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Wu-li Shi-li Ren-li System Approach to a Major Project on the Research of Meta-synthesis System Approach

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Abstract

Since 1999 we have participated in a major project sponsored by National Natural Science Foundation of China (NSFC), which aims to explore the macroeconomic system problems by meta-synthesis systems approach (MSA) proposed by Chinese system scientist Qian Xuesen (Tsien HsueShen). It is found that the oriental *Wu-li Shi-li Ren-li* system approach may be applied to describe the working contents and process all through the project. In this paper we describe the concrete contents of *Wu-li Shi-li* and *Ren-li* in this project. The three kinds of coordination, negotiation coordination, technical coordination and practice coordination are emphasized during the research process. Network analysis is also applied to expose *Ren-li* factors by a variety of scientific collaboration activities and results.

Keywords: *Wu-li Shi-li Ren-li* system approach, Meta-synthesis, Coordination, Social networks

1. Introduction

Meta-synthesis method is proposed to tackle with open complex giant systems by Chinese system scientist Qian, Xuesen (Tsien HsueShen) and his colleagues around early 1990s [1]. The method emphasizes the synthesis of collected information and knowledge of various kinds of experts, and combining quantitative methods with qualitative knowledge. Later it is evolved into Hall of Workshop for Meta-Synthetic Engineering (HWMSE) which emphasizes to make use of breaking advances in information technologies [2, 3]. Then continuous endeavors have been taken to put those ideas into practice. In 1999, Natural Science Foundation of China (NSFC) approved a 4-year major project engaging to implement a pilot HWMSE demonstration for macroeconomic decision making under a budget of 5 million *yuan*, one of the largest investment for one project supported by NSFC in 1990s. Around 60 researchers from 14 nationwide research institutes or universities are involved after several rounds of peer and expert reviews. Those people are separated into 4 groups or subprojects: Group 1. HWMSE platform; Group 2. macroeconomic modeling; Group 3. meta-synthesis method and systematology research; Group 4. knowledge discovery, data-mining and cognitive process analysis of macroeconomic decision making [4]. To facilitate the whole project undertaking, a special group is established for integrative system design and coordination of those 4 groups' work and communications between NSFC and this project as referred as Group 0.

As the members of Group 0 and 3, we find that the oriental *Wu-li Shi-li Ren-li* system approach may be applied to describe the working contents and process all through the project, and some results are analyzed after mid-term assessment of project [5]. In this paper the concrete contents of *Wu-li Shi-li* and *Ren-li* in this project are addressed. Coordinating activities which cover negotiation coordination, technical coordination and practice coordination are taken during the research process. Furthermore, network analysis is applied to the collaboration network formed due to major project for exploring more functions of *Ren-li* factors based on a variety of scientific collaboration activities and results. At first the evolution process of WSR is reviewed briefly.

2. A Brief Review about *Wu-li Shi-li Ren-li* System Approach

Wu-li Shi-li Ren-li approach is an oriental system approach. The Chinese terms, *Wu-li* (Theory of Physics), *Shi-li* (Theory of Doing or Managing) and *Ren-li* (Theory of Humanity) are often used to reflect those laws or rules followed in practical activities as related to different situations. Since the end of 1970s systems engineering (SE) people in China began to discuss those terms. In 1978, a paper titled *Technology for Organization and Management - Systems Engineering* written by Qian, Xu and Wang was published in one Chinese newspaper *Wen Hui Bao* [6]. In that paper, it was addressed that operations research (OR) could also be denoted as *Shi-li* to refer the way of doing and managing regarding that *Wu-li* described the movement of physical world. Moreover, Xu wrote specific paper on *Shi-li*, which was in consistence with the view that OR research includes OR theory, OR mathematics and OR practice [7]. Later, Qian introduced their understandings on SE in a letter to a MIT professor Li Yao Tsu, who agreed with the concepts of *Wu-li* and *Shi-li*, and suggested adding *Ren-li*, which specifically means motivation. However, the saying of *Ren-li* had not got enough attention in the circle of Chinese SE scholars at that time. Gu began to put three terms together in the middle of 1980s and proposed a saying as “knowing *Wu-li*, sensing *Shi-li* and caring *Ren-li*”; while did not think from a methodological level [8]. From the middle of 1980s to the start of 1990s Gu had engaged in several practical projects: Beijing regional development, global climate change, various evaluation projects and water resource management, etc. Some troubles were met when dealing with human relations, decision makers’ behaviors and interdisciplinary knowing in those projects. Gu found that most of existed western hard and soft system methodologies were difficult to solve those kinds of troubles due to special Chinese cultures and social backgrounds.

In 1994 Gu took a 2-month visit to the Centre for Systems Study, University of Hull. He compared those western system methodologies with oriental ones based on his exchanges, observations and his own SE experiences. He had discussed with Zhu (who was a doctoral student in that time) for a long time about Gu’s experiences and troubles during SE practices in China. According to the western experiences in formulating system methodologies they formalized WSR system approach as an oriental system approach whose basic framework including main contents, philosophy, principles and working process were addressed at a research report and later in a paper [9]. Here using the adjective “oriental” they emphasized the differences between eastern and western cultures. A ready successful example of this approach was a undertaking project for local water resource management in Qinhuangdao area, north of China finished in the end of 1994 [10, 11]. Since then Gu and his colleagues have applied WSR approach to a series of practical projects in different fields [12~20]. There are also discussions about WSR and practices in China by other researchers [21~27]. For a detailed WSR introduction, see references [28]. During the working process of the above-mentioned NSFC major project, we find the close relationship between MSA and WSR [29]. We also find the possibility of applying WSR approach to organizing project and understanding the problems aroused during the project implementation. Next we address the WSR contents in the NSFC major project.

3. *Wu-li Shi-li Ren-li* Contents in the NSFC Major Project

In rethinking of mid-term assessment of our major NSFC project in 2002 and adjusting the road map of the project, we applied WSR approach by reviewing our recent progress and considering what kinds of knowledge needed to explain the mechanisms of what is concerned, the final observable technical achievemnts of the project based on 4 groups’ whole work, and coordinating activities and results based on Group 0 and other groups’ work. Figure 1 shows the WSR contents by a 3-dimension figure.

Actually, the axis of *Shi-li* only lists the basic computerized work implemented by all 4 groups. For macroeconomic modeling, which is one of the principal tasks in this project, there developed a variety of models from different perspectives [30]. *Ren-li* aspects emphasize more on human intervention. Linstone and Zhu had compared TOP approach and *Wu-li Shi-li Ren-li* system approach where T, O and P denote technical, organizational and personal, respectively [31]. We argue that such a correspondence does not reflect the essence of *Ren-li* aspect which actually covers more than TOP perspectives. Here we consider those impacts from integration and synthesis endeavors from man-machine, human and human, and hybrid perspectives. Human-machine interaction denotes inter-technical intervention, which covers integrative designing fulfilled by Group 0, distributed discussing, distributed modeling, and MSA working process (combination between intuitive thinking and logic thinking, and qualitative hypothesizing and quantitative validating). Coordination between human and human refers to inter-personal and inter-organizational considerations which includes emotional facet on behavioral patterns, knowledge combination (interdisciplinary research), human relation (members inside the group, members within the groups, members outside the groups, researchers and users) and benefit negotiating. A higher level intervention is inter-situational, which refers to collaboration between hybrids which creates a *Ba* for knowledge creation and wisdom emergence with help of computerized work. *Ba* is noticed by Japanese researchers and defined as a platform where knowledge is created, shared and exploited; the most important aspect of *Ba* is "interaction" [32]. The knowledge-creating process is also the process of creating *Ba*, which means to create a boundary of new interaction [33].

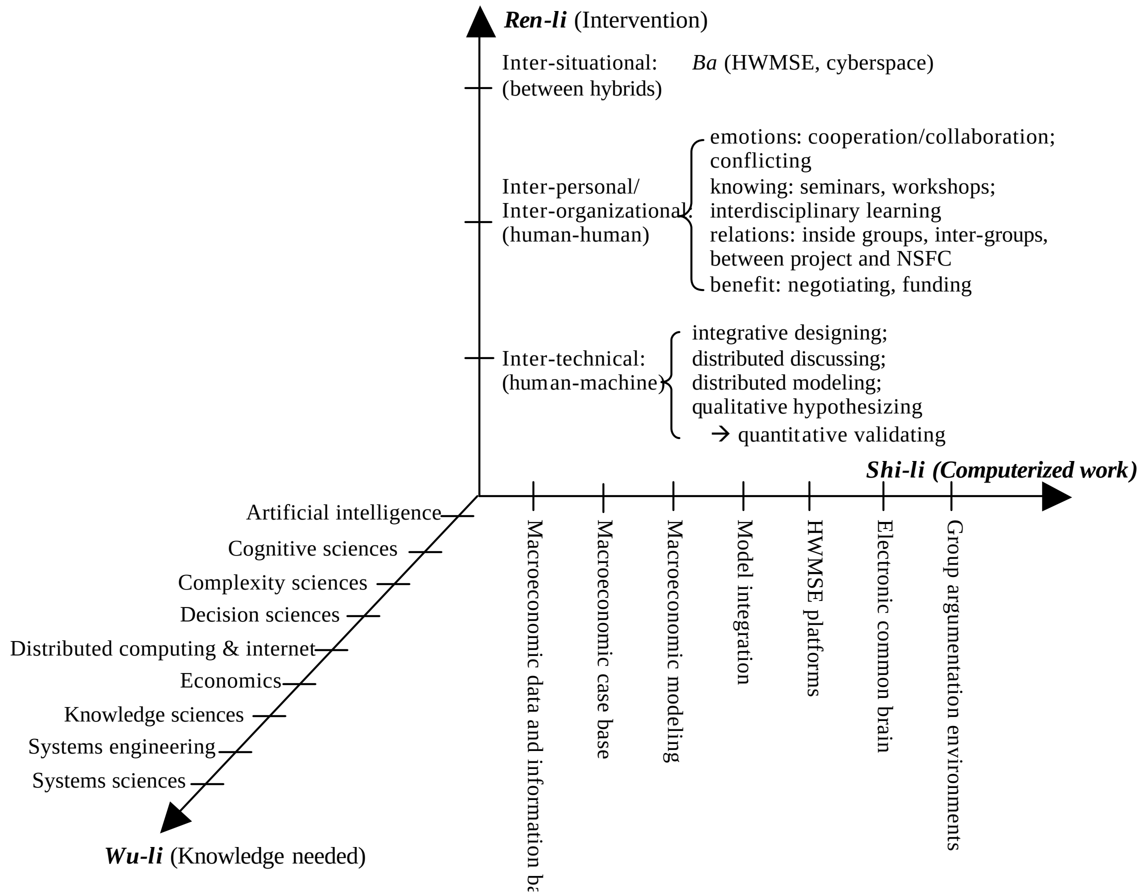

Fig. 1. WSR endeavors in the NSFC major project for demonstration of HWMSE.

4. WSR Working Contents in View of Coordination

Courtney proposed a revised paradigm on decision support system (DSS) in 2001 [34]. In consideration of that paradigm and the evolving of group support system (GSS), one of the two main streams in DSS field, the trend of DSS is analyzed while HWMSE, which is beyond traditional DSS in providing meta-synthetic support for decision making, is regarded as one of an inevitable directions of future advanced DSS [35]. In our project, the main goal is to build an embryonic demonstration of HWMSE to serve a test bed of meta-synthetic support for ill-structured problem solving. Three kinds of coordination, coordination within a concrete DSS (technical coordination – TC), coordination during DSS development (negotiation coordination – NC) and coordination between DSS, users and environments (practice coordination – PC) relevant to DSS, had been studied for effective systemic practice of DSS in reality [36]. Here the relations between three kinds of coordination and WSR in our project. Table 1 briefly lists principal activities from interactions of WSR and coordination views based on work by Group 3 and collaborations with other groups, especially those preparing endeavors for simple demonstrations on how to evaluate China GDP growth with the impact of SARS by MSA for the special session on MSA held in IIASA just after JISR-IIASA workshop on CSM on September 11, 2003. (For introductions about this special session, please browse the relevant web page via IIASA web site.) The demonstration is a result of a meta-synthetic working process.

Table 1. The interrelation between WSR and TC-NC-PC in the major NSFC project

	Wu-li	*Shi-li*	*Ren-li*
TC	Research contents of individual group work (HWMSE platform, macroeconomic modeling, data-mining, model integration, idea generation and knowledge synthesis, systemalogy, etc.)	Integrative design, system methodologies, specific web page and BBS for communications/cooperation, system integration	Distributed discussion rooms in a HWMSE; distributed modeling
NC	Set up the objectives, proposals for NSFC; project's name change (prototype system → simple demonstration), MSA trends	Project organization; interdisciplinary learning (seminars, workshops, visits); international exchanges including series workshops on MCS and KSS; IFIP VEAM'2002; series JISR-IIASA CSM workshops)	Individual → cooperation → collaboration/ or negotiation/conflicts
PC	Validation of macroeconomic modeling; aggregation of computerized results of separate working groups; uncertain factors (e.g. SARS)	Alternatives of system integration: seamless integration → distributed integration → adhesion of group's computerized results; specific tests, MSA special session in IIASA	MSA developments; growing community; interdisciplinary knowing

(where CSM: complex system modeling; IIASA: International Institute for Applied Systems Analysis; JISR: Japan Institute of Systems Research; KSS: Knowledge and Systems Sciences; MCS: Meta-synthesis and Complex Systems; IFIP: International Federation for Information Processing; VEAM: Virtual Environment on Advanced Modeling)

In order to present this demo, principal investigators of all groups communicate more frequently via biweekly seminars on what to report for IIASA and how to integrate those computerized work (including macroeconomic models, data mining models, system reconstructability model, group argumentation environment, macroeconomic database, etc). A commercial software PathMaker is used to serve as the basic platform to integrate all ready resources from Beijing Institute of Information and Control (Group 2), Tsinghua University (Group 4) and Institute of Systems Science, Chinese Academy of Sciences (Group 3). A work flow is designed for demonstration as synchronous meeting I → asynchronous analysis → synchronous meeting II. In detail, we have such a sequence of activities, M0 (preparing meeting); M1-1 (free discussion); M1-2 (topic discussion); brief summary; M1-3 (further discussion); analysis (qualitative modeling); M2 (detailed discussion) and consensus building to exhibit the basic ideas of meta-synthesis from qualitative hypothesizing to quantitative validating [37, 38].

By the experiment design and demonstration in IIASA, some experiences and knowing are achieved as summarized in Table 1, such as the changes of viewpoints about the integration of all computerized work for demonstrations. Initially, all participants wish to achieve a strict seamless integration of all computerized work by each group. Such an idea was quickly abandoned and distributed integration or loose seamless integration seems as a feasible solution which had already been practiced for mid-term assessment of the project. At that time, the demonstration was on the topic about the forecast of GDP growth and computerized work from Group 1, 2 & 4 had been integrated. For IIASA test, most of participants prefer to try again for demonstration on assessment of SARS impact to GDP growth to China. It was necessary to update economic data base, adjustment of parameters for macroeconomic models. However, not all groups actually joined together due to both different standpoints of each group and technology difficulties or problems existed in those computerized work. Here we regard such a situation as *adhesion* instead of *integration* of the computerized work relevant to HWMSE of four groups'. *Ren-li* factors play more important than technology factors in the integration process.

As a matter of course, strict integration or seamless integration is not a necessity for such a basic research project sponsored by NSFC. The fruitful results of the major project can also be reflected from the publications, awards and honors, graduate students training, academic exchange activities and growing community of meta-synthesis research. Next section we analyze the results of the project from social network perspective.

5. Analysis of the Specific Scientific Collaboration Network

As the project was formally ended after 4-year exploration, each group submitted a comprehensive summary for NSFC. A lot of information could be quickly acquired based on those summarized reports, such like published papers, organizing or attending academic meetings, trained graduate students, etc. Even those activities such as discussions within groups and between groups were also recorded. The relationships between groups, principal investigators or even students are changing during the project undertaking process, which finally affected the integration of the computerized results of the whole project. In above sections, *Ren-li* factors are often referred. Here, we try to apply social network analysis to expose further information or explain *Ren-li* factors more formally. The project itself is actually a scientific collaboration network formed for specific goals. Here four kinds of relations may be considered.

1) Co-authorships. Among nearly 400 formal publications, most papers were written by at least two authors. If using graph to represent co-authorship relation, then we get a co-authorship network whose vertex is the author and the link indicates the two connected vertexes co-author one paper. Moreover, the weight of the link indicates the density of co-authorship between vertexes. Obviously, co-authorship is an undirected network.
2) Citation. Each publication has references, from which we could see where some of original ideas come from. For example, Reference [1] is the most frequently cited paper which testifies Ref. [1] is the origin of idea of this project.

   If using graph to represent citation relation, then we get a citation network whose vertex is the paper and the arrowed link indicates the paper in the head of arrow is cited by the paper in the tail of arrow. Obviously, co-authorship is a directed network.
3) Acknowledgement. Authors may thanks some people for their help in the related work described in the paper. Similar to citation network, acknowledge network is a directed network. Only a small portion of papers gave acknowledgement in the major project.
4) Exchange activities. During the project, a lot of academic meetings, workshops and even discussions have been held for communications between groups and participants. If two people have a discussion or attend one workshop, we consider there is a link between two people. Similar as co-authorship network, activity network is also an undirected network.

Those four networks may be joined into an integrated network which synthesizes all those information. In the integrated network, the vertexes are the authors; the links are the collaboration or intercourse between the scientists, such as co-authorship, citation relation, acknowledgement, discussions and academic workshops. Next we apply some social network concepts to analyze our collaboration network. Due to the limitations of our data sets, here we only consider the co-authorship network.

Actually, complex network research is a hot area since late 1990s. A lot of in-depth research on scientific collaborations have been undertaken these years and indicated that scientific collaboration networks are small world network and scale-free network [39-41]. Those studies focused on collaborations within one organization (such as national laboratory) or one discipline. While our co-authorship network is formed via a specific project and is a scale-free network based on all publications.

What we are interested here is not about whether our co-authorship network is either a scale-free network or a small world network, but to explore how a major NSFC project is organized and undertaken by the co-authorship network, how evolving structures reflect changes in active collaborations and how activities improve participants' understanding of others' work and brings changes in human relationships or personal emotions which affect collaborations or even the implementation of system integration.

Here we use a software package UCINET for analysis. Figure 2 shows 9 components of the co-authorship network, where components of a graph denote parts that are connected within, but disconnected between subgraphs. Each component may reflect one dedicated research direction in the project, which is in accord to the reality. The largest component includes people from Group 1, 2, & 3 in the project, while Group 4 is the second largest component. Since Group 4's work is knowledge discovery and data mining, which is relatively focused field, while the other 3 groups focus on meta-synthesis, which is of wider scope. Furthermore, we may also detect cutpoints from Figure 2. Cutpoints indicate the key nodes while removing out will change the structure into unconnected system. Those cutpoints in Figure 2 actually are principal investigators of the whole project, each group or subgroup and members of Group 0. Other analysis may also be undertaken towards about such a network by basic social network methods [42].

As a matter of fact, such kind of network analysis exposes how people connect with each other during the project. It is also expected to explore how such a project disseminates scientific ideas to new participants who share common grounds and enable to form communities and then led to further collaboration. Moreover, how such a project incubates new scientific ideas and enable those ideas developed into validated new theory. Those kinds of work require more information beyond a co-authorship or even the integrated collaboration network. Even our exploration from social network perspective is in the initial stage while some basic results have been gained. However, a lot of mining work is worth to be done to uncover some hidden facts to provide versatile help for management of large-scale scientific project.

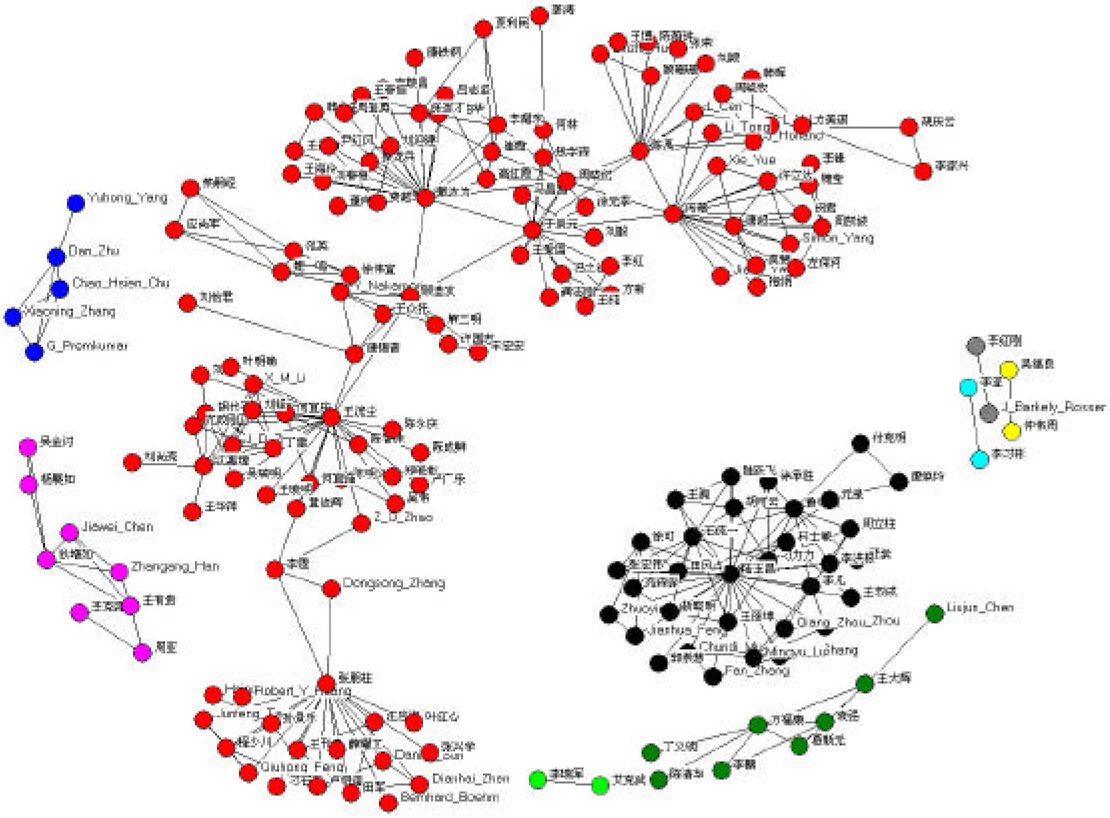

Fig. 2. Components of NSFC major project co-authorship network.

6. Concluding Remarks

In this paper, after a brief review about the oriental *Wu-li Shi-li Ren-li* system approach, we apply it to a NSFC major project. The WSR contents, the purposeful activities for the project from the interactions between WSR and coordination views are addressed. Through a special session on meta-synthesis system approach held by IIASA, some experiences and knowledge are achieved by the whole working process which is mainly consisted of experiment design, seminars, rehearsals and final demonstrations. Some new knowing about integrative designing and integration is acquired and listed in Table 1, especially from a seamless integration to loosely distributed integration and to the adhesion of individual work.

Social network methods are applied to analyze the communications and collaborations among research units and participants. Such kind of work could be used by project sponsor to assess the effectiveness of project organizing or even analyze *Ren-li* factors. Only very simple analysis is given while further research is expected to be done to provide quantitative and objective assessment about large NSFC project for new knowledge creation and wisdom emergence.

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