
Relation exchange mapping as the model of bounded rationality

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Abstracts:

Behavioral studies presented the scheme of human cognitive system, which distinguishes the steps of sensory order (Kahneman 2003). Human cognition begins with perceptions, from which intuition comes off as fast, parallel, automatic, effortless and emotional system. Reasoning is slow, serial, controlled, effortful and rule-governed system of cognition. Sympathy and consent are the only available conduit between and among different cognitive systems of different individuals, from which relation exchange grows out. Sympathy-consent process is indeterminate, incomplete, coincidental, emotional rather than rational, and path dependent process. So, does relation exchange. It is open/indeterminate system in comparison with the closed/determinate system of value-cost rationality model. Open/indeterminate system turns out to be open set, which allows the building of a topological space. The fundamentality of relation exchange over value exchange is proved from the property of open set, which vindicates the legitimacy of relation exchange as the model of bounded rationality.

Keywords

Cognitive system, bounded rationality, sympathy-consent process, relation exchange mapping, open/indeterminate system, open set

JEL code: D01, D03

I Introduction

Although it is rarely brought to our conscious mind, an implicit premise is presumed in the setting of the (value-cost) rationality model. It is the premise of consistent measuring of value-cost indices. Either *ceteris paribus* assumption in the textbook of the principles of economics or the exposition of reflexivity, transitivity and completeness of preference

ordering in graduate textbook reminds us of its matter, more often than not, it is not explicitly pronounced in the papers of economics literature. Revealed preference theory (Samuelson 1938) is not *caveat emptor* which allows us to bypass this problem. Rather, it should be conceived as a reminder to confirm the legitimacy of the premise.¹ Without the premise, the justification of optimization-equilibrium algorithm in economics literature is hardly sustained (Hodgson 1988, section 4.1).²

Clearly, this problem will not be settled without reminding of behavioral studies, which have presented evidences that confronts the assumptions of rational agent model (reference point and loss aversion Kahneman and Tversky 1979; framing Tversky and Kahneman 1986, Kahneman and Lovallo 1993; mental accounting Thaler 1985, 1999; decision bracketing Daniel Read et al. 1999). Judgment heuristics leads to systematic biases which make discrepancies between the dictations of intuitive judgments and extensional reasoning like probability principles, Bayesian inferences and regression analysis (Tversky and Kahneman 1974, 1983). Behavioral studies raise question to the tenet of rational agent model (Kahneman 2003).

On the other hand, new institutional economics approach encountered other fundamental problems, e.g., the choice between market and firm. The efficacy of cost approach, i.e. transaction cost (Coase 1937, 1960, 2006), becomes questioned due to the possibility of opportunistic behavior (Klein, Crawford and Alchian 1978). Opportunistic behavior turned out to be a Pandora box which casted out trouble points to economics: metering (Alchian and Demsetz 1972), hold-up (Klein, Crawford, and Alchian 1978), asset specificity (Williamson 1975, 1985, 1986), principal-agent (Jensen and Meckling 1976; Holmstrom and Milgrom 1991). Although tracking points are different, all the studies adopted similar methods of optimization-equilibrium algorithm, which rendered meager achievement that barely succeeded in identifying the problem in the architecture of the value-cost rationality model. Poor turnout of study as such was not the exception to the modern property rights school when dealing with the problems of incomplete contract theory (Grossman and Hart 1986; Hart and Moore 1988, 1990). The outcomes of studies were not cheering but “hopelessly unrealistic” (Maskin and Tirole 1999a).

It is remarkable to witness the echoing agreements from new institutional economics

¹ The real intension of revealed preference theory (Samuelson 1938) may also be translated as to sustain the forthcoming behavior of relation exchange.

² The supporting arguments of competitive equilibrium theory without the transitivity of preference (Sonnenschein 1971) do not repudiate the need for the logical precedence of the premise before the setting of optimization-equilibrium algorithm in place.

approach (Maskin and Tirole 1999a) and behavioral studies (Kahneman 2003) as well, which calls for the need to develop the model of bounded rationality to rescue the problems of economics. Maskin and Tirole blamed the economists' failure to establish the model of bounded rationality for the disappointing turnouts of studies. Kahneman underscored the need to develop the model of bounded rationality as logical extension from the findings of behavioral studies (Simon 1955, 1957a, 1957b, 1979, 1984, 1991).

Seminal contribution of behavioral studies is the enlightenment on the fact that human understanding and knowledge begin with perception and that there is a sensory order in human cognitive system (Hayek 1952). In this regard, Hume (1739) is considered as the precursor of behavioral approach.

The building of cognitive system begins with the perception at each instance of experience, which gives rise to intuition as fast, parallel, automatic, effortless, associative, slow-learning and emotional process (Paul Rozin and Carol Nemeroff 2002; Daniel T. Gilbert 1989, 2002; Timothy D. Wilson 2002; Seymour Epstein 2003). It is amazingly similar to Humean impression (Hume 1739). Reasoning comes off later as slow, serial, controlled, effortful, rule-governed, flexible and neutral process (Kahneman and Frederick 2002; Ellen J. Langer et al. 1978; Simon and William G. Chase 1973; Gary Klein 1998; Atul Gawande 2002; Shelly Chaiken and Yaacov Trope 1999; Kith E. Stanovich and Richard F. West 2000, 2002; Kahneman 2003).

The outcome of behavioral studies is that intuition (Kahneman 2003) and impression (Hume 1739) are more accessible (E. Tory Higgins 1996) and directly affect the process of decision making than reasoning.³ Consequently, reference point affects the judgment process since perception become reference dependent (loss aversion: Kahneman et al. 1991; Tversky and Kahneman 1992). Decision making remains passive to the framing formulation (invariance: Tversky and Kahneman 1986; narrow framing: Kahneman and Daniel Lovallo 1993; mental accounting: Thaler 1985, 1999; decision bracketing: Daniel Read et al. 1999). Judgment heuristics leads to systematic biases which make discrepancies between the dictations of intuitive judgments and extensional reasoning like probability principles, Bayesian inferences and regression analysis (Tversky and Kahneman 1974, 1983; Kahneman 2003; Binmore 2011).

The grand question, which challenges to the attempts to embed the cognitive structure of behavioral studies into the analytics of economics, is how to explain the interpersonal interaction between and among individuals? Since Adam Smith (1776), economics has confined the analysis only to the cases of market exchange. However, the interactions among

³ In Hume (1739), sensory order is recognized to develop the thesis on relations of ideas and matters of fact.

individuals are much more comprehensive matters than those which are restricted to the activities confined to the market. Sympathy is the common response from empiricists (Hume 1739, 1751; Smith 1759). From different direction, public choice approach proposed public consent as their response to the question (Buchanan and Tullock 1962). In economics literature, relational exchange (or relational contract) has been a familiar issue (Macneil 1978; Williamson 1985; Dore 1983; Goldberg 1980; Richardson 1972), where the effects of relational interaction are added to the analytics of rational agent model.

Relational interaction among individuals, while individuals are separated by different schemes of cognitive system respectively, may be regarded as the outgrowth of utilitarian behavior. The process of sympathy and consent may be considered as the conduit between different cognitive systems. Then, the relational interactions, *viz.*, relation exchange (as will be defined later), among individuals should be conceived as the outcome of sympathy-consent process (Rhee 2012b, 2016b). Since this process of sympathy and consent is indeterminate, incomplete, coincidental, emotional rather than rational and path dependent, the relational interactions among individuals share same properties as well (Rhee 2013b).

As the analytic lineage from sympathy-consent process to relational interaction is drawn out of the cognitive systems of different individuals, the natural question that follows is how relational interactions among individuals are compared with the value exchange of the market in the rational agent model? Approach to this question seems to bifurcate at this juncture: should we follow either the tradition of empiricism or that of value-cost rationalism. The traditional rational agent model belongs to the value-cost rationalism approach. On the other hand, the experimental results of behavioral studies support the empiricism approach. Although the philosophical traditions are distinctively different between two approaches, it seems necessary to rekindle our attention to the fact that the approach of value-cost rationalism requires as premise the consistent measuring of value-cost indices.

The premise of consistent measuring of value-cost indices is introduced to the analytics of human cognitive system and open/indeterminate system is compared with closed/determinate system in Section II. Open/indeterminate system is unfolded to be open set, which allows the building of a topological space of open/indeterminate system in Section III. The fundamentality of relation exchange over value exchange is proved by making use of the property of open set, which vindicates the legitimacy of sympathy-consent process as the analytical dimension, *i.e.*, the dimension of bounded rationality in Section IV. The ramifications from the establishment of sympathy-consent dimension as the dimension of bounded rationality are briefly discussed in Section V. Section VI summarizes paper and presents concluding remarks.

II Open/indeterminate system

Our decisions are not determined by rational choice but by “the common-sense psychology of the intuitive agent” (Kahneman and Tversky 1973, Tversky and Kahneman 1974, Kahneman et al. 1982). “Rational (agent) models are psychologically unrealistic” (Kahneman 2003). Although “most judgments are and most choices are made intuitively,” intuition is prompted by perception. They deal with direct feelings from experiences and take first-tier steps in the cognitive system. Perceptions and intuitions are carried out fast, in parallel, automatically, effortlessly, associatively, as slow-learning, and emotionally (Paul Rozin and Carol Nemeroff 2002). Reasoning is slow, serial, controlled, effortful, rule-governed, flexible, and neutral process as the second-tier steps of human cognition (Kahneman 2003). “Reasoning is done deliberately and effortfully, but intuitive thoughts seem to come spontaneously to mind, without conscious search or computation, and without effort” (Daniel T. Gilbert 1989, 2002; Timothy D. Wilson 2002; Seymour Epstein 2003; Kahneman 2003).

Assumption HCS (human cognitive system): Human cognition is founded on two tier system in accessibility order with perception and intuition as first-tier system and reasoning as second-tier system (Kahneman 2003).

It is amazing to witness the similarity between the cognitive system of behavioral approach and Humean epistemology. Both approaches recognize that human understanding essentially begins with experiences, that the perception from experiences is the most primitive step, that “most thoughts and actions, i.e. reasoning, are normally intuitive” (Kahneman 2003). Opening gateway to empiricist approach, as contrasted with the (value-cost) rationalist approach of traditional economics, is seminal achievement of behavioral studies.

Rational agent model, which contrasts with behavioral approach (Kahneman 2003), denotes the rational choice model, which seeks optimization theory in the literature. However, in order to interpret the rational choice model as optimization theory (Hodgson 1988), we need a premise, which requires consistent measuring of value-cost indices. It does not make sense to seek optimization when the premise is not tenable.

Definition CMVCI (consistent measuring of value-cost indices): The measuring of value-cost indices is held consistent at any instance.

With Definition CMVCI, we are ready to put the optimization theory in place as the operational scheme of rational choice model. If the measuring of value-cost indices is held consistent at any instance, it is natural propensity of rational agent, who is assumed utilitarian,

to seek optimization behavior. Optimization-equilibrium algorithm determines the behavior of rational agent. In other words, the expression for the behavior of rational agent is confined to the outcome of optimization-equilibrium algorithm (Arrow and Debreu 1954; Arrow and Hahn 1971). In this regard, it is denoted as closed/determinate system.

Definition CDS (closed/determinate system): Economic states which are determined by the optimization-equilibrium algorithm as behavioral outgrowth upon taking Definition CMVCI as premise.

Human beings are utilitarian. Hence, if Definition CMVCI is taken as premise, human behavior will be dictated by optimization-equilibrium algorithm. In this regard, the economic states, which are determined as such, are considered as being closed and determinate by the optimization-equilibrium algorithm.

However, if consistent measuring of value-cost indices becomes untenable (Untenable CMVCI), we cannot rely on optimization-equilibrium algorithm to determine economic states. The value-cost rationality is no longer effective navigator. It is the life of bounded rationality. We cannot but rely on experiences. What economic states that are discovered by the guide of experiences would look likely? Experiences happen coincidentally. So do economic states take place. However, their effects leave legacy to the following incidents. Path dependence is idiosyncratic attribute of empiricist economic states.

Examples of such economic states are plenty: experience, trust, friendship, affection, emotion, envy, and so on and on. They are determined by perception, which prompts to intuition and eventually precepts and conceptual representation (Kahneman 2003) or impression, image, matters of facts and relations of ideas (Hume 1739). Their makings are open and indeterminate.

Definition OIS (open/indeterminate system): Economics states which are not dictated by the value-cost rational behavior due to Untenable CMVCI.

Economic states of Definition OIS are the life of bounded rationality, which cannot but rely on the navigation of experiences. What is the border line which distinguishes economics states of closed/determinate system from those of open/indeterminate system? It is CMVCI. If Definition CMVCI is upheld, economic states have no choice but to lead to economic states of Definition CDS. Otherwise, i.e., the case of Untenable CMVCI, economic states will

lead to those of Definition OIS.

According to behavioral studies, Definition CMVCI, which is the premise of rational agent model, is not upheld by human cognitive system, so that it cannot be used as the premise of economic modeling. Definition CMVCI is the gateway leading to the empiricist approach from rational agent model.

III Topological space of open/indeterminate system

In real life, things happen coincidentally. But its effects leaves efficacy to the following incidents (Hume 1739). In other words, path dependence holds effective as idiosyncratic attribute.⁴ It is open/indeterminate system. It is the world of bounded rationality and life of empiricism.

Set $W = \{w: \text{economic states of open/indeterminate system}\}$

Since closed/determinate system is separated from open/indeterminate system by Definition CMVCI, Set W may be written as

Set $W = \{w: \text{economic states of Untenable CMVCI}\}$. (1)

Equation (1) defines the set of economic states which may appear in the open/indeterminate system. Human cognitive system (Assumption HCS) belongs to the open/indeterminate system. In other words, the set of economic states under Assumption HCS represents economics states of individual person under Assumption HCS, which is a subset of the set W .

Economic states of person i is denoted by Set X_i .

⁴ Hume (1739) elaborated his thesis on the theory of causation in Part III Of knowledge and probability in his book (Hume 1739). He indicated perception and impression (intuition in the sense of behavioral approach) as the root cause of human epistemology.

$$\text{Set } X_i = \{x_i: \text{economic states of person } i \text{ under Assumption HCS}\} \quad (2)$$

$$\text{Set } X_i \subset \text{Set } W$$

Economic states of the closed/determinate system are determined by Definition CMVCI, the set of which is denoted by Set Z.

$$\begin{aligned} \text{Set } Z &= \{z: \text{economic states of closed/determinate system}\} \\ &= \{z: \text{economic states under Definition CMVCI}\} \end{aligned} \quad (3)$$

The set of economic states of individual person under Definition CMVCI is denoted by Set Y_i , which is a subset of Set Z.

$$\text{Set } Y_i = \{y_i: \text{economic states of person } i \text{ under Definition CMVCI}\} \quad (4)$$

$$\text{Set } Y_i \subset \text{Set } Z$$

Set Z is upheld by the condition CMVCI, but is distinguished from Set W by the same condition. Economics state z is determinate state. Once the premise of consistent measuring of value-cost indices is accepted, rational agent model is ordained to rein in. Optimization-equilibrium algorithm will locate the determinate states.

However, the findings of behavioral studies (Kahneman 1983, 2003) repudiate the legitimacy of CMVCI condition. Economic state w denotes indeterminate state. It is indeterminate state, which is conceived by perception. It is coincidentally determined, but becomes path dependent after the occurring. It is emotion-driven states and represents wavering behavior.

Set Z and Set W are mutually exclusive incidents. There exists no indeterminateness under the condition of Definition CMVCI. Under Untenable CMVCI, Set Z is recognized as empty set.

Proposition Set Z as Empty Set under Untenable CMVCI: Set Z is empty set under

Untenable CMVCI.

Proof:

Set W is the set of economic states at Untenable CMVCI. Economic states w 's are indeterminate states. However, there is no indeterminate state in Set Z . At the condition CMVCI, every economic state is determined as the outcome of optimization-equilibrium algorithm. Hence, Set $Z = \{\emptyset\}$ at Untenable CMVCI. \square

Condition Untenable CMVCI indicates the inability to sustain CMVCI, which precisely denotes Assumption HCS. Economic state w sets out from the condition Untenable CMVCI. Indeterminate state w can approach indefinitely and infinitely to determinate state z , but cannot get onto it. Once condition CMVCI is attained, these indeterminate states turn to determinate states immediately.

$$W = (\{w\}, \{\emptyset\}) \tag{6}$$

Equation (6) denotes the open set property of Set W . Indeterminate economic state w can approach to determinate state z infinitely, but never gets onto it.

Now, we are ready to present the most critical thesis of this paper.

Proposition Open Set W : Set W is open set.

Proof:

Open set property of Set W requires that any economic state should be open set itself. Equation (6) shows that Set W approaches to determinate state $\{\emptyset\}$ infinitely but does not include it. Any economic state w can form an open ball, hence is open set. \square ⁵

⁵ I have benefited from the discussion with Professor Jae-Hyun Gwon of Incheon University.

Set Z is complement set of Set W , hence is closed set.

Proposition Closed Set Z : Set Z is closed set.

Proof:

Set Z is complement of Set Y , the distinction between two sets of which are divided by condition CMVCI. Since Set W is open set, Set Z is closed set. \square

Upon the assumption of human cognitive system (Assumption HCS), the value-cost rationality dimension becomes the empty set in the dimension of bounded rationality. With Open Set W and with Closed Set Z as empty set as well, we can build a topological space (W, T) on Set W .

Proposition Topological Space (W, T) : Class T of subsets of W which is built on Definition HCS makes topological space (W, T) .

Proof:

The following three axioms have to be vindicated.

Firstly, Set W as well as Set Z as empty set belongs to Class T of subsets of Set W , which is upheld by Untenable CMVCI. The existence of Set Z as empty set of Set W proves this axiom.

Secondly, the union of any number of sets in T belongs to T . Any set in T is the set of economic states at Untenable CMVCI. The union set is also the set of economic states at Untenable CMVCI, which belongs to T .

Thirdly, the intersection of any two sets in T belongs to T . The intersection set is also the set of economic states at Untenable CMVCI, which belongs to T . \square

Assuming human cognitive system (Assumption HCS or assuming Untenable CMVCI), we could build Topological Space (W, T) on Set W as the analytical dimension of bounded rationality. This topological space is the foundation of analytics upon which to present the model of relation exchange.

IV Fundamentality of relation exchange over value exchange

In order to understand how exchange takes place in the analytical architecture of human cognitive system, we need to introduce the concept of relation exchange and sympathy-consent process. Relation exchange denotes interpersonal exchange of relationship. Sympathy-consent process denotes the interactive communication process between or among different cognitive systems of different human beings (Hume 1739; Smith 1759; Rhee 2012b).

Definition RX (relation exchange): Relation exchange denotes the interpersonal exchange of relationship.

Definition SCP (sympathy-consent process): Sympathy-consent process denotes the interactive communication process between or among different cognitive systems of different human beings.

According to the findings of behavioral studies, human cognitive system relies more on perception and intuition than on reasoning. Rational agent model is built exclusively on the reasoning with value and cost as instrumental measures. Hence, rational agent model could use price as essential instrument which integrates different cognitive systems of different individuals. However, if human cognitive system relies more on perception and intuition than on reasoning, price is no longer able to assume such integrating role (Kahneman 2003). Under Assumption HCS (human cognitive system) or by assuming Untenable CMVCI, it becomes not price but sympathy and consent process that integrate different cognitive systems of different individuals. Exchange has to replace price by sympathy-consent process as integrating mediatory instrument (Rhee 2012b, 2016b).

The analytical findings when exchange activities are recognized in the open/indeterminate system rather than in the closed/determinate system are tremendous. Most of all, the instance of relation exchange comes off coincidentally, though its effect imbeds into human cognitive system as content (Kahneman 2003 Figure 1). In other words, relation exchange as well as sympathy-consent process is path dependent. Price becomes a part of the sympathy-consent

process, which will be elaborated later in this paper.

An idiosyncratic feature of relation exchange is wavering. Indeterminate state like wavering doesn't exist in the closed/determinate system such as rational agent model. Either action or no action exists in rational agent model. However, wavering is an idiosyncratic feature of relation exchange in the open/indeterminate system. Wavering is frequent and usual behavior of life, the existential entity of which is unable to be recognized in rational agent model.⁶

Set R denotes the set of relation exchanges. Then, Set R is a subset of Set W.

$$\text{Set R} = \{r: \text{interpersonal exchange of relationship}\} \quad (7)$$

$$\text{Set R} \subset \text{Set W}$$

Sympathy-consent process (SCP) is relation exchange mapping π with topology T from interpersonal cognitive interface $\prod_i X_i$ to relation exchange Set R.

$$\text{Relation exchange mapping } \pi: \prod_i \text{Set } X_i \rightarrow \text{Set R} \quad (8)$$

where \prod_i indicates Cartesian product. Relation exchange mapping π is not function in general because the value of relation exchange mapping π is not uniquely determined, i.e., is indeterminate.

To enhance our understanding of relation exchange mapping, let's introduce the market exchange case of Apple smart phone (A-phone in short). Rational agent model presumes that both buyers and sellers meet in the market with their schedules of demand and supply functions because they can measure the values and costs of A-phone. Under Assumption HCS, Definition CMVCI is untenable. Buyers' knowledge and understanding of A-phone is merely their perception, not the value and cost of the thing in itself. Buyers' perception is vulnerable

⁶ The market failure of Akerlof's used car market may be better understood if it is interpreted as wavering behavior (Akerlof 1970). The institutionalization of standards for quality assessment will help to restrain wavering behavior and prompt a huge increase in exchange.

to the influence of marketing activities. Buyers' cognition remains undetermined between the image, which is influenced by Apple's marketing activities, and suspicion.

Supplier Apple's position is no better. Although cost schedule of production is often believed to be unshaking, the real story is not so taut (metering Alchian and Demsetz 1972; hold-up Klein et al 1978; agency Jensen and Meckling 1976; asset specificity Williamson 1975, 1985; incomplete contract Grossman and Hart 1986). On the other hand, marketing action may be considered as opportunistic behavior. CEOs fill the vacuum, which is created by buyer's cognitive cavity and uncertain components of production, with strategic management of entrepreneurship. Entrepreneurship is really actions of sympathy-consent process.

Exchange transaction of A-phone is determined as the outcome of sympathy-consent process, not the outcome of market clearing system $D(p)=S(p)$. So, exchange transaction is indeterminate, incomplete, coincidental, emotional, path-dependent, and wavering process. It is different from the case of rational agent model because in the case of the latter, exchange transaction is determinate and complete process. It is precisely the case of Akerlof's lemon market (Akerlof 1970). Akerlof confined lemon market to limited cases. However, Assumption HCS generalizes the case to every exchange transaction.

What is the role of price in the relation exchange mapping? It is a partial component of sympathy-consent process which is determined by haggling, auction, offer/bid, mark-up, and administered pricing.

In fact, under Assumption HCS, exchange is the outcome of sympathy-consent process. Hence, the exchange can be extended to interpersonal interaction from the exchange transaction in the market. Trust, affection, friendship and so on are some of them, which grow out from interpersonal interaction that is sought after as human utilitarian propensity.

The question is whether relation exchange is more fundamental than value exchange of rational agent model. It is the matter of legitimacy of relation exchange vis-à-vis value exchange. Human cognitive system of behavioral studies vindicated the legitimacy. Then, can we establish the legitimacy of relation exchange as mathematical analysis for the securing of the model for bounded rationality? Now, we need to compare relation exchange with value exchange.

Let v denotes optimization-equilibrium algorithm (OEA) mapping in Set Z .

Optimization-equilibrium algorithm (OEA) mapping $v: \prod_i \text{Set } Y_i \rightarrow \text{Set } V$ (9)

where Set V denotes the set of value exchanges. Set V is a subset of Set Z. $\text{Set V} \subset \text{Set Z}$. OEA mapping v is function in general and is attained by means of price as mediatory instrument (Arrow and Debreu 1954; Arrow and Hahn 1971).

Now, we have two questions to adjudicate the fundamentality between relation exchange and value exchange. One is if we can extend relation exchange mapping π to recognize Set V. The other is if we can extend OEA mapping v to recognize Set R. Let's take the first question into consideration firstly.

We can define sympathy-consent-free mapping ψ with topology T , which maps from Set X to $\{\emptyset\}$. It is called sympathy-consent-free (SCF) mapping (Rhee 2012b, 2016b).

Definition Sympathy-consent-free (SCF) mapping ψ : $\psi: \prod_i \text{Set } X_i \rightarrow \{\emptyset\}$. (10)

Proposition SCF mapping ψ belongs to SCP mapping π : SCF mapping ψ belongs to relation exchange mapping π , i.e., $\psi \in \pi$.

Proof:

SCP mapping or relation exchange mapping π as well as SCF mapping ψ share topology T . So, both mappings share empty set $\{\emptyset\}$, which is defined on Set Z at Untenable CMVCI. Hence, $\psi \in \pi$. \square

The affirmative answer to the first question is vindicated. Upon acknowledging that the open/indeterminate system, the appearance of which is upheld by Untenable CMVCI, builds an open set, Topological Space (W, T) on Set W allows the vindication for the legitimacy to extend SCP or relation exchange mapping π to value exchange Set Z which becomes empty set $\{\emptyset\}$ at Untenable CMVCI.

The second question asks if OEA mapping v can be extended from Set Z to Set W. From Proposition Open Set W and Proposition Closed Set Z, Set Z is closed set and Set W is open set. So, the second question becomes if OEA mapping v which is defined in closed set Z can be extended to open set W. To attain this mapping, we should be able to build topological space on Set Z which is extended to Set W, which is not possible.

Proposition Inability of OEA mapping v to be extended to Set W: OEA mapping v which is defined in Closed Set Z cannot be extended to Open Set W.

Proof:

Open set W can define closed set Z, but not vice versa. Hence, OEA mapping v cannot be extended to Open Set W. \square

From the studies of these two propositions, we found the answer to the question: relation exchange is more fundamental than value exchange. This finding is critically important because it establishes the legitimacy for the introduction of relation exchange and sympathy-consent process as analytical dimension. Otherwise, value exchange of rational agent model can supersede the arguments of relation exchange and sympathy-consent process.⁷

Finding (1) Fundamentality of Relation Exchange: Relation exchange is more fundamental than value exchange.

Finding (2) Fundamentality of Sympathy-Consent Process: Sympathy-consent process is more fundamental than Optimization Equilibrium Algorithm.

Finding (3) Price as a Part of Sympathy-Consent Process: Price becomes a part of sympathy-consent process in the sympathy-consent dimension.

These findings establish the sympathy-consent process as new analytical dimension which represent the dimension of bounded rationality in economics. The corresponding exchange is not value exchange of rational agent model, but relation exchange of human cognitive system. Other name of sympathy-consent process is the process of bounded rationality. Other name of sympathy-consent dimension is the dimension of bounded rationality.

⁷ The proof of the fundamentality of relation exchange was first introduced in Rhee (2012b), where the path dependence as the attribute of relation exchange and sympathy-consent process was used as instrument.

V Ramifications

What is indicated in Findings (1), (2), and (3) is that relation exchange replaces the role of value exchange in the analytics of economics and it is the sympathy-consent process, not market clearing system (MCS in short) that determines exchange. It is the setoff for the model of bounded rationality. We have to rely on experiences from which to draw out perception and intuition as navigator, rather than reasoning and optimization as the extension thereof, in order to attain the exchange transaction. Firstly, exchange becomes the outcome of sympathy-consent process (or the process of bounded rationality), not the outcome of market clearing system (MCS), i.e., $D(p) = S(p)$. Secondly, the augmented analytical dimension allows us to pull out from the optimization-equilibrium algorithm of the closed/determinate system and make a landing at the world of empiricism to perceive economic states of the open/indeterminate system.

Economics is heavily reliant on the analytical architecture which is built on MCS. The taxonomy of partial-general equilibrium analysis should be made up for by the phenomena of sympathy-consent process. The path dependence of price is a typical example. Before the introduction of empiricist approach, price was considered to be determined by MCS. However, upon the adoption of Assumption HCS, price becomes a part of the sympathy-consent process. It is not MCS, but haggling, auction, offer/bid, mark-up, administered pricing that determine pricing. It is profound change. The exchange, which is not confined to the market, is more highlighted than the market. In this regard, the law of one price (Lamont and Thaler 2003), rational expectation (Sargent and Wallace 1975), and efficient market hypothesis are bound to be reinterpreted.

The second point of change highlights the open/indeterminate system of nascent empiricist approach in contrasts with the closed/determinate system of rational agent model. Open/indeterminate system is epitomized by the indeterminateness of decision making like wavering behavior. Wavering is frequent phenomena of human action which ceaselessly confronts our minds at the moment of decision making. Wavering is not reined in by the change of price. Akerlof (1970) considered it as market failure at used car market when buyers reveal wavering action at seller's opportunistic behavior with informational advantage. However, economic agents, either buyer or seller, didn't leave the market. They are wavering. To perceive wavering behavior, sympathy-consent process has to be recognized as the analytic taxonomy. In other words, we have to accept the process of bounded rationality as analytical dimension.

The advantage of sympathy-consent process and relation exchange as its outgrowth is its ability to recognize the efficacy of institution on human action. Institutions like morality or law work on relation exchange and rein in opportunistic behavior, which soothes wavering behavior and lifts off the volume of exchange. Now, we come to understand the institutional profile of market, which has been missing in rational agent model. Market may be considered

as institutional profile which ameliorates wavering behavior and incites exchange transaction. It is open/indeterminate system. Hence, institution is not the only catalyst. The role of marketing or entrepreneurship is recognized as galvanizer of exchange transaction.

VI Concluding remarks

Human cognitive system begins with perception. Cognitive systems are distinguished by sensory order, according to which perceptions are perceived. The system of intuition constitutes the first tier, which denotes fast, parallel, automatic, effortless, associative, slow-learning, and emotional process of cognition (Kahneman 2003). It is more accessible process than the second tier of cognitive system. The second tier of system is reasoning, which is slow, serial, controlled, effortful, rule-governed, flexible, and neutral process of cognition. Rational agent model is built on the assumption that human cognitive system is the single tiered system which exclusively relies on reasoning.

Once we accept the human cognitive system which begins with perception, it opens the gateway to the empiricist approach. Perception is the experience of perception. Experiences happen coincidentally but makes efficacy to the following steps of cognitive process. Path dependence is the idiosyncratic attribute of behavioral approach. In Kahneman's terms, the process of cognition makes cognitive contents.

This world of empiricism is entirely different from that of value-cost rationalism. The former is open/indeterminate system, whereas the latter is closed/determinate system. This paper proved that open/indeterminate system is open set, whereas the closed/determinate system is closed set. Moreover, the latter becomes the empty set of the former. Hence, we can create topology space (W, T) . Making use of the property of topological space, the fundamentality of relation exchange over value exchange is proved. It vindicates the legitimacy of sympathy-consent dimension or the dimension of bounded rationality.

This finding is profound. Most of all, the analytics of economics is now able to conceive the open/indeterminate system and launch the approach of empiricism. Wavering is typical feature of open/indeterminate system, by means of which Akerlof's market failure turns out to be wavering behavior rather than the failure of market. Horizon of economics is stretched out to include non-market actions on top of market.

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