subsystems, or even data from the similar space program, e.g. in the previous type, sometimes even borrowed data from similar test in other countries. But sometimes it is still not enough to make analysis, and then we use mathematical model or simulation to

produce some data. If we still couldn't get conclusion well, finally we will ask a group of experts to give the estimation of risk. ESA had applied the expert's judgment in their risk assessment for ESA Space program [ESA, 1991].

Metasynthesis Knowledge System (MSKS)

When we understand the knowledge system consisted not only of knowledge, but also data, information, model, experience of experts and wisdom of experts and decision makers. We may extend our knowledge much more wide. Especially in the knowledge system if the ***metasynthesis,*** or the ***integration*** and ***synthesis*** are emphasized, we may call it ***metasynthesis knowledge system***. Here we wish mention two examples in the fields of environment and economy system problems. Both of these two systems are belongs to open complex giant system. A lot of data and models had been utilized in solving such kind of the system problems. During constructing the models the data and knowledge in specific domains are required. Then we wish solve the first problem that how to integrate the models is very crucial. The second problem is that sometimes only the existed data and knowledge and some new data and knowledge derived from models are still not enough, peoples with different disciplines were asked to discuss some phenomena or issues, which from old separate knowledge couldn't be explained. So the interdisciplinary study, various meeting and exchange of views on the Internet or email, and questionnaire are required to supplement. But in most time the opinions from different experts are quite divergent, we shall solve the problem for building consensus.

Knowledge Management System toward Sustainable Society [Nakamori, 1989,2000]
In the end of 80s Sawaragi, Nakayama and Nakamori proposed the Shinayakana systems approach [Sawaragi et al. 1988]. When design a decision support system or solve a complex problem, this approach requires three "I", interactive, intelligent and interdisciplinary. Interactive means human-computer interaction. Intelligent means knowledge required. Interdisciplinary asks solving the problem with different experts with different knowledge in multidisciplinary fashion. Referring to the researcher's attitude three "H" are summarized: honesty in modeling the reality, humanity in designing support systems, and harmony of the research group [Sawaragi and Nakamori, 1991]. In their work they had paid much attention on the knowledge data and ***integration on utilization of the knowledge and judgment of experts in relevant fields.***
In the middle of 90s Nakamori and his colleagues engaged in constructing the environment framework model (EFM), EFM is a set of models, which can give an integrated knowledge

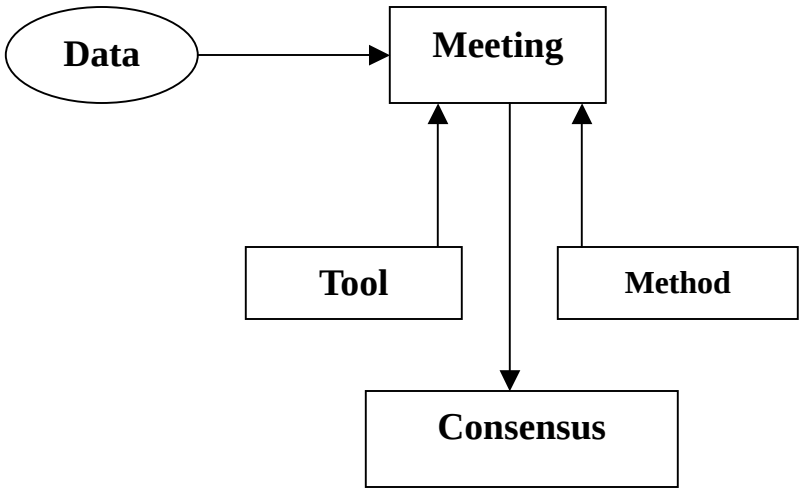
on environment problems in the form of matrix system [Nakamori, Kusube, Morita, 1996] But in that time they also thought to integrate knowledge-information and to develop a mathematical model are not enough to solve the global environmental problem. Even if we use a very good model and a very good support system, the final decision is left to user. In the paper [Nakamori Sawaragi, 1999] authors had mentioned the ***model integration***. They assumed there exist a lot of models in researchers who located in different sites, so wish design a system to integrate models on the network system in Ishikawa and environment business had introduced. Since 1999 Nakamori had moved to school of knowledge science, JAIST, the environment of knowledge science and social science forced him go to furthermore to combine the natural science and social science, so he proposed **the *i*-system,** which can be called as a knowledge creation system [Nakamori, 2000]. The system integrates statistical data and individual person's fragmentary knowledge, and then creates new knowledge nobody had before. The members of the project or relevant people constitute a part of system the *i*-system has five subsystems: Intelligence, imagination, involvement, integration and intervention. The role of intervention subsystem is ***metasynthesis***. So in total I would like to call this system as ***metasynthesis environment system***. As applications of the *i*-system, two ongoing projects related with the environment are now carrying out.

Model Integration

Now usually when we wish model a complex system, we have to use a series of models. How can we integrate all models is the first important problem, which we will deal with solving the complex system problems. Tang had made a detail review on the trends of model integration [Tang, 2001] In her review she introduces three approaches to model integration: ***Top-Down Architecture***; ***Bottom-up***; ***System Approach*** Top-down approach requires that one object is broken into fundamental parts or modules (using functions for each module) and then assembled using functions. For using this approach, a comprehensive model about the concerned problem should be clarified so as to decompose the problem efficiently. Bottom-up or distributed approach reflects distributed and decentralized activities during implementing model integration and management. System approach combines the human behavior and modeling techniques. Recently the Integrated Modeling Environment (IME) is developing for modeling and model integration. Some special platforms of model integrations are designed. Here we give three examples: DOME, SWARM and Decision Net. Using Internet technique MIT had developed DOME (Distributed Object-based Modeling and Evaluation) to provide a platform of model integration. DOME is mainly for product design, but recently is also applied to solving

Environment problem. [Pahng et al.,1999; Steven et al., 2000]. *Consensus building*

The second important problem which attracted our great attention is that how can we ***synthesize the opinions from different experts*** or different information resources. In recent ten years the investigation on consensus building and its practice have attracted a lot of attentions from both theoretical researchers and practitioners. In USA, Europe there emerged much new research institutes, like Consensus Building Institute in USA and consulting companies, like Consensus Technology, Executive Decision Service, EETIMES, Team Resource Center, Community X Inc. SkyMarker etc. They have developed the basic concepts, procedure and principles for the consensus. Also a series of useful computer tools and software have been developed rapidly, such as PathMaker, Mediator, and Choice Navigator. [Gu, 2001]



During the discussion meeting or running survey by questionnaire how can we collect the opinions from different experts and from their opinions how can we create some new knowledge or make final decision. On the basis of recent survey on the large amount of literatures and information from Internet now we suggest so-called DMTMC (Data-Meeting-Tool- Method-Consensus) system (see Figure). As a whole when we convene a meeting we wish use the data (including data base, data warehouse and Data mining technologies, KDD and Knowledge Base), tool (especially accommodated by advanced conferencing tool) and method (the metasynthesis methods are required) to let our meeting more efficient but also we must let the meeting be more effective and consensual.

According to the ***Wuli-Shili-Renli (WSR) system approach*** for the meeting it requires not only care for Wuli (Physical equipments) and Shili (Management Science, Decision

Science and metasynthesis methods), but also use Renli (Human relation, behavior science and leadership theory) to deal with the relationship, motivation, benefit and conflict of these participants at meeting. The facilitation and mediation are very useful for interaction between participants. The good *ba* for discussion and exchange of different point of views fully is very important. According to different purpose we divide meeting into three types:

1) Kexie type (Simple discussion),

2) Kewei type (Detail discussion with deep research),

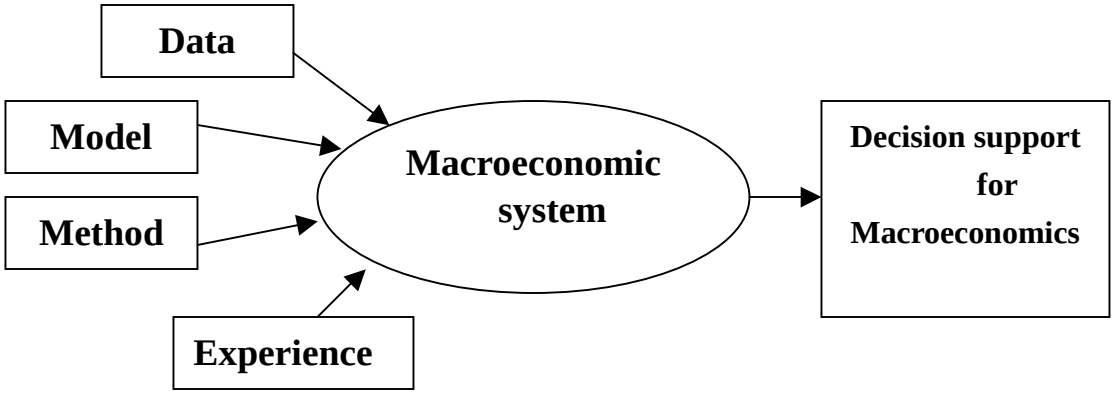
3)Jiwei type (Decision Making)

For different types of meeting different budgets, tools, time and procedure of meeting will be required [Gu, 2000].

LARGE KEY PROJECT BY NSFC

We have mentioned a large key project titled in "Metasynthesis systems with combination between man and machine for decision support of macroeconomics" (1999-2003). This is a project supported by NSFC. This project has been divided into four subprojects:

- P1.Information and *model systems* for macroeconomics and their functions;
- P2.Metasynthetic systems with combination between man and machine and *supporting environment*;
- P3.*Metasynthetic method systems* and *systematology* researches for *decisions support* of macroeconomics;
- P4.Knowledge discovery system (*KDD*) and *cognitive* researches for macroeconomics.



Though this project is under progress, but we found some specific features during running the project. They are:

1) Follow some system methodologies, like metasynthesis system approach, Wuli-Shili-Renli (WSR) system approach and Spiral Propulsion system approach;

2) Provide economic data base, economic information, data mining;
3) Design the meeting, using facilitation, mediation, *Ba* etc. ;
4) Provide different economic models, and model integration;
5) Provide metasynthesis methods, which may synthesize the data, information, models and experience, e.g. NGT, AHP, System reconstruction, and some consensus methods, such as voting, group decision methods;
6) Study on the some theoretical topics related to the economic complex systems.

The project has lasted two years. The virtual prototype of Metasynthetic Engineering Hall can be demonstrated. It based on the Internet Platform, interface between man and computer. One special scenario is designed for simulating the discussion process between three experts and one chairman on the topic of basic judgment on the trends of GDP in China. Some special software for metasynthesizing data, knowledge and models, software for synthesizing the expert's opinions, software for model integration using the agent technology and special platform for synthesizing the group decision, knowledge and information (so-called Electronic Brain) have been designed. Some advanced economic models have been constructed. The Data Base and Data mining technique are preparing for Hall. Three system methodologies, Metasynthesis System approach, Wuli-Shili-Renli system approach and Spiral System methodology have been applied during running the project. Some theoretical problems concerning the complexity happened in the economic system have been investigated. The special issue (including 16 papers) titled in "Metasynthesis and Complex System" has been published in October of 2001 in the Journal of Systems Engineering [Gu, Wang, Tang,2001]. Further work is under progress.

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