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Exploring Formation Mechanism of Medical Collaborative Practices in Multi-level Market from an Infra-marginal Perspective

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Abstract: ***This study aims to formally analyze the emergence and evolution of medical collaborative practices (MCPs) in multi-level market. From an infra-marginal perspective, it constructs a role generation model of collaborators, and extracts eight role models and six structures with corner equilibrium. Finally, three structures (structure A with no market, structure CN with single-level market and structure CC with two-level market) have global equilibrium. With the increase of learning cost of medical services and medical transaction services, two evolution paths of MCPs " A - >CN -> CC " and "CN -> CC ->A" are more likely to appear.***

Keywords: Medical collaborative practice, Neoclassical economics, Infra-marginal analysis, Medical transaction service, Multi-level market.

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1. Introduction

There has been a long-term coexistence of the imbalanced allocation and low utilization efficiency of medical resources in China. Most current healthcare reforms in China have tried to encourage a variety of medical collaboration practices (MCPs) as privileged means to improve the quality and efficiency of care delivery (Li, 2019; Zeng et al., 2019). One is to develop a large-scale comprehensive hospital, emphasizing the inter-professional collaborative relationships within intra-organization, such as the First Affiliated Hospital of Zhengzhou University, which has 7000 beds. At the same time, the state and local governments in China have issued a series of policies to develop inter- professional medical collaboration among different medical institutions, such as the new rural cooperative medical scheme (NCMS) (for protecting rural households from catastrophic medical expenditure) (Li, 2019; Zeng et al., 2019), and the various medical consortia (for improving the system of tiered medical service to balance inadequate medical resources) (Yang et al., 2020).

Furthermore, with the increasing popularity of the Internet and mobile devices, a lot of internet companies (such as Hao doctors, Chunyu Doctor and Weiyi) are pouring into medical service industry. Up to 2018, the market size of China's Internet medical service has reached 30 billion yuan, and the number of users is 190 million, covering the entire process of patient care. Nearly 20% of third-level hospitals have participated in Internet medical cooperation (Kantar Consulting, 2019). In addition to traditional medical institutions, this kind of medical collaboration, which plays the role of a third-party healthcare trader, involves a lot of Internet medical service transaction platforms. There has been a coexistence of inter-professional, inter-organizational and inter-industrial collaborative relationships in the medical collaborative practices in multi-level market expand access to healthcare for residents.

However, there are some very contradictory phenomena around various MCPs. On the one hand, there is a consensus that medical cooperation is needed whether for reducing costs, expanding access to health care (Braun and Cusick, 2016) and improving service quality and efficiency (Li, 2019; Zeng et al., 2019). When faced with technique, managerial or policy changes, all kinds of MCPs oriented by policy or enterprise investment or spontaneous behavior of organization will be promoted (Kantar Consulting, 2019; Touati et al.,2018). On the other hand, health care institution is regarded as professional bureaucracies, and professionals are very concerned about their professional jurisdiction. The occurrence of medical cooperation may be hindered, and MCPs at different levels of health care delivery may become very difficult (Dutta and Sun,2017; Lamothe and Dufour, 2007; Oborn and Dawson, 2010; Touati et al.,2018; 2019). Many MCPs have not achieved the desired results. For example, Zeng et al. (2019) show that there is no significant difference between the distribution of inpatients in county hospitals and in township hospitals before and after the implementation of NCMS in China. It becomes an interesting and important topic why and how various medical collaborative practices emerge and develop.

The existing empirical studies have found that MCPs may be affected by factors at individual, organizational and system levels, such as disease characteristics, collaborators' knowledge and experience (Touati et al., 2018; 2019), mutual trust (Bussu & Marshall, 2020; McComb et al., 2017) , participation motivation (Touati, et al.,2018), public infrastructure (Zeng, et al., 2019), IT infrastructure (Ding etl., 2019; Nicolini, 2007; Nilsen,2011), medical policies, investment of public funds (Zeng et al., 2019), remuneration methods (Dutta and Sun, 2017) etc. However, there are various and contradictory conclusions about the influence of these factors on MCPs (Touati et al.,2018). This situation may be caused by the interaction of many factors. Therefore, it is necessary to analyze the nature of these factors on MCPs from the perspective of system and process.

Some scholars have explored MCPs from the perspective of process. Touati et al. (2018) analyze that the emergence and development and institutionalization of medical collaboration across organizational boundaries, and collective learning will contribute to the institutionalization of specific MCPs. Touati et al. (2019) suggest that professional role identity may be at the heart of medical collaboration across organisational boundaries, and a particular role identity and a specific collaborative practice meaningfully entangled through a complex net of features of individual (physician and patient), organization and system. Various forms of MCPs have been explored. Touati et al. (2019) elicit three specific modalities of collaboration: quasi-inexistent, restrained, and extended. Dutta and Sun (2017) explores four innovative care models aimed to expand access to dental care: expanded coordinated care, colocated care, integrated care and virtual dental home. Huang and Li (2010) divide the medical alliance into three types (compact, semi-compact and loose) according to the closeness of the contact. These studies always mainly focus on the collaboration of medical services in single market, not including medical transaction service based on big data and Internet without multi-level market. There is little research on the medical collaborative practices in the multi-level market. In addition, Touati et al. (2018, 2019) use the theory of social structure, while most studies mainly intuitively analyze to understand the origin and development of medical cooperation (Dutta and Sun, 2017; Huang and Li, 2010).

Based on the existing research, the goal of this paper is to explore a set of methods to formally display and analyze the nature and laws of the emergence and evolution of all kinds of MCPs in multi-level market. Accordingly, the study was guided by the following research questions:

(1) How to integrate the influencing factors and process views to build a decision model for collaborators?

(2) How to formalize the entanglement and interaction between the professional role identity of collaborators and various MCPs?

(3) How to evaluate the stability of different forms of MCPs and analyze their possible evolutionary paths?

The research will provide theoretical basis for the government to select, formulate and implement the relevant policies of a specific MCP, and help IT companies better develop internet medical service transaction platforms.

2. Theory and Method

2.1 The New Classical Infra-marginal Analysis

Grounded on the new classical infra-marginal analysis (Yang, 1990; Yang and Ng, 1993), this paper puts influence factor, role identity and collaborative structure into a framework, and explores a set of methods to formally analyze and display the nature and laws of the emergence and evolution of various MCPs.

Division of labor and cooperation and infra-marginal analysis. Medical collaboration refers to a process that occurs when a group of autonomous stakeholders with various medical resources to communicate and coordinate each other to share decision making, goal setting, and implementation of a plan of care (McComb et al., 2017; Touati et al., 2019; Yang et al., 2020). The members of medical collaborative community have both cooperation and division of labor. Due to the characteristics of autonomy and limited available resources, there is division of labor everywhere, such as the division of labor between physicians and nurses (McComb et al., 2017), the division of labor between family physicians and specialists (Touati et al., 2019), etc. At the same time, the collaborative community is different from the simple addition of the original individuals, and relies on the value rationality among members to have a unique social structure oriented to the ultimate goal of common commitment, which can support members to collaborative work (Adler et al., 2008).

Adam Smith (1776) argued that humankind's inclination for exchange will promote the development of the division of labor. Emile Durkheim (1933) believes that the division of labor is the result of survival, and different occupations can coexist without destroying each other. The increase of division of labor will increase the number of transactions. Because each transaction will produce costs, that is, transaction costs, higher-level division of labor must produce higher-level transaction costs. The trade-off between specialized economy and transaction cost means that the level of division of labor is determined by transaction efficiency. If the transaction efficiency is low, then individuals will choose to be self-sufficient (this is a kind of infra-marginal decision), because the transaction cost is greater than the specialization economy generated by the division of labor. If transaction efficiency is fully improved, then individuals choose division of labor (which is also an infra-marginal decision), because transaction costs are offset by specialized economy (Liu & Yang, 2000). Infra-marginal analysis is the combination of marginal analysis and total cost-benefit analysis. Under the background of social division of labor, infra-marginal decision-making may be more important than marginal decision-making (Liu & Yang, 2000).

Liu and Yang (2000) used the method of inframarginal analysis to explain why the organization size will become smaller with the passage of time. The smaller the size of the organization, the more cooperation with the outside. It is an infra-marginal decision. Therefore, the decision of whether to choose medical collaborative practice or not is based on the trade-off between medical service specialization economy and transaction cost. From the analysis of labor division and transaction cost, we can discuss the development of division of labor within a medical organization or among medical organizations or between industries, that is, different modes of medical collaborative practices with multi-level markets.

Role identity and medical collaborative structure. There are both cooperation and division of labor in medical collaborative community, so each collaborator as a decision maker is both a producer and a consumer. Giddens' social structure theory (1984) holds that social agents use three complementary dimensions of social structure (signification rules, legalization rules and dominant resources) to produce and reproduce practice. Neoclassical infra-marginal analysis emphasizes that producers and consumers are included in a unified decision-making model (Liu et al., 2017), by introducing the needs of different cooperators, various factors affecting cooperation and three dimensions of social structure. Compared with the traditional decision-making model of neoclassical economics based on the perspective of a single producer or consumer, the decision-making model of medical collaborators based on neoclassical infra-marginal analysis can more reasonably describe the medical cooperative relationship, which is more in line with the objective reality.

Grounded on Giddens' social structure theory, Touati et al. (2019) shows that there is a gradient in modes of collaboration between family physicians and specialists, which appears recursively entanglement with different medical identity roles. Under Giddens' social structure theory, structure exists as an attribute of social practice and should not be an exogenous concept. The neoclassical economics proposed by Yang (2003) studied organization topological properties by introducing transaction costs. Organizational structure is endogenous rather than exogenous, and the development and evolution of organizational structure is nonlinear, which is the result of trade-off between specialized economy and transaction cost. Partners make decisions for their own self-interest under a specific structure, and their decisions are affected by other decision makers in the structure. Finally, the specific structure pattern will be presented from the macroscopic morphology by interaction and balance of the interest of partners. Yang (2003) proposed the method of infra-marginal analysis combining the corner equilibrium analysis and global equilibrium analysis to explore the production and re-production of organizational structure and partners' role, and display the process of endogenous and nonlinear of organizational structure and partners' role. The process of MCP is the process of social division of labor, the realization of specialized economy, the identification of specific professional roles, and the emergence of specific medical collaboration, and these processes are presented in a way of entanglement. Inframarginal analysis is a powerful tool to explore and display these processes.

2.2 Scope of Division of Labor

Due to the increasing demand for comprehensive diseases and the classification of medical specialties tends to be more detailed, multidisciplinary comprehensive treatment is the general trend. All these phenomena show that professional collaboration in the division of labor in various medical services (MSs) is necessary (McComb et al., 2017; Touati et al., 2018;2019). Dutta and Sun (2017) have observed that the inter-professional relationship between medical providers and dental hygienists in pediatric health care is a strategic way to expand dental care opportunities into a symbiotic manner, and use this as a basis for exploring four innovative nursing models.

In China, with the rapid development of big data technologies and the increasing popularity of the Internet and mobile devices, a lot of Internet medical service transaction platforms have been emerged (Kantar Consulting, 2019), which are called medical transaction service providers. They provide information query and connects medical services through Internet and big data technology, such as Baiyulan remote consultation platform, district-level imaging and inspection center, and various Internet hospitals, such as Chunyu Doctor, Hao Doctor, Pingan good Doctor, Dingxiang and Weiyi etc. This kind of medical transaction service platform can more easily obtain or even integrate all kinds of medical resources, and facilitate patients' medical opportunities (Ding et al., 2019; León et al., 2016). There is another kind of platform, such as Changankang wechat platform for rectal cancer patients, which helps patients integrate all kinds of medical resources and design personalized treatment according to different course of disease. Therefore, the popularization of big data and Internet technology may catalyze the birth of medical trading services, resulting in a higher level of division of labor and forming a trading market for medical trading services.

So, the paper involves two types of labor division: the division of labor with medical services, and the division of labor with medical services and medical transaction services, which may construct multi-level market.

2.3 Study Process

We argue that the reason for the origin of MCPs is the division of labor. Based on Yang’s (1990,1993) neoclassical infra-marginal analysis, the study processes are:

(1) To construct a unified decision model including producers and consumers. The form of this model can reflect the value dependence of collaborators under the constraints of specific organization, technology and other factors, and can also reflect how decision makers use resources and meet the needs of comprehensive medical services under specific constraints from individual, organization and system levels. Based on the model, we can formally show the process of social agent's using signification rules, legalization rules and dominant resources to produce and reproduce practice in the theory of social structure. So, the model is also called role generation model.

(2) To formalize the entanglement between role identity and specific MCP. Through calculating the corner solution of the decision model, the labor division and specialization degree of the specific collaborator are be determined, role models of decision-makers (configurations) are extracted. Then, by combining all kinds of decision-makers' role models to form various structures with meeting the market clearing conditions (also known as MCPs) and calculating the corner equilibrium of these structures, and role identifies of the collaborators are confirmed by other collaborators in the specific MCP.

(3) To formally analyze the stability conditions and possible evolution path of various MCPs. This paper compares the total cost benefit of all kinds of structures under different environmental conditions, to analyze the general equilibrium and determine the stability conditions. At the same time, the possible evolutionary paths are determined by sensitivity analysis of the stability conditions of these structures.

3. Results

3.1 Role Generation Model: Specification of the Unified Decision Model

The MCP is the evolution from independent provision of services to joint provision of medical services through the division of labor.

Under the ubiquitous market logic, a professional with autonomy (Adler and Kown, 2013; Goodrick and Reay, 2010) must first take time and effort to obtain expertise and experience, which is domination resources in MCP, and use these abilities to serve for patients. The processes of obtaining and using expertise are the process of value supply and one of value realization, which are constrained by the environmental conditions (including available time and funds, etc.) that the cooperators are in, to make the value dependence rationality. This constrained process is also the process of value transmission, which makes the decision makers to be the integration of consumers and producers. So, MCPs are the process of value supply, value realization and value transmission. These three processes correspond to the three complementary dimensions of structures in social structure theory (signification rules, legalization rules and dominant resources), respectively. In the neoclassical economics proposed by Yang (2003), three kinds of functions (production function, utility function and constraint function) are drawn upon to construct a unified decision model which reflects these three processes of MCPs.

Based on the unified decision model, each collaborator who is both a consumer and a producer, implements the three processes to carry out MCP, determines the division of labor and the degree of specialization, and shapes the role boundaries. So, the unified decision model is also called role generation model.

Based on the theory of neoclassical economics (Yang, 2003), the role of collaborators and the mode of collaboration are endogenous. So, the paper first considers an economy with M ex ante identical consumer-producers, two medical services X and Y, and a transaction service T.

From the perspective of value supply as producers. Collaborators should decide what kind of service expertise they can acquire with available time and cost, which involves their division of labor and degree of specialization in different services. The supply ability of decision-maker as a producer involves production functions and an endowment constraint.

$$x^p = x + x^s = Max\{r_X - \lambda, 0\} \tag{1}$$

$$y^p = y + y^s = Max\{r_Y - \lambda, 0\} \tag{2}$$

$$t^p = t + t^s = Max\{r_T - \rho, 0\} \tag{3}$$

$$r_X + r_Y + r_T = 1 \tag{4}$$

Where x^p, y^p and t^p represent the total supply of medical services X and Y and medical transaction services T separately; x, y and t represent self-used services separately; x^s, y^s and t^s are these services for the partners separately; r_i (i=X, Y or T) is a decision-maker's labor share (i.e., level of specialization) in producing server i; the parameters λ and ρ respectively represent fixed learning cost of medical service and medical transaction service.

Giddens' social structuration theory (1984) argues that social actors as knowledgeable agents will possess and apply knowledge to product and re-product that we encounter every day. Kinchen et al. (2004) found that prior experience of specialist will influence on the choice of general practitioners (GPs) under collaboration practices between GPs and medical specialists. However, the acquisition of medical service expertise needs long-term professional training, as well as various on-the-job internships and training (Dutta and Sun,2017), which are called as fixed learning cost of medical service. The fixed learning cost of medical service will affect whether a decision-maker is willing to invest in labor to acquire expertise.

The establishment and operation of medical transaction service platform needs the investment of technology, labor and capital. These investments constitute a fixed learning cost for medical transaction services, which has been changed dramatically with the development of the Internet and big data technologies (Ding, et al., 2019). The fixed learning cost of medical transaction services will affect decision-maker division of labor and the level of specialization within medical transaction service.

From the perspective of value realization as consumers. Decision makers integrate all kinds of services to form collaborative medical care to meet patients' complex healthcare needs. A Cobb Douglas utility function is used to represent the characteristics of diversified and integrated medical services. Hence, the utility function of each decision-maker as consumer utility function can be specified as:

$$U = (x + \varepsilon \cdot x^d)(y + \varepsilon \cdot y^d) = [x + (t + \delta \cdot t^d)x^d][y + (t + \delta \cdot t^d)y^d] \tag{5}$$

All kinds of medical services (MSs) constituting comprehensive medical services, can be provided by themselves and obtained from partners. x^d and y^d represent the final demand for the partners' medical services separately. ε

represent the transaction efficiency of medical services X and Y, which also indicates the ability of collaborators to obtain and integrate complementary MSs from outside. This ability can be obtained by self-providing or externally requesting medical transaction services (MTS). So, the MSs' transaction efficiency is defined as $\varepsilon = t + \delta \cdot t^d$. Where t represents self-used service of medical transaction, and t^d represents the demand for the partners' MTS, δ and $1\text{-}\delta$ are the transaction efficiency and transaction cost of MTS T, respectively.

Touati, et al. (2019) emphasize that transaction cost can't be ignored in all kinds of collaboration, involving various factors of individual, organization and clinical level. Collaborative practice requires collaborators to share rules, beliefs and codes of conduct (Touati, et al., 2018), on which there are often differences in collaborators' cognitions. These differences will incur transaction costs, affect the results of collaborative practice. McComb et al. (2017) showed that physicians and nurses in general medical units (GMUs) have different perceptions of role responsibility and mutual trust, which cause obstacles to the cooperation in GMU. Communication problems among collaborators often persist and seriously affect the implementation of collaboration. Without video conferencing, some diagnostic pathways (visual, clinical examination) would be lost in the interaction between cardiologists and family doctors (Nicolini, 2007). The traditional written referral usually leads to incomplete information, thus affecting the quality and comprehensiveness of communication (Nilsen, 2011). There are also some factors in system level that lead to low transaction efficiency and high transaction cost. For example, poor public infrastructure may affect the operation of NCMS in China (Zeng et al., 2019).

From the perspective of value transmission. In collaborative practice, each decision-maker should not only provide services for others, but also obtains services from outside. Dutta and Sun (2017) shows that the remuneration methods will affect the choice of collaborative care models between medical providers and dental hygienists in pediatric health care. Zeng et al. (2019) show that different payment methods will affect residents' medical behavior (where to choose to be hospitalized), thus affecting the optimization of medical service resources at different levels in the New Rural Cooperative Medical Scheme in China.

Assume that the market prices of medical services X, Y and medical transaction service T are p^X, p^Y and p^T, respectively, then the budget constraint conditions of each decision-maker can be expressed as:

$$p_X \cdot x^s + p_Y \cdot y^s + p_T \cdot t^s = p_X \cdot x^d + p_Y \cdot y^d + p_T \cdot t^d \quad (6)$$

3.2 Role Boundaries Analysis Grounded on Corner Solution

According to Yang (1990), each consumer-producer's optimum decision is always a corner solution in the decision model. For this model, involving combinations of zero and non-zero values of 9 decision variables (x, x^s, x^d, y, y^s, y^d, t, t^s and t^d), there are 2^9=512 corner solutions. So, each decision maker is faced with choosing an optimal solution among many corner solutions (Liu & Yang, 2000). We follow the approach of Borland and Yang (1995) to apply the Kuhn–Tucker theorem (*according to the necessary condition for an optimum decision: an individual does not produce and purchase a good at the same time and sells at most one good*), many combinations of zero and nonzero variables are excluded from the candidates list for a consumer-producer's optimal decision.

A combination of zero and non-zero variables which satisfied Kuhn–Tucker conditions is called a configuration. For each configuration, corner solutions with a given set of relative transaction prices can be solved by consumer-producers (Liu & Yang, 2000). Each configuration actually embodies the level of division of labor, including the levels of specialization and the number of professional activities, and also reflects the role boundaries of decision-maker in MCPs. So, the configuration is also known as role model.

In the current decision model, there are eight configurations that can be divided into five types. A profile of zero and nonzero variables in the consumer-producer's decision problem and the role boundaries are summarized in Table 1. The configurations are denoted by (ij/r), where i, j and r can be medical service X and Y, or transaction service T. Each consumer-producer choosing (ij/r) self-provides service i and j, provides service i for the partners and requests service r from the partners.

Role Type 1: Autarkic configuration as medical service provider with multiple roles.

In autarkic configuration (also known as configuration 1 (XY)), all decision-makers are mainly medical service providers. Each consumer producer acts as a medical expert in multiple medical services.

Role Type 2: Partial specialization configuration as medical service provider with multiple roles.

In this type, each consumer-producer plays multiple roles, but the main role is the medical expert in a particular medical service (MS), followed by the coordinator who self-provides medical transaction service (MTS), not providing MTS for the partners. The role type involves configuration 2 (XT/Y) and configuration 3 (YT/X).

Role Type 3: Partial specialization configuration as medical transaction service provider with multiple roles.

In this type, each consumer-producer plays multiple roles, but the main role is the coordination expert in MTS, followed by the medical professional who self-provides MS, not providing MTS for the partners. The role type involves configuration 4 (TX/Y) and configuration 5 (TY/X).

Role Type 4: Complete specialization configurations as medical service provider with single role.

Different from partial specialization configuration of medical service provider, the type of each consumer-producer plays a medical expert with single role and provides specialized medical services for the partners. The role type includes configuration 6 (X/YT) and Configuration 7 (Y/XT).

Role Type 5: Complete specialization configuration as medical transaction service provider with single role.

Different from partial specialization configuration of medical transaction service provider, each consumer-producer choosing Configuration 8 (T/XY) is a coordination expert with single role, providing specialized MTS for the partners.

Table 1: Configuration and Role boundaries

Configuration	a profile of zero and nonzero decision variables	Role type	Role boundaries
Configuration 1 (XY)	$x, y, r_X, r_Y > 0$, $x^s = y^s = t^s = x^d = y^d = t^d = r_T = 0$	Role type 1	medical expert in multiple MSs
Configuration 2 (XT/Y))	$x, x^s, y^d, t, r_X, r_T > 0$, $x^d = t^d = t^s = y = y^s = r_Y = 0$	Role type 2	multiple roles Primary role: medical expert in a particular MS Auxiliary role: coordinator who self-provides MTS
Configuration 3 (YT/X)	$x^d, y, y^s, t, r_Y, r_T > 0$, $y^d = t^d = x^s = t^s = x = r_X = 0$		
Configuration 4 (TX/Y)	$x, y^d, t, t^s, r_X, r_T > 0$, $x^s = x^d = y = y^s = t^d = r_Y = 0$	Role type 3	multiple roles Primary role: coordination expert in MTS Auxiliary role: medical expert who self-provides MS
Configuration 5 (TY/X)	$x^d, y, t, t^s, r_Y, r_t > 0$, $x = x^s = y^s = y^d = t^d = r_Y = 0$		
Configuration 6 (X/YT)	$x, x^s, y^d, t^d > 0$, $x^d = y = y^s = t = t^s = r_Y = r_T = 0$	Role type 4	single role medical expert in a particular MS
Configuration 7 (Y/XT)	$y, y^s, x^d, t^d > 0$, $x = x^s = y^d = t = t^s = r_X = r_T = 0$		
Configuration 8 (T/XY)	$t, t^s, x^d, y^d > 0$, $x = x^s = y = y^s = t^d = r_X = r_Y = 0$	Role type 5	single role coordination expert in MTS

Role-collaboration patterns: the entanglement of role identities and collaborative structures

Each configuration, obtained by corner solutions, shows that the consumer-producer's utility function is maximized when the production capacity, endowment constraint and budget constraint are satisfied under given external market conditions, without considering the mutual benefit and balance of interests among partners (Liu & Yang, 2000). However, the role identity of decision-makers relies on value rationality of other partners in the MCP (Touati et al., 2019). In the new classical infra-marginal analysis proposed by Yang (2003), configurations are combined to satisfy the market clearing conditions to form simply structure or medical collaborative network, and to equilibrate total corner-demand with total corner-supply of each traded serve, and equalize consumer-producers' utility levels. This kind of equilibrium is called corner equilibrium (Liu & Yang, 2000). When a structure achieves corner equilibrium, it means that all configurations in the structure will be chosen only if utility level is equal across the configurations (Liu & Yang, 2000), and the role identity of partners are mutually recognized grounded on a specific structure.

There are six structures of MCPs (shown in Figure 1) that can be divided into three types with different corner equilibriums (shown in Table 2)

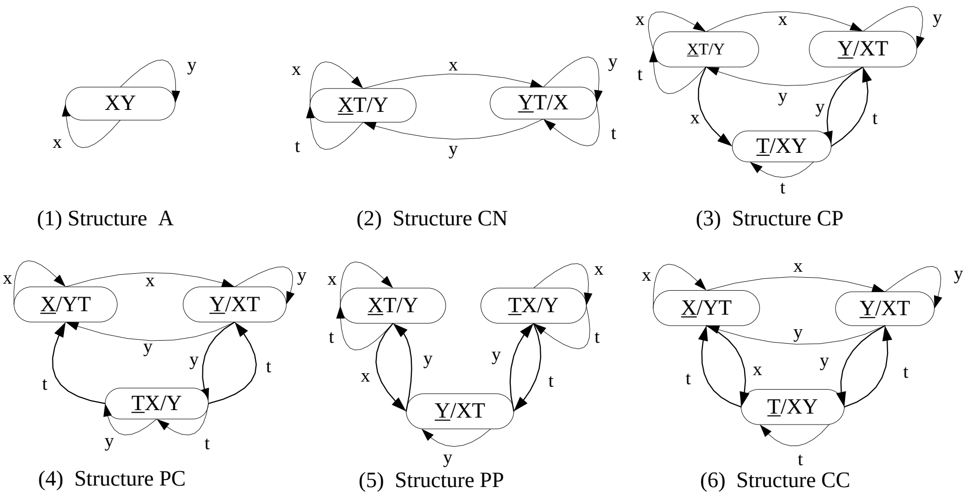

Figure 1: Six types of MCPs with corner equilibria

Table 2: The corner equilibria of collaborative medical practices

Market	Structures	Relative service price	Equilibrium income	collaboration paths	
				MS	MTS
NO	A	-	$U_A = (\frac{1}{2} - \lambda)^2$	0	0
MS market	CN	$\frac{p_X}{p_Y} = 1$	$U_{\text{CN}} = \frac{(1-\lambda-\rho)^3}{27}$	1	0
MS market and MTS market	CP	$\frac{p_X}{p_Y} = \frac{\sqrt{3}\delta^{\frac{1}{3}}(1-\lambda)(1-\rho)^{\frac{2}{3}}}{2(1-\lambda-\rho)^{\frac{3}{2}}}$ $\frac{p_T}{p_X} = \frac{8(1-\lambda-\rho)^{\frac{3}{2}}}{3^{\frac{3}{2}}(1-\rho)^2}$ $\frac{p_T}{p_Y} = \frac{4\delta^{\frac{1}{3}}(1-\lambda)}{3(1-\rho)^{\frac{4}{3}}}$	$U_{\text{CP}} = \frac{\delta^{\frac{1}{3}}(1-\lambda)(1-\rho)^{\frac{2}{3}}(1-\lambda-\rho)^{\frac{3}{2}}}{18\sqrt{3}}$	3	1
	PC	$\frac{p_X}{p_Y} = 1$ $\frac{p_T}{p_X} = \frac{p_T}{p_Y} = \frac{\delta^{\frac{1}{2}}(1-\lambda)^{\frac{3}{2}}}{(1-\lambda-\rho)^{\frac{3}{2}}}$	$U_{\text{PC}} = \frac{\delta^{\frac{1}{2}}(1-\lambda)^{\frac{3}{2}}(1-\lambda-\rho)^{\frac{3}{2}}}{27}$	2	2
	PP	$\frac{p_X}{p_Y} = \frac{\delta^{\frac{1}{3}}(1-\lambda)}{1-\lambda-\rho}$ $\frac{p_T}{p_X} = 1, \frac{p_T}{p_Y} = \frac{\delta^{\frac{1}{3}}(1-\lambda)}{1-\lambda-\rho}$	$U_{PP} = \frac{\delta^{\frac{1}{3}}(1-\lambda)(1-\lambda-\rho)^2}{27}$	2	1
	CC	$\frac{p_X}{p_Y} = 1$ $\frac{p_T}{p_X} = \frac{p_T}{p_Y} = \frac{4\delta^{\frac{1}{3}}(1-\lambda)}{3(1-\rho)^{\frac{4}{3}}}$	$U_{\text{CC}} = \frac{\delta^{\frac{2}{3}}(1-\lambda)^2(1-\rho)^{\frac{4}{3}}}{36}$	3	2

Type 1 of MCPs (Autarky) with no market: medical collaboration across medical professional roles within a single decision maker.

Type 1 of MCPs only includes structure *A*, which consists of autarkic configuration. In such a structure, there is no trade for MSs, so there is no trade for MTSs. Each consumer-producer self-provides both *X* and *Y* medical services for patients' comprehensive diagnosis and treatment. It is a medical collaboration among multiple medical professional roles within a single decision maker. It can be instantiated as the collaboration between different roles of medical experts with different medical professional knowledge, or the collaboration between different departments in comprehensive medical institutions. There is no market in structure *A*, so the kind of collaboration is similar to quasi-inexistent collaboration (Touati, et al., 2019).

Type 2 of MCPs with single-level market: medical collaboration across decision makers within medical serves.

In type 2, collaboration only includes structure *CN*, where there are medical serves collaborations between decision makers as medical experts without MTSs' collaborations. Only the medical services market will appear in the kind of MCPs.

In this type, each decision maker plays multiple roles, but the main role is the medical expert in a particular MS, followed by the coordinator who self-provides MTS, without providing MTS for the partners. The role type involves configuration 2 (XT/Y) and configuration 3 (YT/X). For example, specialized hospitals have superior medical services for certain types of diseases, but they do not have the ability to provide medical services for the complications associated with such diseases. At this time, specialized hospitals need to request other medical institutions to provide complementary medical services. So, structural *CN* is a kind of inter professional collaboration among different decision makers in the industry.

Type 3 of MCPs with multi-level market: inter-professional collaboration across decision makers across industry.

In type 3 of MCPs, there are four structures: structure *CP*, structure *PC* structure *PP* and structure CC. There are both medical serves and medical transaction services collaboration across decision makers. So, multi-level market will appear in these MCPs.

In the structure *CP*, there are three types of decision-makers: medical expert with single role (configuration 7 (Y/XT)), medical expert with multiple roles (configuration 2 (XT/Y)), and coordination expert with single role (configuration 8 (T/XY)). There are three kinds of MSs' collaboration, which are between "configuration 2-configuration 7", "configuration 2-configuration 8" and "configuration 7-configuration 8". There is also one collaboration on MTSs between "configuration 7-configuration 8".

In the structure *PC*, there are three types of decision-makers: two medical experts with single role (Configuration 6 (X/YT) and Configuration 7 (Y/XT)) and one coordination expert with multiple roles (Configuration 4 (TX/Y)). There are two collaborations on MSs, which are between "configuration 6-configuration 7" and "configuration 7-configuration 4". There are two kinds of collaborations on MTSs, which are also between "configuration 6-configuration 4" and "configuration 7-configuration 4".

In the structure *PP*, there are three types of decision-makers: a medical expert with single role (Configuration 7 (Y/XT)), a medical expert with multiple roles (Configuration 2 (XT/Y)) and one coordination expert with multiple roles (Configuration 4 (TX/Y)). There are two collaborations on MSs, which are between "configuration 2-configuration 7" and "configuration 7-configuration 4". There is also one collaboration on MTSs between "configuration 7-configuration 4".

In the *CC* structure, there are three types of decision-makers: two medical experts with single role (Configuration 6 (X/YT) and Configuration 7 (Y/XT)) and one coordination expert with single roles (Configuration 8 (T/XY)). There are three kinds of collaborations on MSs, which are between "configuration 6-configuration 7", "configuration 6-configuration 8" and "configuration 7-configuration 8". There are also two collaborations on MTSs, which are between "configuration 6-configuration 8" and "configuration 7-configuration 8".

3.3 Stability and Institutionalization of MCPs: General Equilibrium and Its Comparative Statics

The corner equilibrium for a given structure is locally Pareto optimal, which only reflects that utility levels of all partners can be equalized. The general equilibrium is globally Pareto optimal, which embodies that utility levels of all partners in the structure can be equalized and greater than that in other structures in a special parameter space (Wang and Yang,1996). Touati et al. (2018) show that collective learning is an important condition to promote the institutionalization of specific collaborative practice. This paper formalizes collective learning by general equilibrium. For specific environmental conditions, only when the individual interests are the largest, the interests of all partners are balanced, and the collective interests are the best, can the collaborative practices operate stably.

Considering the production feasibility of decision makers, if $\lambda > 1/2$, structure *A* is not possible; if $\lambda + \rho > 1$, structure *CN*, *CP*, *PC* and *PP* are not possible. The numerical simulation results show that: no matter how the values of three economic parameters change, per-capita real incomes of structures *CP*, *PC* and *PP* are less than that of structure *CA* or *CT* if $\lambda + \rho > 1$ and $\lambda > 1/2$, and less than that of structure *CA* or *A* or *CT* if $\lambda + \rho > 1$ and $\lambda < 1/2$. After comparing the corner equilibrium income of the six structures, only three structures of *A*, *CN*, and *CC* have general equilibrium, and corresponding parameter spaces are divided (shown in Table 3).

Table 3: Static analysis of general equilibrium

λ	<1/2						>1/2		
$\lambda + \rho$	<1				>1		<1		>1
ρ	$< \rho_0$		$> \rho_0$						
δ	$< \delta_1$	$> \delta_1$	$< \delta_0$	$> \delta_0$	$< \delta_0$	$> \delta_0$	$< \delta_1$	$> \delta_1$	
Equilibrium structure	CN	CC	A	CC	A	CC	CN	CC	CC

In Table 3, ρ_0 is the critical fixed learning cost of MTS for the transition between structure *A* and *CN*, and can be described as follows by comparing U_A and U_{CN}:

$$\rho_0 = 1 - \lambda - 3\left(\frac{1}{2} - \lambda\right)^{\frac{2}{3}} \tag{7}$$

$\delta_0$is the critical transaction efficiency for the transition between structure *A* and *CC*, and can be described as follows by comparing U_A and U_{CC}:

$$\delta_0 = \frac{27(1-2\lambda)^3}{(1-\lambda)(1-\rho)^2} \tag{8}$$

δ_1 is the critical transaction efficiency o for the transition between structure *CN* and *CC*, and can be shown as follows by comparing U_{CN} and U_{CC}:

$$\delta_1 = \frac{8(1-\lambda-\rho)^{\frac{9}{2}}}{3^{\frac{3}{2}}(1-\lambda)^3(1-\rho)^2} \tag{9}$$

Proposition 1: When $\lambda > 1/2$ and $\lambda + \rho > 1$, a complete specialization structure *CC* with multi-level market will yields the highest per-capita real income.

If $\lambda > 1/2$, each decisionmaker cannot self-provide two types of MSs to satisfy the requirements of comprehensive medical services, and the level of division of labor in various medical services will be increased. Hence, structure *A* (Autarky) with no market is not optimal choice.

If $\lambda + \rho > 1$, each decision maker cannot develop both activities of MSs and MTSs, and must promote division of labor between MSs and MTSs. Hence, structure *CN* with single market is not optimal choice.

Therefore, if $\lambda + \rho > 1$ and $\lambda > 1/2$, the complete specialization structure *CC* as inter-professional collaboration across decision makers across industry will yield the highest per-capita real income.

Proposition 2: When $\lambda < 1/2$ and $\lambda + \rho > 1$, if $\delta > \delta_0$, a complete specialization structure *CC* with multi-level market will yields the highest per-capita real income; otherwise, Autarky structure *A* with no market will yields the highest per-capita real income.

If $\lambda < 1/2$ and $\lambda + \rho > 1$, it means that each decision maker is able to self-provide two types of MSs, but can't self-provide MTS and MS at the same time. So, structure *CN* is not optimal choice.

$\delta_0$is the critical transaction efficiency for the transition between structure *A* and *CC*, and indicates whether the medical transaction service exists. If $\delta < \delta_0$, the transaction costs of medical transaction service outweigh economies of specialization generated by the division of labor for medical transaction service. So, the medical transaction service will not exist, and autarky structure *A* will be the best choice. If $\delta > \delta_0$, economies of specialization generated by the division of labor for medical transaction service outweigh the transaction costs, each decision maker will not choose to self-provide medical transaction service, and structure *CC* will yield the highest per-capita real income.

Proposition 3: When $\lambda > 1/2$ and $\lambda + \rho < 1$, if $\delta > \delta_1$, a complete specialization structure *CC* with multi-level market will yields the highest per-capita real income; otherwise, structure *CN* with single-level market will yields the highest per-capita real income.

If $\lambda > 1/2$ and $\lambda + \rho < 1$, it means that each decision maker is able to self-provide medical transaction service and one type of medical services, but can't self-provide two types of medical services. So, structure *A* is not optimal choice.

$\delta_1$is the critical transaction efficiency for the transition between structure *CN* and structure *CC*, and indicates whether the medical service is provided by oneself or by a third party. if $\delta > \delta_1$, economies of specialization generated by the division of labor for medical transaction service outweigh the transaction costs of medical transaction service, structures *CC* will yield the highest per-capita real income. if $\delta < \delta_1$, the transaction efficiency for medical transaction service becomes higher than that for labor, the self-supply mode of medical service is better than the third-party supply mode. Hence, the per-capita real income of structure *CN* will be higher than one of structure *CC*.

Proposition 4: When $\lambda < 1/2$and $\lambda + \rho < 1$, if $\rho < \rho_0$, structure *CN* or structures *CC* will yield the highest per-capita real income; otherwise, structure *A* or structures *CC* will yield the highest per-capita real income.

If $\lambda < 1/2$, it means that each decision maker is able to self-provide two types of medical services. If $\lambda + \rho < 1$, it means that each consumer-provider is able to self-provide medical transaction service and one type of medical services. So, when $\lambda < 1/2$and $\lambda + \rho < 1$, all three structures are likely to yield the highest per-capita real income.

ρ_0 is the critical fixed learning cost of transaction service for the transition of structure *A* and *CN*. If $\rho < \rho_0$, λ/ρ is relatively large and the fixed learning cost of medical transaction service is relatively small. So, the division of labor for different medical services is better than one for medical services and medical transaction service, structure *CN* is better than structure *A*. Otherwise, structure *A* is better than structures *CN*.

3.4 The Sensitivity of the Transitions Among the MCNs with General Equilibrium

Proposition 5: When $\lambda < 1/2$, the threshold value ρ_0 will increase with an increase in learning cost of medical services λ, making it more attractive to enter into structure *CN* and less likely that structure *A* will appear.

if $\lambda < 1/2$, $\frac{\partial \rho_0}{\partial \lambda} > 0$. This indicates that as learning cost of medical services λ increases, the threshold learning cost of medical transaction service (ρ_0) for the transition between structure *A* and *CN* will increase. As shown in Figure 2, the curve of ρ_0 move left to right with an increase in learning cost of medical services (λ). The parameter space of structure *CN* is expanded and one of structure *A* compressed. This means that the thresholds for switching from structure *CN* to structure *A* have become higher, the transition from structure *CN* to structure *A* becomes more difficult. For the same learning cost of medical transaction service (ρ) and transaction efficiency (δ), decision makers prefer structure *CN* to structure *A* with the increase of λ. In other words, when decision makers are in structure *A*, they are more sensitive to the increase of fixed learning cost of medical services, thereby promoting the division of labor for medical services. Finally, they are more willing to transfer from autarky into inter-professional collaboration among decision makers within industry.

Proposition 6: The threshold value of transaction efficiency (δ_0) will decrease with an increase in learning cost of medical services (λ), making it attractive to enter into structure *CC* not structure *A*.

By calculating the differential relationship between threshold transaction efficiency ($\boldsymbol{\delta_0}$) and the learning cost of medical services (λ), we can conclude that

$$\frac{\partial \delta_0}{\partial \lambda} < 0 \tag{10}$$

As shown in Figure 2, the curvel of δ_0 moves down right with increasing λ, which compresses the parameter space of structure *A* and expands one of structure *CC*. This means that the thresholds for switching from structure *A* to structure *CC* have become lower. For the same learning cost of medical transaction service (ρ) and transaction efficiency (δ), people prefer structure *CC* to structure *A* with a decrease in the threshold transaction efficiency (δ_0). In other words, when decision makers are in structure *A*, they are more sensitive to the increase of fixed learning cost of medical services (λ) and easily become unstable; when decision makers are in structure *CC*, they aren't more sensitive to the increase of λ.

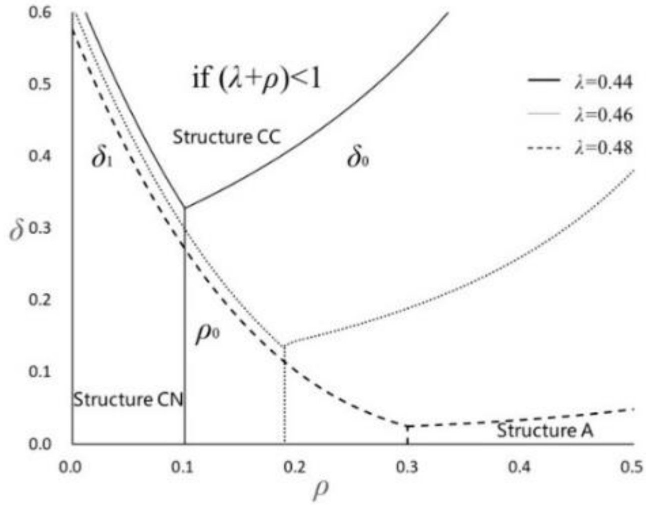

Figure 2: Changes of ρ_0, δ_0 and δ_1 under different λ

Proposition 7: The threshold value of transaction efficiency (δ_1) will decrease with an increase in learning cost of transaction medical services (ρ), making it attractive to enter into structure *CC* not structure *CN*.

By calculating the differential relationship between threshold transaction efficiency (δ_0) and learning cost of medical transaction service (ρ), we can conclude that

$$\frac{\partial \delta_1}{\partial \rho} < 0 \tag{11}$$

As shown in Figure 3, the curve of δ_1 moves down left with increasing ρ, which compresses the parameter space of structure *CN* and expands one of structure *CC*. This means that the thresholds for switching from structure *CN* to structure *CC* have become lower. For the same transaction efficiency (δ) and learning cost of medical transaction service (λ), people prefer structure *CC* to structure *CN* with a decrease in the threshold transaction efficiency (δ_1). In other words, when decision makers are in structure *CN*, they are more sensitive to the increase of learning cost of medical transaction service (ρ) and easily become unstable; when decision makers are in structure *CC*, they aren't more sensitive to the increase of learning cost of MTS (ρ).

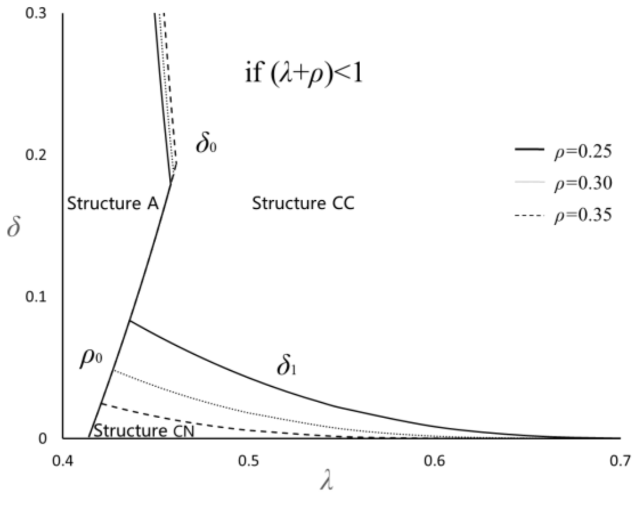

Figure 3: Changes of δ_0 and δ_1 under different ρ

4. Discussion and Conclusion

With the flourishment of Internet technology and big data technology, all kinds of IT enterprises have chocked on the medical service industry, forming a multi-level market of medical cooperation. The pattern of MCPs and the role identity of participants are becoming more and more rich, diverse and changeable. From the infra-marginal perspective, the paper is to explore an appropriate method to formally analyze and demonstrate the nature and laws of the existence and evolution of various MCPs and legalization of the role identity of partners.

The first problem to be solved is how to build a role generation model for collaborators.

This paper argues that MCPs originate from the professional division and cooperation of different MSs and MTSs. Drawing upon the new classical infra-marginal analysis (Yang, 2003), producers and consumers are included in a unified decision model known as role generation model of collaborators, which reflects the coexistence of division and cooperation.

According to the theory of social structure, three complementary dimensions of structure (signification rules, legalization rules and dominant resources) are the basis for the production and reproduction of social agents. The practice of medical collaboration is a process in which all partners create value together, including value supply, value realization and value transmission. These three processes correspond to the three complementary dimensions of structures in social structure theory. Production function, utility function and constraint function, which represent these three processes respectively, constitute the unified decision model.

In the existing empirical studies, various factors at individual, organizational and system levels are identified to affect medical collaboration (Touati, et al.,2018). According to the possible influence of these factors on the three processes of value synergy, this paper reduces these factors to three economic parameters (learning cost of medical service, learning cost and transaction efficiency of medical transaction service), by which the production function, utility function and constraint function are constructed.

Therefore, the unified decision-making model of "producer-consumer", which is composed of three functions and involves three economic parameters, formally integrates the influence of factors and the formation of value synergy process, coordinates the division of labor and cooperation, and takes into account both autonomous behavior of individual and the constraints of environment. Grounded on this model, collaborators' role identity and MCPs can be entangled to produce and re-produce, so it is also called role generation model.

The second problem to be solved is how to formalize the confirmation of role boundary (role models) and the legalization of role identity (structure of MCPs).

By calculating the corner solution of the role generation model, eight decision-makers' role models (configurations) reflecting the division of labor and specialization degree are obtained. Such role models determine the role boundaries of various collaborators, reflecting the mode of individual division of labor with maximum utility under the constraints of production capacity and budget.

A combination of configurations with satisfying market clearing conditions are formed (also known as simply structure or medical collaborative practice (MCP)). The corner equilibriums of these structures are analyzed, and all configurations will be chosen only if utility level is equal across the configurations in a specific structure (Liu & Yang, 2000; Wang & Yang, 1996). The mutual recognition and legalization of partners' roles are associated with specific cooperation structures.

The research shows: the determination of role boundaries is infra-marginal decisions which consider the maximization of individual interests by the realization of division of labor and specialization; the identification of role identity is the balance of interests of all parties in the collaboration, and is in different ways in different structures. For example, configuration 2 (XT/Y) as a medical expert with multi roles who is also a medical service coordinator, in structure *CN*, its role identity is confirmed by cooperating medical serves with another medical expert configuration 3 (YT/X) with multiple roles; in the structure *CP*, its role identity is legalized by collaborating medical services with Configuration 7 (Y/XT) and configuration 8 (T/XY). In the structure *PP*, its role identity is identified by collaboration on medical services with another medical expert configuration 7 (Y/XT) with single role. Touati, et al. (2019) found that three professional identities (medical expert, care coordinator, and team member) were instantiated in three specific modalities of collaboration (quasi-inexistent, restrained, and extended). The paper extracts eight role models and analyzes six structures of MCPs with corner equilibrium, and further formalizes the different ways of legalization of specific role identities in different collaborative practices in no market, or single-level or multi-level market.

The third problem to be solved is how to analyze the stability conditions or institutionalization conditions of various MCPs, and the possible changes of this stability which include the evolution path of structures accompanied by the transition of role identity of collaborators.

By analyzing general equilibrium of various MCPs with corner equilibrium, the parameter space is divided, under which total utility of a specific MCP is the largest. The results show that not all structures with corner equilibrium are general stable, and only three structures (structure *A* with no market, structure *CN* with single market and structure *CC* with multi-level market) are stable in a specific parameter space. In four MCPs of type 3 with multi-level market (inter-professional collaboration across decision makers across industry), only the complete specialization structure *CC* has general equilibrium, and the other three partial specialization structures are unstable. MCPs' general equilibrium and parameter space are used to show the importance of collective learning in the institutionalization of collaborative practice (Touati et al., 2018).

Three structures with global equilibrium are globally optimal in different parameter spaces, which means that no particular form of MCPs is absolutely better than another one. More exactly, different parameter spaces (which represent the sum of the factors that affect cooperation), that is, different scenarios should choose the appropriate medical collaboration practice. If the choice is not appropriate, collaborative practice will be failure. For example, when various factors cause the higher learning cost of medical services, that is, it takes a lot of time and energy to master the professional knowledge and ability of medical services, which makes it difficult for medical service providers to become high-level comprehensive medical service experts, but can only become high-level specialists in specific fields. At this time, the cost of the big data processing required by medical transaction service is high. However, the development of technology enriches the communication mode, improves the communication quality, and reduces the loss of information in communication (Nicolini, 2007; Nilsen, 2013). Meanwhile, the standardization of clinical guidelines and the reform of organizational structure, which are promoted by development of IT, improve transaction efficiency and reduce transaction cost. In this scenario, a complete specialization structure *CC* with multi-level market (inter-professional collaboration across decision makers across industry) may be a better choice.

The transitions among three MCPs with general equilibrium are analyzed. As learning cost of medical services λ increases, the threshold learning cost of medical transaction service (ρ_0) will increase and the threshold transaction efficiency δ_0 and δ_1 will decrease. At this moment, the transition from structure *A* to structure *CN* or structure *CC* will become easier; the transition from structure *CN* to structure *A* will become more difficult, but to structure *CC* easier; the transition from structure *CC* to structure *A* and structure *CN* will become more difficult. In other words, it is easier to change from the structure with low degree of division to one with higher degree of division, such as from structure *A* to structure *CN*, from structure *A* to structure *CC* and from structure *CN* to structure *CC*. Hence, with the incease of learning cost of medical services λ, the structural evolution path " *A* - >*CN* -> *CC* " is more likely to occur.

As learning cost of medical transaction services (ρ) increases, the threshold transaction efficiency (δ_0) will increase, and the threshold transaction efficiency (δ_1) will decrease. Meanwhile, the transitions from structure *CN* to structure *CC* and from structure *CC* to structure *A* will become easier, but ones from structure *A* to structure *CC* and from structure *CC* to structure *CN* will be more difficult. In this way, the structural evolution path "*CN* -> *CC* ->*A*" is more likely to occur.

With the evolution of the structures, role boundaries will change, re-define and recognize. For example, the structural evolution path "*A* - > *CN* - > *CC*" may include four role transition paths starting from configuration 1 (XY) (shown in Figure 4).

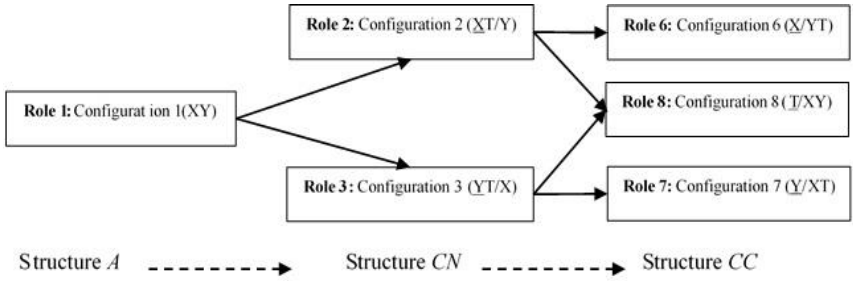

Figure 4: The evolution of the structures and role boundaries with the increase of ρ

With the development of big data technology and Internet technology, IT enterprises can enter different medical collaboration practices with different identities, which is affected by three parameters (show in table 3). In zone 3 and 5, IT enterprises may directly invest in the establishment of various comprehensive hospitals to carry out self-sufficient medical serves as comprehensive medical experts. In zone 1 and zone 7, IT enterprises directly invest in the establishment of various kinds of specialized hospitals. As medical experts in one field, they carry out medical collaborative practices with medical experts in other fields. In zone 2, 4, 6, 8 and 9, they can invest in establishing a medical service trading platform. As specialists of medical service transaction, they coordinate various medical service experts to carry out medical cooperation practice in multi-level market.

Similarly, the formation and development of suppliers of medical service transaction (MTS) and multi-level market are the result of the trade-off between specialized economy and transaction cost. There are various ways to legalize the role of MTS specialist. The auxiliary role of medical expert (configuration 2, 3) will be legalized in the structure of *CN*, *CP* and *PP*; the main role of coordination expert with multi roles (configuration 4, 5) will be legalized in the structure of *PC* and *PP*; the single professional role of coordination expert (configuration 8) will be legalized in the structure of *CP* and *CC*. However, all of these legalizations may not be stable. Whether they are stable or not depends on whether a particular structure has a general equilibrium. The multi-level market structure *CP*, *PC* and *PP* do not have a general equilibrium, so the legalization of the related roles is difficult to develop sustainably.

The results of this study make a number of important contributions.

At a theoretical level, we provide a systematic method to analyze and display the nature and laws of the existence and evolution of various MCPs under multi-level market by drawing upon the new classical infra-marginal analysis. Secondly, the integration of influencing factors and process views will help to better understand the diverse influence paths of factors on collaboration, and thus better explain many contradictory conclusions of factor research. What is more, our work has also shed light on the diversity of evolution paths of MCPs and the diversity of role changes under the evolution process of MCPs. This paper displays the distortion of the stable parameter space of different collaboration types caused by the change of related parameter. If decision makers want to adapt to this distortion, they should adjust the collaboration mode and modify the role boundary as collaborators.

At a more practical level, this research is beneficial for Internet medical platforms and medical institutions to choose a more appropriate decision-making mode according to the technical and economic environment, and to establish a suitable collaborative medical network with appropriate partners. It helps the government understand what conditions can make the relevant policies implemented efficiently or how to design a better policy environment based on existing conditions, and finally better promote the realization and development of the desired medical alliance.

However, the study only considers the impact of the learning cost difference between medical services and medical transaction services. In fact, there are always differences of learning costs among different medical services, and the differences will cause the different way of the emergence, stability and evolution of various forms of MCPs. Therefore, the formation mechanism of collaborative medical network considering differences of learning costs among various medical services needs to be further explored.

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