國立交通大學

資訊管理研究所

博 士 論 文

可變空間下的決策、習慣領域及認同圈的量化

Decision Making in Changeable Spaces, Habitual Domains, and Quantification of Identification Spheres

研 究 生： 黃鴻順

指導教授： 游伯龍 博士

中 華 民 國 一 百 零 一 年 三 月

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中文摘要

可變空間下的挑戰性問題存在許多複雜決策參數的特性，這些參數（例如準則、方案…等）可能隨著時間和環境的變動而改變。這些重要的參數也許是得到有效解答的關鍵，但潛藏在潛在領域的深處。在這快速變動的世界（包括科技和看法…），如果沒有注意到在可變空間下的問題，我們可能由於決策陷阱、決策盲點及決策震驚而容易導致嚴重的錯誤決策。本論文首先簡要敘述多目標決策的發展朝向可變空間下的挑戰性問題；接著闡述人類動態決策流程、習慣領域學說及認同圈，及其對尋找相關參數和決策的重要影響；接著介紹能力集合且說明在可變空間下的決策盲點、決策陷阱及決策震驚，並提供找出重要決策參數的方法及檢查表；接著提出一個系統性尋找重要決策參數的動態循環架構－「創新動態學」，該架構著重於潛在領域裡參數的動態變化；接著舉例說明習慣領域三大工具箱可幫助決策者深入潛在領域，擴展及豐盛決策者的習慣領域，讓決策者有系統的方法避免決策盲點和陷阱，更能有效地處理挑戰性問題

本論文用習慣領域的認同圈的概念，定義及探討認同函數、認同程度、認同矩陣、認同圈和不認同圈之量化與估算。並用兩個應用範例解說，人對人之間，針對某事件所形成的認同圈及其影響。範例一（見 7.1.）說明如何善用認同程度和認同圈的概念，制定新的選舉規則，這規則的最大特點之一，是選民對候選人表達認同程度，不是只有黑白或零（不認同）一（認同），選民也可以表達不認同程度，在此新規則下，眾多的選舉形式可展現出不同的選舉結果，被選上的人也較能反應民意。範例二（見 7.2.）說明如何善用認同矩陣，設定一個認同門檻，選出社群內最少或成本最低的成員組合（核心人物、意見領袖…），含蓋（影響、關照）所有關係人的數學規劃。當企業要進行新理念或產品推行時，若能先與這些核心人物進行理念的溝通或產品的試用，善用他們對社群組織成員的影響力，則企業可更能有效行銷新理念或新產品。

關鍵字：習慣領域，可變空間下之決策，能力集合分析，決策盲點，決策陷阱，決策震驚, 創新動態學，認同圈，不認同圈，認同函數，認同矩陣.

Decision Making in Changeable Spaces, Habitual Domains, and Quantification of Identification Spheres

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Abstract

Challenging decision problems in changeable spaces are characterized by existence of complex decision parameters that are changing with time and situations, including criteria and alternatives. Some of these parameters may be critical for their effective solutions, but hidden in the depth of potential domains. In this rapid changing world, including technology and attitude, without paying attention to the problems in changeable spaces, we could easily commit serious mistakes due to decision blinds, decision traps and/or decision shocks. The dissertation starts with a brief description of the evolution of MCDM (Multiple Criteria Decision Making) toward challenging problems in changeable spaces. Then it briefly sketches a dynamic human behavior mechanism, identification spheres, and habitual domain theory which provide an effective list for us to search relevant decision parameters and pave the way for latter discussion. Competence set analysis, derived from habitual domain, is then introduced to exemplify decision blinds, decision traps and decision shocks in challenging decision problems. Checking lists and methods for discovering blinds and traps and for dealing with shocks are also provided. Innovation dynamics, a systematic network of thoughts, is introduced to further look out relevant key parameters in dynamic challenging problems. The related academic subjects in each link of the innovation dynamics are also explained, which allow us to see the complexity and interconnectivities among different challenging problems in changeable spaces. Three habitual domain tool boxes to empower ourselves to expand and enrich our thoughts into the depth of the potential domains of the challenging problems are introduced, which allows us to more effectively identify hidden parameters, problems and competence sets to reduce decision blinds, avoid decision traps and solve the problems, or dissolve the problems before they occurs.

A quantitative approach to study the identification conception is proposed. Specifically, based on the definition of identification sphere of Habitual Domains Theory, we define and explain the concepts of identification function, degree of identification, identification matrices, identification spheres and dis-identification spheres. The quantitative concepts are then applied to formulate the mathematical models of election of a social group leader. The models consider both degree of identification and that of dis-identification. Different models lead to different results, which enrich our thinking about election. We also introduce mathematical programming models, utilizing identification matrices, and thresholds of identification, to find an optimal combination of key members to influence all targets in a social group. The results are important for marketing promotion of a new product, service or that of a new concept.

Keywords: Habitual domains; Decision Making in Changeable Spaces; Decision Blinds; Decision Traps; Decision Shocks; Competence Sets Analysis; Innovation Dynamics; Identification Sphere; Dis-identification Sphere; Identification Function, Identification Matrices.

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黃鴻順　謹誌於新竹

中華民國101年3月

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Chapter 1. Introduction

Every living system has a set of goals or equilibrium points to pursue and maintain, respectively. For example, we try to hit a mosquito when it approaches us because we do not want to be bitten. Most of the time, we are unsuccessful in hitting the mosquito because she wants to survive. Humans have attempted to exterminate mosquitoes, both manually and chemically. However, mosquitoes still ubiquitously exist because they succeed in their goals of "perpetuation of their species." Mosquitoes and higher living organisms, including humans, have multi-goals in the lives. In this example, mosquitoes have two goals, as follows: (i) survival, and (ii) perpetuation of their species. Humans at the higher or highest end of evolution have developed a set of complex goals, including the following: (i) survival and security, (ii) perpetuation of the species, (iii) feeling of self-importance, (iv) social approval, (v) sensuous gratification, (vi) cognitive consistency and curiosity, and (vii) self-actualization (Yu, 1990, 1995, 2002, 2009). Therefore, multiple criteria decision making (MCDM) problems, as part of the problems that living systems must solve, are not unusual.

Literature of human history recorded MCDM and their dynamic changes. However, the application of dynamic decision making problems into mathematical analysis began in the nineteenth century by economists and applied mathematicians, including Pareto, Edgeworth, Von Neumann, and Morgenstern (Yu, 1985; Zeleny, 1982). The rapid development of MCDM occurred by expanding single-criterion optimization to multiple-criteria optimization, considering decision dynamics, examining multiple decision makers in the decision process, and introducing uncertainty, and unknown and neural physiology in the complex system of decision making (Tzeng & Huang, 2011). In the last four decades, research on MCDM covered

a wide range of concepts, methodologies, and application areas, which resulted in a substantial number of studies (Dong et al., 2005; Peng et al.; Shi, 2001; Shi et al., 2007, 2009; Tzeng & Huang, 2011; Willenius et al., 2008; Yu, 1985). The challenging decision problems in changeable space have seldom been studied (Chen, 2010; Chen & Yu, 2009; Chen, Huang, & Yu, 2012; Yu & Chen, 2010a, 2010b).

Non-trivial decision making can be characterized by various dimensions of parameters that involve a number of elements, such as decision alternatives, decision criteria, decision outcomes, decision preferences, and decision information inputs. According to Yu (1990, 2002) and Yu and Chiang (2002), Non-trivial decision making also involves the following four environmental facets: decisions as a part of the behavior mechanism, stages of the decision process, the players involved, and unknowns in decision making. These parameters can interact with each other, and vary with time and situations, and with changes in the psychological states of the decision makers involved. Some of them are observable, whereas some are hidden and can be neglected. To demonstrate this occurrence, consider the following example.

Example 1: Dog food

To relieve concerns of pet owners regarding the problem of overweight dogs, a dog food company designed a special package of dog food that was both nutritious and could reduce the weight of dogs. The company wanted to know if this product can be popularized; therefore, a statistical test was conducted to ask pet owners if they wanted to buy this special package. The statistical testing market was positive, and the company started “mass production.” Its dog food supply fell short of meeting the overwhelming demand. Therefore, the company doubled its capacity. However, after

one to two months of excellent sales, the customers and wholesalers began to return the dog food package because the dogs did not like eating it.

Several parameters in human behavioral systems, such as goal setting, state evaluation, charge structure, attention allocation, information inputs, decision elements, and decision environmental facets are involved in Example 1. Some of these parameters are noticeable, whereas others are not. The dog food company observed the problem of overweight dogs, which created a high level of charge (a precursor of mental stress) to pet owners; they noticed the pain and frustration of pet owners. To make a correct decision, they conducted a statistical market test to determine if the new product was worth producing. The positive statistical testing result was a crucial (and observable) decision parameter (information inputs) that prompted the company of mass producing this dog food. However, they neglected the key players, the dogs, which was a critical parameter that determined the outcome of the decision. Their inability to recognize this hidden key parameter resulted in the failure of the dog food company.

The MCDM has evolved rapidly over the past five decades.

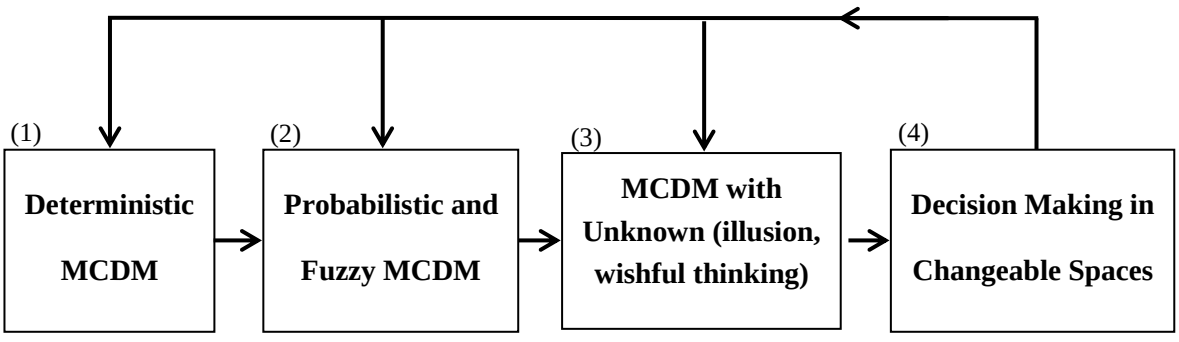


Figure 1. The evolution of MCDM.

Its evolution is depicted roughly in Figure 1. Although Figure 1 is

self-explanatory, a brief explanation is provided, as follows:

According to Habitual Domains (HDs) theory, human behavior gradually stabilizes, although it is dynamic. Therefore, people have *habitual* concepts and ways of thinking, acting, judging, and responding (Yu, 1990, 1995, 2002, 2009). The MCDM, as a part of human behaviors, may reach a steady state and exhibit habitual patterns with time. Consequently, in mathematical programming or ordinary decision-making problems, people may unwittingly assume that the decision parameters (or variables) are well-known or deterministic. Models and techniques for this type of problem belong to deterministic MCDM (box (1) in Figure 1). Subsequently, people become aware of the existence of decision parameters that are not deterministic. By assuming that these non-deterministic parameters vary with a certain shape of probabilistic distributions or fuzzy membership functions, researchers developed models of probabilistic and fuzzy MCDM (box (2) in Figure 1), such as Carlsson and Fuller (1996), Chiou and Tzeng (2002), Hsu et al. (2003), Lin et al. (2010), Ana and Francisco (2011), and Opricovic (2011). However, certain parameters may be intangible in reality. We may be unaware of their existence without special effort, as demonstrated in Example 1. Even when they are noticed, their dimensions, ranges, and shapes may not be easily predetermined or assumed, as shown in box (3) of Figure 1. The perception of decision makers may be subject to the influence by their wishful thinking and illusions. All intangible or invisible parameters can be grouped under an umbrella of "unknown." Decision models with these features, including contingency solution, are called *MCDM with unknown* (box (3) in Figure 1). However, several real challenging decision problems involve invisible parameters, and the related parameters are also changeable as the situation and psychological states of mind of the decision maker changes. Discovering and controlling the change

of these parameters is often a vital part of the process to solve challenging decision problems. This type of problems is called *decision making in changeable spaces* (box (4) in Figure 1) (Yu & Chianglin, 2006; Yu & Chen, 2010a, 2010b, 2010c). The main difference between the problems of boxes (3) and (4) is that box (3) supplants all unspecified parameters into "unknown," whereas box (4) actively searches for the unspecified parameters, which are treated as crucial variables for the solutions. Please refer to Appendix 1 for a more precise delineation of the main differences among the models of boxes (1) to (4).

Because most current MCDM studies (Dong et al., 2005; Peng et al.; Shi, 2001; Shi et al., 2007, 2009; Tzeng & Huang, 2011; Willenius et al., 2008; Yu, 1985) are based on the assumption that the parameters are well-known or partially (fuzzily or probabilistically) known, their results cannot be applied effectively in the challenging decision problems in changeable spaces. Optimal solutions to the challenging problems in changeable spaces are usually found after these parameters are properly located, studied, searched, and restructured. The challenging decision problems of boxes (3) and (4) may also contain a number of parameters with the same properties of those in boxes (1) and (2). Once the crucial parameters of challenging problems (boxes (3) and (4) in Figure 1) are explored and located properly, this problem may become a fuzzy or deterministic problem (boxes (1) and (2) in Figure 1), and the models and techniques developed in boxes (1) and (2) can subsequently be used to sharpen and/or identify the "best" solution for the problems (see Chapter 3 for a detailed classification of a routine, fuzzy, and challenging problem).

According to Yu (1990, 2002), "Superior strategists find the best strategies by changing the relevant parameters, while ordinary strategists find the optimal solutions

within some fixed parameters." Every living system has a set of goals or equilibrium points to pursue and maintain, respectively. We must interact with other people or organizations in our life processes. Theoretically, the interactions among people and/or organizations are the interactions of the HDs that they carry. The importance of knowing the HDs of ourselves, other people, and/or organizations cannot be overstated in solving nontrivial decision problems. HDs provides a set of unified concepts and techniques for us to sharpen our capacity to know ourselves, others, and environments, and to form optimal strategies for solving our problems (Yu, 2002). These concepts[1], in a similar manner to social comparison theory, identification spheres, and similarity effects, can be quantified for more specific use. Identification sphere is chosen because (i) it is an important phenomenon in human relation, an important part of human systems, and its pervasive influence on human behavior and decision making, including social networking, election, strategic alliance, marketing promotion, etc (Adler & Adler, 1987; Kreiner & Ashforth, 2004; Sluss & Ashforth, 2007; Yu, 2002), and (ii) by knowing a person's identification spheres over different events and people/organizations, to a large degree, we could roughly know that person's HDs. To illustrate this, chapters 6—7 will focus on the quantification and applications of identification spheres.

The main contributions of this dissertation can be listed as follows:

- This dissertation explores the dynamic nature of decision making. By being unaware of the dynamic nature of the decision problems, decision makers may unwittingly fall into decision blinds, traps (Yu & Chianglin, 2006), and shocks, and make considerable mistakes. Understanding the behavioral dynamics and

[1] Please see Yu (2002) for more concepts of HDs and it's significant impacts on decision making.

HDs of ourselves and others can enable us to examine, search, and identify the optimal change of the relevant parameters to become superior strategists. A checklist of decision parameters is provided to help decision makers gain insight into the challenging problems and their possible solutions in changeable spaces.

- Based on HD theory and competence set analysis (described in Chapter 3), a framework to solve challenging decision problems is provided, that is, Innovation Dynamics (Chen, 2010; Chen & Yu, 2009; Chen, Huang, & Yu, 2012; Yu & Chen, 2010a, 2010b). It systematically describes processes of dynamic decision making in changeable spaces. By examining the operations of each link in innovation dynamics, decision makers can understand if each link is properly developed to continually upgrade their products/services and create maximal value by relieving the pains and frustrations of customers in the potential domains (PDs, one of the four sub-concepts of HDs, is described in Section 2.1). This framework also indicates that each link must be properly examined and developed. Omitting any link can lead to substantial or disastrous mistakes.

- The quantitative model of identification spheres based on HD theory was first suggested in several research areas, including psychology, political science, economics, and management science (Adler & Adler, 1987; Kreiner & Ashforth, 2004; Sluss & Ashforth, 2007). We defined and explained the concepts of identification function, degree of identification, identification matrices, identification spheres, and dis-identification spheres. The quantitative concepts were subsequently applied to formulate the mathematical models of election of a social group leader. The models considered both degree of identification and that of dis-identification. Different models lead to different results, which enrich our

thinking on elections. We also introduced mathematical programming models, and the use of identification matrices and thresholds of identification to identify an optimal combination of key members, to influence all targets in a social group. The results are crucial for marketing promotion of a new product, service, or concept.

The remainder of this dissertation is divided into seven chapters. In Chapter 2, the relevant literature and concepts of HD and identification sphere are described, including their considerable effects on decision making.

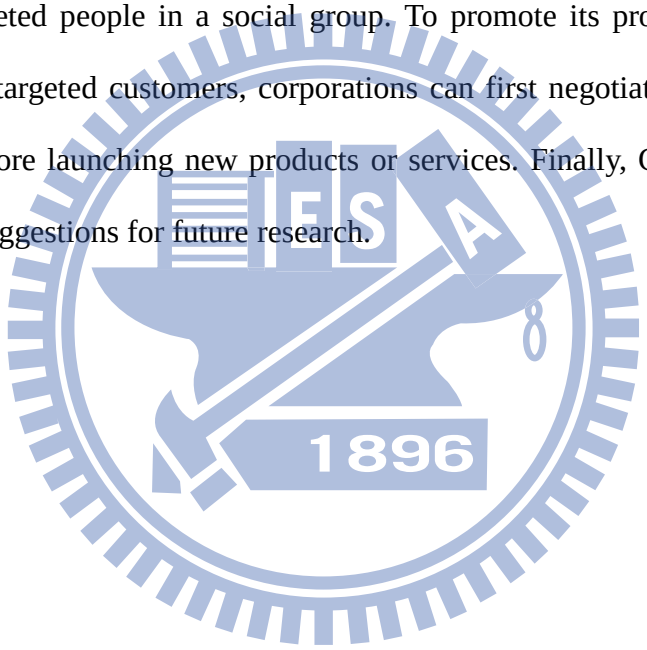
As a vital application of HD, the concept of competence set and related decision analysis, including decision blinds, decision trap, and decision shocks are introduced in Chapter 3. This chapter contains a description of a checklist of decision parameters.

In Chapter 4, an anatomy of Innovation Dynamics, a systematic framework, is described. Innovation dynamics consists of a number of key components, which involve a number of decision parameters. By assessing the list of these potential challenging problems and decision parameters, decision makers may gain insight into challenging problems and their possible solutions in changeable spaces.

Three tool boxes of HD are provided in Chapter 5 to help decision makers identify and discover hidden parameters, and to make effective decisions in changeable spaces. Chapter 6 details the formation of identification and quantitative identification model, including identification function, degree of identification, identification matrices, identification spheres, and dis-identification spheres.

Applications of identification spheres are explained in Chapter 7. Section 7.1

provides the applications of the quantitative model to electing a group leader. In this approach, voters can express their degree of identification with candidates, as well their degree of dis-identification. Furthermore, we present various forms of election by using this new rule of election, which leads to various election results and enriches our thinking on elections. Section 7.2 presents the application of the introduced identification concepts to marketing promotion. Specifically, we introduce a mathematical programming model, and the use of identification matrices and thresholds of identification to identify an optimal combination of key members to influence all targeted people in a social group. To promote its products or services effectively to its targeted customers, corporations can first negotiate with this set of key members before launching new products or services. Finally, Chapter 8 offers a conclusion and suggestions for future research.

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Chapter 2. Literature Review on Habitual Domains Theory and Identification Spheres

2.1. Habitual domains theory

Habitual domains was first suggested in 1977 (Yu, 1977) and further developed by Yu and his associates (Chan and Yu 1985; Yu 1980, 1981, 1985, 1990, 1991, 1995, 2002, 2009 and quotes therein). It states that over a period of time, the set of ideas and concepts which we encode and store in our brain can gradually stabilize in certain domain, known as **Habitual Domains (HDs)**; unless there is an occurrence of extraordinary events, our thinking processes will reach some steady state or may even become fixed. This phenomenon can be proved mathematically (Chan & Yu, 1985; Yu, 1985). To lubricate our discussion, let us consider the following example.

Example 2: What is it inside the frame?

Assume the frames of perception are represented by the "lighted" (white) areas as illustrated progressively in Figure 2(a) to 2(d). In Figure 2(a), we can see something fuzzy in the lighted area, but do not understand what is in the frame; but when our frame is expanded, as in Figure 2(b), we might be able to guess it is "ICE". Progressively, as the lighted area gets larger, we see "NICE" in Figure 2(c) and then "NOT NICE" as in Figure 2(d).

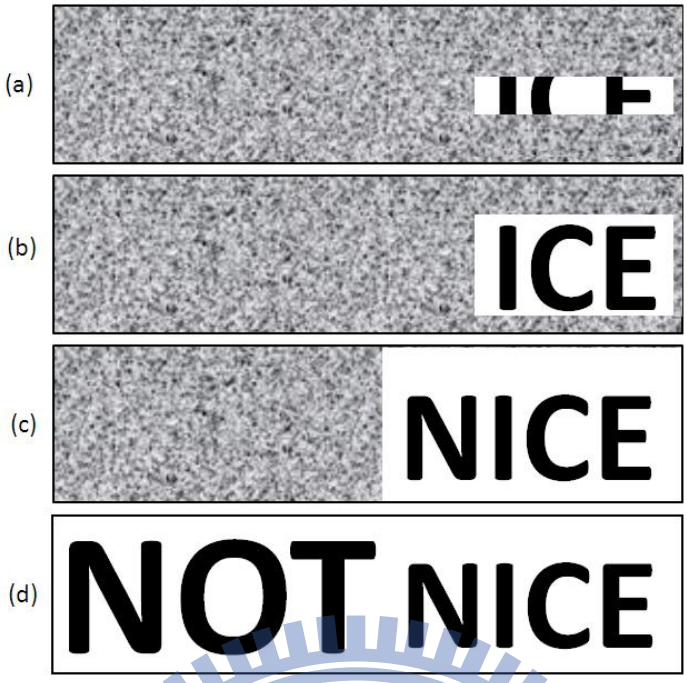

Figure 2. NOT NICE

Example 2 illustrates that as our perception frames are enlarged, we could see the picture clearer with fuzziness reduced. In terms of habitual domains, as our HDs expand, we could see the problems clearer with fuzziness reduced.

In terms of HD, it is related to the concepts of circuit patterns, attention allocation, analogy and association, etc. We shall introduce these concepts of HDs and the human behavior mechanism as to understand the hidden parameters that might have great impacts on our decision making.

Habitual domains at time t, HD_t, include the following four sub-concepts:

(i) *Potential domain*, designated by PD_t, is the collection of all ideas and operators (thinking processes) which can be potentially activated with respect to specific events or problems by one person or by one organization at time t. In general, the larger the PD_t, the more likely that a larger set of ideas and operators will be

activated, holding all other things equal.

(ii) *Actual domain*, designated by AD_t, is the collection of ideas and operators which are actually activated in our minds at time *t*. Note that not all the ideas and operators in the potential domain can be actually activated. Also note that the AD_t is a subset of the PD_t, that is $AD_t \subset PD_t$.

(iii) *Activation probability*, designated by AP_t, is defined for each subset of PD_t and is the probability that a subset of PD_t is actually activated or is in AD_t. For example, people who emphasize profit may be more likely to activate the idea of money, while people who study mathematics may be more likely to generate equations.

(iv) *Reachable domain*, designated by RD_t, is the collection of ideas and operators which can be generated from a given set in an AD_t. In general, the larger the idea set and/or operator set in AD_t, the larger the RD_t.

At any point in time, without specification, HD_t is the collection of the above four subsets. That is,

$$HD_t = \{PD_t, AD_t, AP_t, RD_t\}$$

Note it is humans that make decisions. Understanding human behavioral systems plays a vital role in making good decisions. The complex processes of human behaviors have a common denominator resulting from a common behavior mechanism. The mechanism depicts the dynamics of human behavior. Based on the literature of psychology, neural physiology, dynamic optimization theory, and system science, Yu (1980, 1981, 1985, 1990, 2002 and 2009) described a dynamic human behavior mechanism as presented in Figure 3 which is briefly explained below:

(i) **Box (1)** is our brain and its extended nervous system. Its functions may be described by the four hypotheses (**H1-H4**) in Table 1.

(ii) **Boxes (2)-(3)** represent two basic functions of our mind, Goal Setting and State Evaluation, explained by **H5** in Table 2.

(iii) **Boxes (4)-(6)** represent how we allocate our attention to various events, described by **H6** in Table 2.

(iv) **Boxes (8)-(9), (10)** and **(14)** represent a *least resistance principle* which humans use to release their charges (precursors of mental stress), described by **H7** in Table 2.

(v) **Boxes (7), (12)-(13)** and **(11)** represent the information input into our information processing center (**Box (1)**). **Boxes (10) and (11)** are two important functions of human thinking and information processing. **Boxes (7), (12)-(13)** represent external information inputs, an important parameter in decision making, which are explained in **H8** in Table 2.

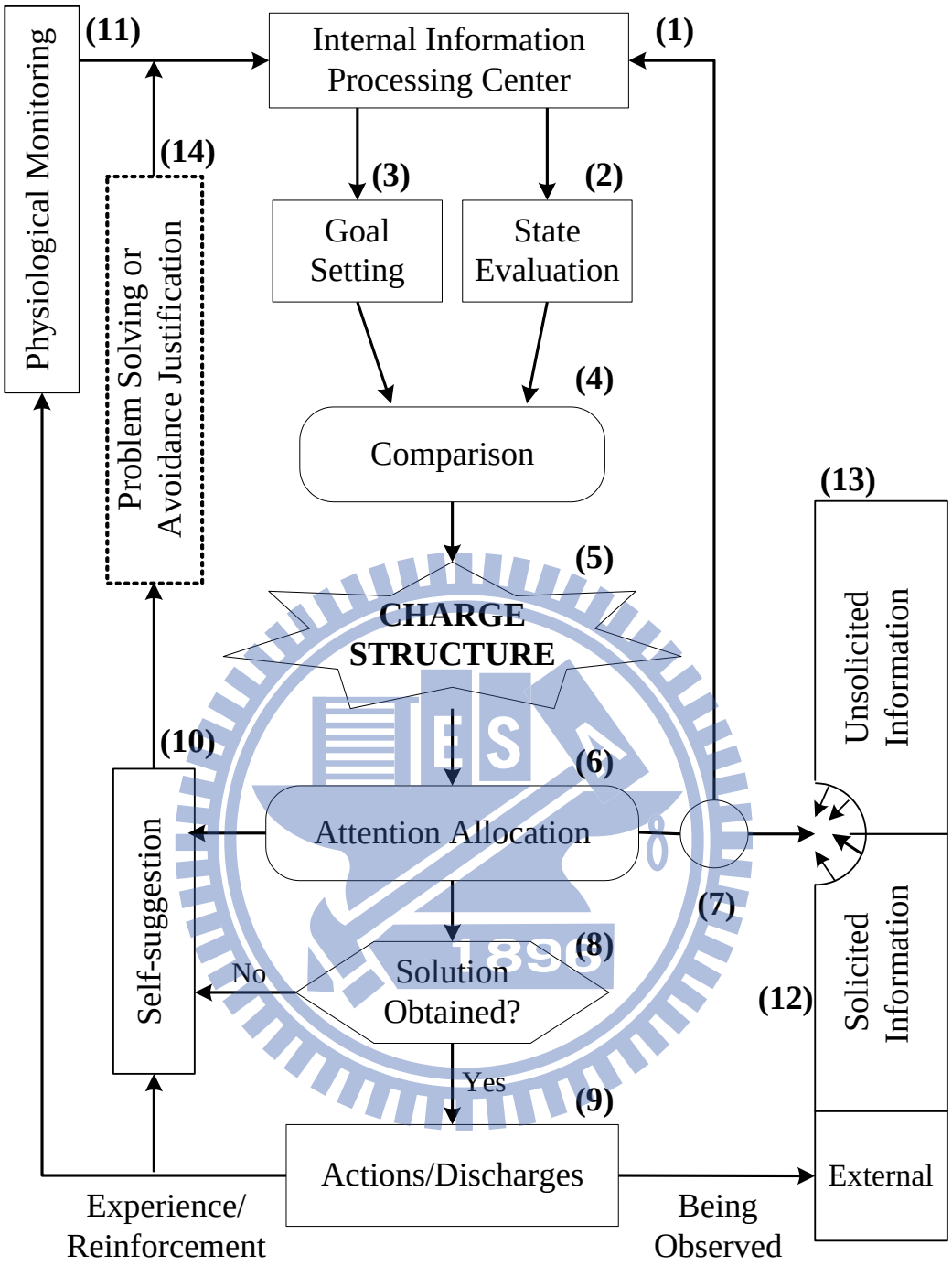

Figure 3. The behavior mechanism

From "Habitual domains and forming winning strategies" by Yu, P. L., 2002, p.26. Taiwan: NCTU Press.

Table 1. Four hypotheses of brain operation

Hypotheses		Descriptions
H1	Circuit Pattern Hypothesis	*Thoughts, concepts or ideas are represented by circuit patterns of the brain. The circuit patterns will be reinforced when the corresponding thoughts or ideas are repeated. Furthermore, the stronger the circuit patterns, the more easily the corresponding thoughts or ideas are retrieved in our thinking and decision making processes.*
H2	Unlimited Capacity Hypothesis	*Practically every normal brain has the capacity to encode and store all thoughts, concepts and messages that one intends to.*
H3	Efficient Restructuring Hypothesis	*The encoded thoughts, concepts and messages (H1) are organized and stored systematically as data bases for efficient retrieving. Furthermore, according to the dictation of attention they are continuously restructured so that relevant ones can be efficiently retrieved to release charges. (Precursors of mental stress, see H6.)*
H4	Analogy/Association Hypothesis	*The perception of new events, subjects, or ideas can be learned primarily by analogy and/or association with what is already known. When faced with a new event, subject, or idea, the brain first investigates its features and attributes in order to establish a relationship with what is already known by analogy and/or association. Once the right relationship has been established, the whole of the past knowledge (preexisting memory structure) is automatically brought to bear on the interpretation and understanding of the new event, subject or idea.*

From "Habitual domains and forming winning strategies" by Yu, P. L., 2002. Taiwan: NCTU Press.

Table 2. Four hypotheses of mind operation.

	Hypotheses	Descriptions
H5	Goal Setting and State Evaluation Hypothesis	*Each one of us has a set of goal functions and for each goal function we have an ideal state or equilibrium point to reach and maintain (goal setting). We continuously monitor, consciously or subconsciously, where we are relative to the ideal state or equilibrium point (state evaluation).*
H6	Charge Structure and Attention Allocation Hypothesis	*Each event is related to a set of goal functions. When there is an unfavorable deviation of the perceived value from the ideal, each goal function will produce various levels of charge (a precursor of mental stress). The totality of the charges by all goal functions is called the* ***charge structure*** *and it can change dynamically. At any point in time, our attention will be paid to the event which has the most influence on our charge structure.*
H7	Discharge Hypothesis	*To release charges, we tend to select the action which yields the lowest remaining charge (the remaining charge is the resistance to the total discharge) and this is called the least resistance principle.*
H8	Information Inputs Hypothesis	*Humans have innate needs to gather external information. Unless attention is paid, external information inputs may not be processed.*

From "Habitual domains and forming winning strategies" by Yu, P. L., 2002. Taiwan: NCTU Press.

Note that there are four hypotheses (H1-H4 of Table 1) describing the information processing functions of the **brain** and four hypotheses (H5-H8 of Table 2) describing the general framework of the operation of our **mind**.

From the behavior mechanism of Figure 3 and the eight hypotheses, we notice that human's behavioral system involves the following parameters: *goal setting, state evaluation, charge structure, attention allocation, information inputs, physiological monitoring, memory,* etc. Each parameter also involves complex subsystems. For instance, goal setting involves the following subparameters: survival and security,

perpetuation of the species, feelings of self-importance, social approval, sensuous gratification, cognitive consistency and curiosity, self-actualization, etc.

Recall in Example 1, the overweight problem of dogs created high level of charge to pet owners (H5-H6). It is the observable parameters in actual domain, AD_t, that affected the company to make decisions (H5-H8 of company). As a way to reduce fuzziness and unknown, a statistical market test was conducted to see if the new product worth producing (H5-H8). Here, the parameters of goal setting and state evaluation were involved. The positive statistical testing result and sales (information inputs, in actual domain, AD_t) prompted the company to massively produce this dog food (goal setting and state evaluation again, in reachable domain, RD_t). Unfortunately they neglected the key players in potential domain, PD_t, the dogs, which was a critical parameter that determines the outcome of the decision making. Note that H1-H4 are implicit in the above statements.

In Example 2, when we just arrive at Figure 2(a), our HD is unable to comprehend what in frame (H1-H4). The fuzziness may prompt us to expand our HD or explore more about the frame, "curiosity" in the goal setting may create high level of charge (H5-H6). As we progressively move to Figure 2(b)-Figure 2(d) H5-H7 can play the vital role interactively in the decision. If the progressive expansion is accomplished with the external world, then H8 is involved. Note, H1-H4 are also actively involved in the decision of moving from Figure 2(a) to Figure 2(d).

As people change any or some of these parameters, his/her perception and/or decision will change. Awareness of the existence and changes of the relevant parameters play an important role in understanding human behavior and making good decisions. For more details, see Yu (1990, 2002, 2009) and Yu & Chiang (1999).

2.2. Identification and identification spheres

Identification is an important concept in numerous areas, such as politics, economics, and management. For example, the identification of the public with political leaders, party philosophy, economic policy, corporate leaders, and corporate operational policy, has great impact on leadership, team building, coalitions, and effectiveness and efficiency of policy execution (Adler & Adler, 1987; Kreiner & Ashforth, 2004; Sluss & Ashforth, 2007).

The concept of identification as used by psychologists refers to a process in which an individual connects with other individuals or groups to improve his self-image (Adler & Adler, 1987). Previous studies have primarily focused on group-level organizational identification. Kreiner and Ashforth (2004) indicated that organizational identification is the process in which an individual develops attachment and sense of belonging to a group through connecting individual identity with group identity. In recent years, researchers have discussed relational identification on an interpersonal level. Sluss and Ashforth (2007) defined relational identification as the process in which an individual defines himself through his relationships with others. When an individual positively identifies with others and feels there is consistency between him and others, he will connect with others to enhance his concept of self, and define himself according to the level of connection between himself and others.

Chien (2008) suggested that Identification and dis-identification both refer to defining oneself through a third person (organization). The degree of identification is the strength of connecting with a specific subject and that of defining oneself according to the attributes of the specific subject. Dis-identification refers to the process of cutting oneself off from a specific subject and determining self-boundaries through highlighting differences.

Yu (1990, 2002) suggested that identification can change with time, events and situations. He uses degree of identification, which is a function of time, events and situations, to quantify the degree of connection or identification among different people. From this function, he introduced identification spheres and dis-identification spheres. As an example, in a football game between a Canada team and an America

team, Canadians, in general, will cheer for the Canada team because they identify with that team. In other words, the Canada team is in their identification sphere while the America team may be in their dis-identification sphere. We can also say that Canadian have a high degree of identification with the Canada team and a low degree of identification with the America team.

Recall that degree of identification can change with time, events and situations. At a certain point in time, with specific people, events, and surroundings, two people may be in each other's identification sphere. At another point in time, these two people may no longer identify with each other. For example, because Canadians identify with the Canada team, they cheer for it when it faces the America team in a sporting competition. However, if the issue were politics or religion, then positions could be very different, even mutually opposed. No two people's identification spheres remain entirely the same at various times and with different people and events.

Note that if someone is in the core of your identification sphere, he/she will have a great influence on you. Likewise, if someone makes you in the core of his/her identification sphere, you would have a significant influence on that individual. For example, a mother and child each makes the other an element of the core of his identification sphere. Should the mother disappear, the child would be inconsolable. Likewise, should the child disappear, the mother would also be greatly disturbed (Yu, 1990, 2002).

According to Yu (1990, 2002), most people believe that individuals who share similarities can more easily grow fond of or close to each other compared to individuals who are dissimilar. People more easily identify with those who share their perspective or principles (compared to those who do not), leading to the formation of organizations, groups, and communities where these individuals mutually influence each other.

It is human beings who are making decisions, including social networking. Without paying adequate attention to human system management it would be difficult to succeed in business. For further discussion in this aspect, see Zeleny (2005, 2006,

2008) and quotes therein. The uprising and success of social network are, to a large degree, based on human's strong desire to identify with other people or social group.

Psychologists have attempted to explain the thought processes and behavior associated with identification (Sandler, 2004 and quotes therein). Their researches have helped us understand the concept of identification. Nevertheless, there are no quantitative methods for studying this concept more precisely. Based on the concept of identification spheres (Yu, 1990, 2002), we explore a quantitative method for studying the concept of identification in chapter 6 and illustrate its applications in human networking, including election of a leader and effective marketing in chapter 7.


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Chapter 3. Competence Set and Analysis of Decision Problems

3.1. The concept of competence sets

For each decision problem or event *E*, there is a competence set (CS), consisting of ideas, knowledge, and skills for its effective solution (Yu, 2002). When the decision maker thinks he/she has already acquired and mastered the CS as perceived, he/she would feel comfortable making the decision. Note that through training, education, and experience, CS can be expanded and enriched (i.e. its number of elements can be increased and their corresponding activation probability can become larger). Given a problem different people might see the needed CS differently. Note that CS are dynamic and can change with time *t*. In order to more precisely understand CS, we shall distinguish "perceived" and "real" CS, and "perceived" and "real" skill set Sk (those CS acquired and/or mastered).

Thus, there are four basic elements of CS for a given problem *E*, described as follows (to emphasize the time, a subscript t is used):

(i) *The true competence set* ($Tr_t(E)$): consists of ideas, knowledge, skills, information and resources at time *t* that are truly needed for solving problem *E* successfully.

(ii) *The perceived competence set* ($Tr_t^*(E)$): the truly needed competence set at time *t* as *perceived* by the decision maker.

(iii) *The acquired skill set* ($Sk_t(E)$): consists of ideas, knowledge, skills, information and resources at time *t* that have actually been acquired by the decision maker.

(iv) *The perceived acquired skill set* ($Sk_t^*(E)$): the acquired skill set at time *t* as *perceived* by the decision maker.

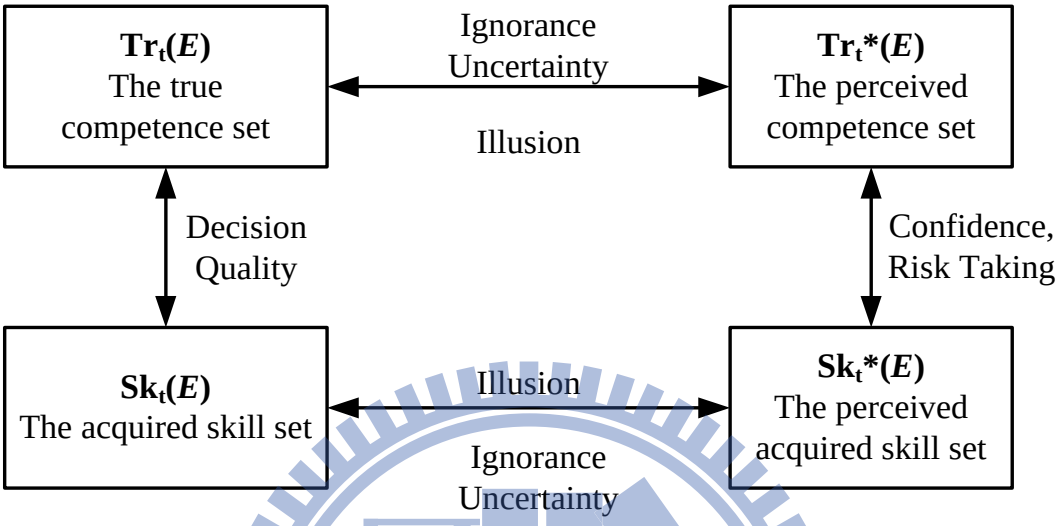

Figure 4. The interrelationships among four elements of CS
From "Habitual domains and forming winning strategies" by Yu, P. L., 2002, p255. Taiwan: NCTU Press.

Note that the above four elements are some special subsets of the HD of a decision problem *E*. According to the different relations among the four elements, we have the following observations:

(i) The gaps between the true competence set ($Tr_t(E)$ or $Sk_t(E)$) and perceived competence set ($Tr_t^*(E)$ or $Sk_t^*(E)$) are due to ignorance, uncertainty and illusion;

(ii) If $Tr_t^*(E)$ is much larger than $Sk_t^*(E)$, the decision maker would feel uncomfortable and lack of confidence to make good decisions; conversely, if $Sk_t^*(E)$ is much larger than $Tr_t^*(E)$, the decision maker would be fully confident in making decisions;

(iii) If $Sk_t(E)$ is much larger than $Sk_t^*(E)$, the decision maker underestimates his/her own competence; conversely, if $Sk_t^*(E)$ is much larger than $Sk_t(E)$, the decision maker overestimates his/her own competence;

(iv) If $Tr_t(E)$ is much larger than $Tr_t^*(E)$, the decision maker underestimates the difficulty of the problem E; conversely, if $Tr_t^*(E)$ is much larger than $Tr_t(E)$, the decision maker overestimates the difficulty of the problem E;

(v) If $Tr_t(E)$ is much larger than $Sk_t(E)$, and decision is based on $Sk_t(E)$, then the decision can be expected to be of low quality; conversely, if $Sk_t(E)$ is much larger than $Tr_t(E)$, then the decision can be expected to be of high quality.

3.2. Decision problems in terms of competence set

The study on CS analysis began with Yu (1989), as a derivative of HDs theory. Its mathematical foundation was built by Yu and Zhang (1989, 1990, and 1993). Recall section 2.1 that concepts and ideas are represented by circuit patterns in our brain. The concepts and ideas can be activated depending on our charge structures, attention allocation and the attended events. Through association and analogy and our HDs, given that an event has our attention, some ideas and concepts can be activated and some cannot. For instance, the event of talking about your boy/girl friend may trigger the activation of his/her name, image and some special memory about him or her. It may less likely activate the concepts of Ralph Waldo Emerson or your grandfather. Talking about an upcoming job interview may immediately activate the concepts of being neat, knowledgeable and a good listener. You would less likely activate the concept of earthquake or hurricane.

Given an event or a decision problem E which catches our attention at time t, the probability or propensity for an idea **I** or element in $Sk_t(E)$ to be activated is denoted by $P_t(\mathbf{I}, E)$. Like a conditional probability, we know that $0 \le P_t(\mathbf{I}, E) \le 1$, that $P_t(\mathbf{I}, E) = 0$ if **I** is unrelated to E or **I** is not an element of PD_t (potential domain) at time t, and that $P_t(\mathbf{I}, E) = 1$ if **I** is automatically activated in the thinking process whenever E is presented. Empirically, like probability functions, $P_t(\mathbf{I}, E)$ may be estimated by determining its relative frequency. For instance, if **I** is activated 7 out of 10 times whenever E is presented, then $P_t(\mathbf{I}, E)$ may be estimated at 0.7. Probability theory and statistics can then be used to estimate $P_t(\mathbf{I}, E)$.

Let us define the *α-core of competence set for E* at time t denoted by $C_t(\alpha, E)$ to be the collection of the skills or elements of $Sk_t(E)$ that can be activated with a propensity larger than or equal to α. That is, $C_t(\alpha, E) = \{\mathbf{I} | P_t(\mathbf{I}, E) \ge \alpha \}$

For ease of presentation, unless otherwise specified, assume $Tr_t(E)=Tr_t^*(E)$. Depending on $Tr_t(E)$, $Tr_t^*(E)$, $Sk_t(E)$ and $C_t(\alpha, E)$, we may classify decision problems into the following categories:

(i) If $Tr_t(E)$ is well known to decision maker and $Tr_t(E) \subset C_t(\alpha, E)$ or $Tr_t(E) \subset C_t(\alpha, E)$ with $\alpha \to 1$ or high value of α, then the problem is a *routine problem*, for which satisfactory solutions are readily known and routinely used. Note that the first condition means that the true CS is well-known, and the second condition means that the decision maker has mastered the set.

(ii) If $Tr_t(E)$ is only fuzzily known and may not be contained in $C_t(\alpha, E)$ with a low value of α, then the problem is a *fuzzy problem*, for which the solutions are fuzzily known. Note that as t progresses, through experience and training, the $Tr_t(E)$

can be gradually clarified and contained in $C_t(\alpha, E)$ with a high value of α. As much, the fuzzy problem can gradually become routine problem.

(iii) If $Tr_t(E)$ is unknown or partially contained in our $Sk_t(E)$, which implies that $Tr_t(E)$ cannot be contained in any $C_t(\alpha, E)$, no matter how small α is, then the problem is a *challenging problem*. Note that a decision problem E is also a challenging problem if $Tr_t(E)\backslash Tr_t^*(E)$ is very large (thus, E is largely misjudged), even $Tr_t^*(E)$ is contained largely in the $C_t(\alpha, E)$.

(iv) If $Tr_t(E)$ is outside of $Sk_t(E)$ for all time t, then we are very likely unable to understand and solve the problem E.

Each of the above four decision problems can be changed with time. The above categories can be depicted as in Figure 5.

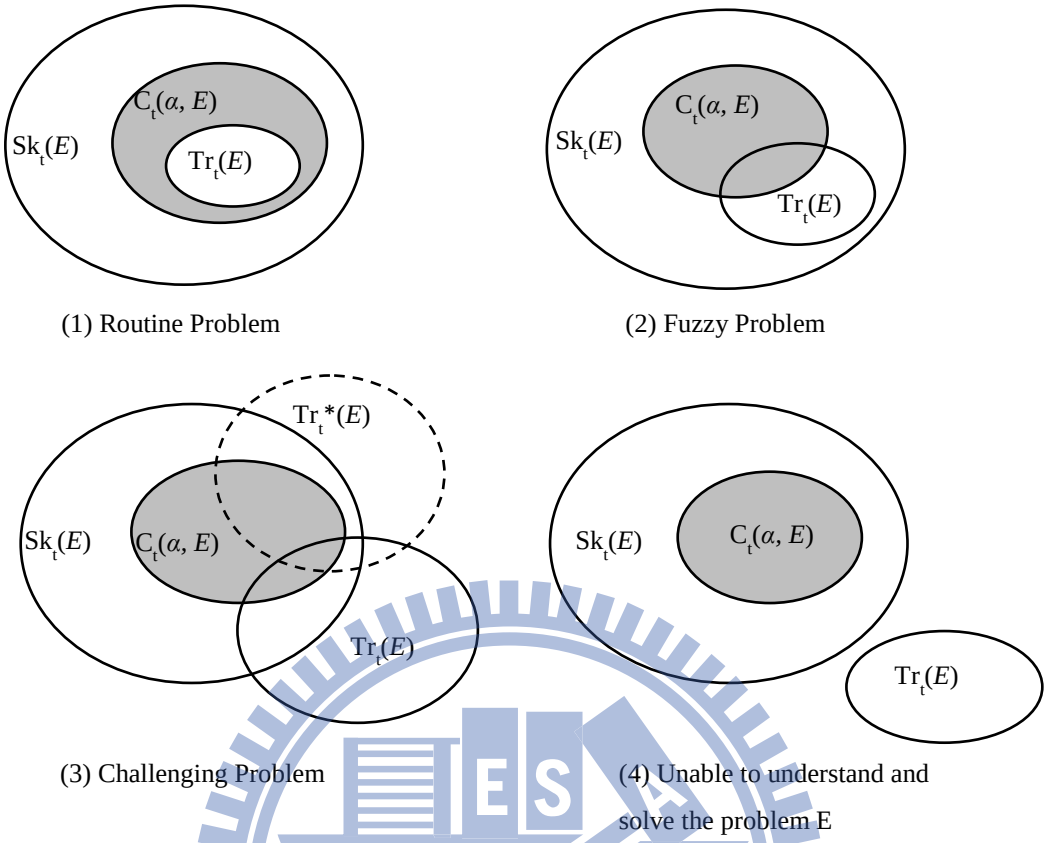

Figure 5. Routine, fuzzy, and challenging decision problems.
From "Habitual domains and forming winning strategies" by Yu, P. L., 2002, p233-246. Taiwan: NCTU Press.

3.3. Decision blinds, decision trap and decision shocks

Remark 3.1.

*Suppose that $C_t(\alpha, E)$ in Figure 5(3) is fixed for all α. Then $Tr_t(E)\backslash C_t(\alpha, E)$ would be the **decision blind**, the set of all the competences required but not seen by the decision makers at time t. The larger the decision blind, the more likely decision makers might make dangerous mistakes.*

*Suppose that $C_t(\alpha, E)$ is fixed for all t or trapped in a certain domain and $Tr_t(E)\backslash C_t(\alpha, E)$ is large even with small α. Then we tend to make mistake in decision and we are in a **decision trap**. Decision trap (i.e. $C_t(\alpha, E)$ is fixed, independent of t*

and α) can lead to dangerous mistake, especially when $Tr_t(E)$ changes rapidly with time and $Tr_t(E)\backslash C_t(\alpha, E)$ becomes very large (Yu, 2002; Yu & Chianglin, 2006; Yu & Chen, 2010c).

Note that in Example 1, the dog food companies had decision blind because it did not see the key parameters, the dogs, and their food preference. As a consequence, they also committed a "decision trap" in a broad sense.

CS for a problem is an HD projecting to that particular problem. Thus it, like HD, implicitly contains potential domains (PD_t), actual domains (AD_t), activation probability (AP_t), and reachable domain (RD_t) as discussed in section 2.

Let the core of CS be $C_t(\alpha, E)$ with a high level of α, the collection of ideas or skills that would almost surely be activated when problem E is presented. To be competitive and avoid decision blind and trap, the core CS should be adequately flexible, adaptable and can be easily integrated or disintegrated as needed to solve the arriving problems faster and more effectively than that of the competitors.

We can reduce decision blinds and/or avoid decision traps by systematically moving the actual domain AD_t or changing the relevant parameters. For illustration, assume that $Tr_t(E)=Tr_t^*(E)$ and $Sk_t(E)=Sk_t^*(E)$. Suppose that $Tr_t(E)$ is given as depicted in Figure 6. Suppose we start at point A as AD_t at time $t=0$. Let $RD_t(A)$ be the reachable domain generated from A. In terms of the definition of $C_t(\alpha, E)$, $RD_t(A)$ tend to be large if α is small and t is large; $RD_t(A)$ tend to be small if α is large and t is small.

For ease of presentation, assume that all points in researchable domains $RD_t(A)$ will be activated. Then as we move the AD_t from A to B, then to C, our decision blind reduces progressively from $Tr_t(E)\backslash RD_t(A)$ to $Tr_t(E)\backslash(RD_t(A) \cup RD_t(B))$ then $Tr_t(E)\backslash(RD_t(A) \cup RD_t(B) \cup RD_t(C))$. Note that here A, B, C,… can be the actual domains or relevant parameters. More details of changing parameters systematically and empower decision making by HD tools are provided in section 4 and 5.

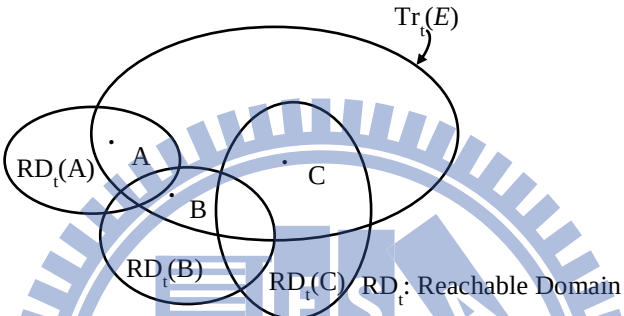

Figure 6. Decision blind reduces as we move our AD_t from A to B then to C.
From "Habitual domains and forming winning strategies" by Yu, P. L., 2002, p.226. Taiwan: NCTU Press.

Remark 3.2.

Note that the gaps between the true competence set ($Tr_t(E)$ or $Sk_t(E)$) and perceived competence set ($Tr_t^*(E)$ or $Sk_t^*(E)$) can be due to ignorance, uncertainty and illusion (Yu,2002). *Suppose that $C_t(\alpha, E)$ in Figure 5(3) is fixed for all t and $Tr_t(E)\backslash Tr_t^*(E)$ is getting larger, then we tend to make mistake in* ***decision shocks****. This can occur when unexpected things happen suddenly and must be solved in a short time, and we have no abilities (true competences) to cope with it within some allowable time. Normally, this situation let us stay in a very highly charged state of mind in short time, and we have difficulty to find a good solution to release the charge.* For instance, in Example 1, when the wholesalers and customers began to return the

dog food packages, might give the company a decision shock.

In front of decision shock, people may be so overwhelmed by possible disaster or serious impacts on their life goals, that they may not be able to see some good ideas in the potential domain (PD_t) of CS. The following steps, by shifting *attention* (which is a parameter, see section 2.1), might help decision maker to cool off as to be more able to see the depth of the potential domain to find good solutions.

Step 1: Ask if I could solve this problem successfully, my CS would be increased, what would be the good impacts of these increases of CS on my career and on my life, considering with time of 1 year, 2 years, 3 or 5…year later. (In this step, we will move out attention to see the bright side of the challenging problem.)

Step 2: Ask what are those competences needed to solve the problem effectively. (Locating and discovering the competence for solving the problem.)

Step 3: Ask how to effectively obtain or acquire those elements in the CS. (From experts, or our colleagues, friends, even our partners in supply chain. This will allow us to get into the potential domains of our self and other people, and expand and enrich our potential domain.)

Step 4: Ask how do I acquire those elements in the CS and solve the problems, and enjoy the process of doing so.

Note in step 2 and step 3, we get into the active problem solving process; in step 4, we set our mind to enjoy, not avoid or simply suffer from the occurrence of decision shock. When we set our mind to enjoy, our mind tends to open as to be able

to absorb new idea, acquire ideas more effectively.

3.4. A checking list of decision parameters

There are many parameters in decision problems, especially in challenging problems. In addition, the parameters themselves can vary over certain ranges or domains. All of these make challenging decision problems very complex. To avoid distraction, the interested readers are referred to Appendix 2 and Appendix 3 which summarize the sub-parameters within the major parameters for evaluating a corporation for acquisition problems (Datta & Yu, 1991). Every parameter could be considered in either challenging problems or fuzzy problems and routine problems. Take the *market parameter* (Kotler & Keller, 2011) for example, as depicted in Figure 7, the features and configuration of the products could be a challenging problem because their success is highly related to the features and configurations of the competitors' product, and to the potential consumers' preference. It is also related to technology advancement and competitor strategies. Once the features and configuration of the products are determined, its corresponding design and production can be set. The problems can then be reduced to a set of routine problems or fuzzy problems, if there are no major technical problems.

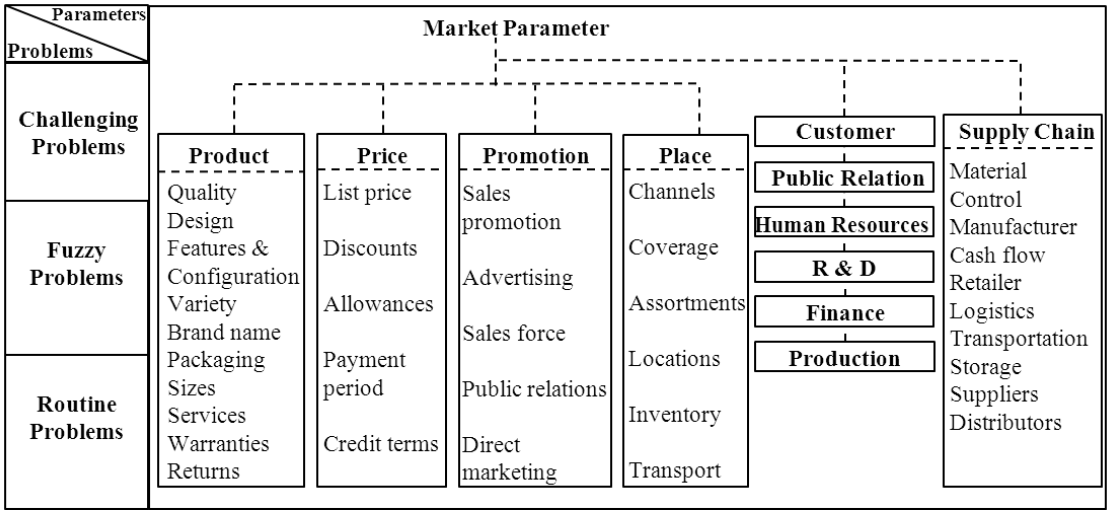

Figure 7. Decision problems in terms of market parameter.

Let us explain another example, *channels* within the *place* parameter in Figure 7. There are so many channels to reach out the potential customer. First, we need to determine who the potential customers are. What are the most effective ways to reach the potential customers over so many channels? These could be challenging or fuzzy problems. Once, the channel is determined, the execution could be becoming more routine problem. Note that these market parameters can be interrelated. In general, the parameters (major parameter) at a higher level of Figure 7 contain more complex challenging problems and less routine problems; those parameter (subparameter or sub-subparameter) at a lower of Figure 7 contain less challenging problem and more routine problems.

Most of these parameters are interrelated. If one competitor changes the features and configuration of its product, it may cause a series of changes of that of its competitors. As an example, the recent emergence of iPad and iPhone by Apple Inc., undoubtedly has caused of series of changes in product features and configurations of its competitors, which can prompt Apple to redesign its features and configuration as to

maintain competitiveness. Consciously being aware of these decision parameters (especially those in PD_t) will help decision makers reduce decision blind, and avoid decision trap and decision shock, and improve the quality of the decision making. See chapter 4 for further discussion.

It's worth to mention that top managers make decisions affecting the entirety of the firm. Top managers in most organizations have a great deal of managerial experience and have moved up through the ranks of management within the company or in another firm. For effective decision making and execution, top managers should pay more attention to challenging problems, including exploring, controlling, and restructuring the key decision parameters in the potential domain (PD_t).

3.5. Research issues of competence set analysis

CS analysis has two inherent domains: competence domain and problem domain. Like HDs, each domain has its actual domain and potential domain, as depicted in Figure 8.

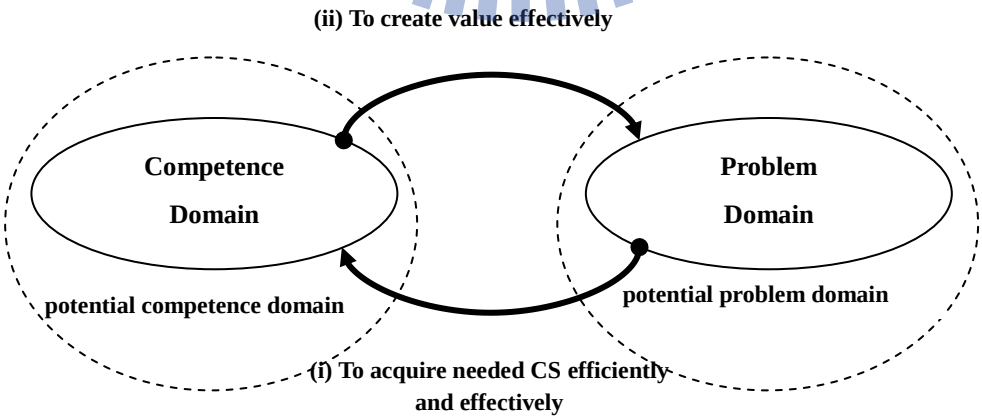

Figure 8. Two domains of competence set analysis

From "Habitual domains and forming winning strategies" by Yu, P. L., 2002, p.256. Taiwan: NCTU Press.

From these two domains, there are two main research directions:

(i) Given a problem or set of problems, what is the needed CS? How to acquire it efficiently and effectively? A mathematical foundation for such competence analysis is provided by Yu and Zhang (1990). Under some suitable assumptions, the problem can be formulated and solved by decision tree, graph theory, spanning trees, spanning tables and mathematical programming (Feng & Yu, 1998; Huang, Wang & Yu, 2004; Li & Yu, 1994; Li, Chiang & Yu, 2000; Li, 2004; Lin, 2006; Shi & Yu, 1996; Yu & Zhang, 1989 and quotes therein). Earlier researches have focused mostly on the deterministic situation, as mentioned in Chapter 1. However, one could remove this assumption to include uncertainty, fuzziness, and unknowns. In the recent studies, some heuristic methods, such as genetic algorithm (GA), hybrid genetic algorithm (hGA), multicriteria genetic algorithm, multi-objective evolutionary algorithm (MOEA), data mining technology, and forest learning technique have also been incorporated into the analysis of CS expansion (Chen, 2002; Hu, Chen, Tzeng & Chiu, 2003; Huang, Ong & Tzeng, 2006; Li, 2004; Opricovic & Tzeng, 2003 and quotes therein).

(ii) Given a CS, how to locate a set of problems to solve as to maximize the value of the competence? There are lots of studies of CSs analysis working in this direction. For example, Chen (2001) established several indices that have impact on consumers decision making and provided a framework for helping firms in expanding the benefits of their products to fully address the consumer's needs. Hu *et al* (2002, 2004) generate learning sequences for decision makers through CSs expansion to help them make better decisions. See Reference (Yu & Chen, 2010a; Chianglin, Lai & Yu, 2007; Chang & Chen) for more discussion of value creation.

Indeed, how to maximize one's existing CSs as to create value is a challenging problem for individuals and corporations. In the next section we will propose an integrated framework, innovation dynamics, which emphasizes decision making in changeable spaces and focuses on the exploration of parameters in potential domains. The framework allows us to get into the depth of potential domains to explore the expansion of CSs and creation of value.

Chapter 4. Innovation Dynamics: A framework to gain insight to see challenging problems and their possible solution in changeable spaces

In order to facilitate our presentation, let us consider the following examples.

Example 3: Nokia (adopted and summarized from Gartner (2011); Ben-Aaron (2009) and Ewen (2010))

Nokia, the world's largest manufacturer of mobile phones, was one of the key developers of GSM (Global System for Mobile Communications), the second-generation (2G) mobile technology. GSM's high-quality voice calls, easy international roaming and support for new services like short message service (SMS) laid the foundations for a worldwide boom in mobile phone use. Unlike its main competitor, Motorola, which emphasized the product functionality, Nokia endeavored to develop mobile phones that were not only durable but also attractive in outlook. Its innovative product design were so popular that by the time when GSM came to dominate the world of mobile telephony in the 1990s, Nokia beat all the other competitors such as Motorola, Ericsson, Siemens, etc. and became the top winner in the mobile communication industry.

Unfortunately, when the main trend of mobile telephony came into the third generation (3G) from 2G, Nokia’s operating platform for smartphones, Symbian, cannot keep the company in the leading position. The basic functions of Symbian system worked fine, but as users’ requirement in mobile communication were getting more complicated, Symbian system appeared to be inflexible and could not satisfy the users.

Nokia started to lose its market share when Apple's iPhone was launched. Its initial reaction to iPhone explored Nokia's stepping into decision blinds: "we'd tried touchscreens before, and people didn't like them." Nokia's underestimations and misjudgments to iPhone, including that it had no multimedia messaging (MMS) capability, the reception and sound quality were poor, it could not be used with one hand, etc., prevented the company from exploring the dynamic change of customers need and developing products that the customers really want. Although being very good at the beginning of the mobile era, Nokia have lost largely the game at the time being of 2011.

Example 4: Quick barber shop (adapted and summarized from the Economist (2006) and QB-House website)

Started from Japan in 1996, quick barber shop has become a very popular model in the barbering industry. It simplifies the traditional barbering process. The customer purchases a coupon (which costs about 3 USD) from a machine and waits for his/her turn. When his/her turn comes, he/she hands the coupon to the first available barber. Barbers handle no money and can concentrate on cutting hair. Instead of shampooing, barbers clean hair by using a vacuum-suction device and the whole barbering process can be done in less than 10 minutes. The first quick barber shop, called QB House, was operated by QB Net Co. in 1996. It was awarded the New Business Prize and the Asian Innovation Award for 1998. Now this kind of barber shops has been wildly spread out in many Asian countries such as Taiwan, Singapore, and Malaysia. Its cost-effectiveness and efficiency surely change people's way of cutting hair.

In corporate management field, "Corporate competitiveness" has always been a hot topic. To be competitive, corporations must continually innovate to provide good

products or services that satisfy the needs of customers faster and more-effectively than their competitors, which allows them to create value and distribute the value to all stakeholders. Clearly, innovation is a process which involves a number of decision parameters and challenging problems in changeable spaces. By checking the list of these potential challenging problems and decision parameters therein, we could reduce the decision blind and avoid decision trap; and by deliberating the possible occurrence in the potential domain of each possible problem, we could avoid or reduce the possible decision shocks when we are confronted the challenging problems.

According to the HD theory and CS analysis, all humans and things can release pains and frustrations for certain group of people or living things at certain situations and time. Thus, all humans and things carry the competence (in broad sense, including skills, resources, functionalities, even attitudes). If we regard all humans and things as a set of different CSs, then producing new products or services can be regarded as a *transformation* of the existent CS to a new form of CS. With this concept, we could depict a comprehensive and integrated framework, of ***Innovation Dynamics*** as in Figure 9.

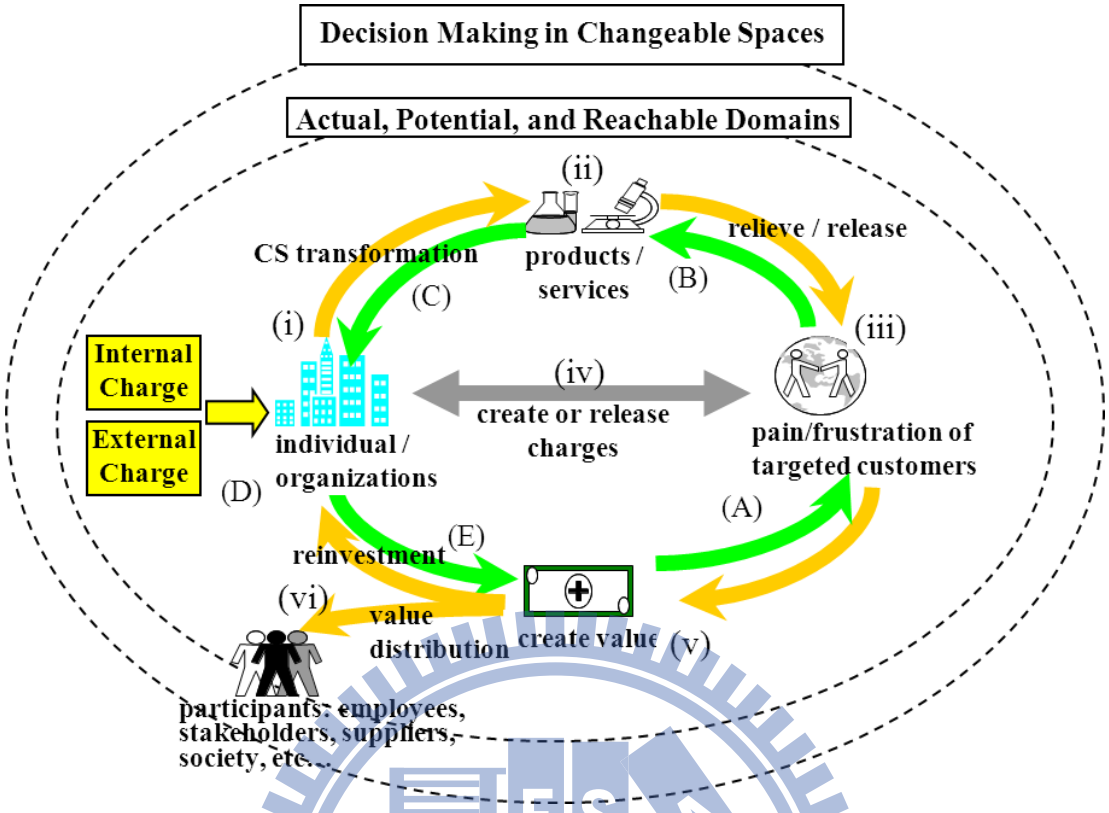

Figure 9. Innovation dynamics.

From "Habitual domain, decision making in changeable spaces, and innovation dynamics" by Chen, Y. C., 2010, p.28. Taiwan: NCTU press.

Let us explain briefly the innovation dynamics in the following subsections.

4.1. Competence sets expansion and transformation (see Figure 9 (i) and (C))

The change of corporate or individual charge structure is the origin of creativity, and also the starting point of the innovation cycle. The charge structure may be changed internally (such as a corporation wanting to pursue sustainable growth, or create value for all participants…), or externally (such as the industrial environment or market structure changes, which force the corporation to pursue innovation; or customer cognition or preference changes, resulting in the corporation having to reform the product or service). The change of the charge structure will impact the attention allocation of a corporation or individual and the generation of creativity. As

mentioned in section 2.1, each event is related to a set of goal functions, these goal functions can be regarded as parameters, observable or hidden, that affect the charge structure and further impact the decision making. Recall in Example 1, the dog food company noticed the pet owners' worries of dogs' overweight problems. The discovery of this parameter (the change of pet owners' charge structure) prompted the company to produce healthy dog food products.

Being able to sense the change of charge structures and understand the CSs owned or needed are very important in this stage. From the perspective of business management, the activities in this link involve a number of related issues, including "how to enrich and expand self CSs internally and externally and "how to transform the CSs". Human resource management, organization management, production management, logistics management, etc., are all closely related to the transformation of CSs. For example, in Example 4, quick barber shop enhance its production/operations management by utilizing "system unit" facilities: a chair on top of a dust box into which the barber sweeps hair; a closet for the customer's coat and bag; a mirror on the closet door; and shelves for sterilizer, neck papers, combs, and "air washer." All these facilities carry CSs and these CSs are integrated into the barber shop to shorten the time and to cut the cost of operation, resulting in the barber shop which was transformed into a more efficient and effective one.

4.2. Providing product/service to release the pain and frustration of target customers (see Figure 9 (ii)-(iii) and (B))

The CSs transformation appears in tangible or intangible forms, which results in the products and services provided. Whether it is tangible product or intangible service, it must be able to release the pains, frustrations and stress/charge for target

customers. Note that there are actual domains, reachable domains, and potential domains for the target customers, and for their pains, frustrations, and stress/charge.

The target customers (and their pains and frustrations) in actual domains can be easily observed, therefore most corporations often focus on goals and problems that can be seen when devoted to innovation. However, the needs or desires that lead to frustration or create charge are often hidden in the potential domains, and even the target customers, sometimes, are not aware of their existence until pointed out. If a corporation can provide a product/service that meets the invisible need of customers, and release their pain and frustration hidden in the potential domains, it can be more competitive than the others in the industry.

In Example 3, when Nokia beat Motorola in the 2G era of mobile communication, its focusing on product design (e.g. the light and handy outlook; the colorful and removable covers, etc.) really released customers' charge of curiosity and met their hidden needs of customization. However, as described earlier, human's preferences, goal settings, charge structures, etc., which are all important parameters in this link, are changing with time and situation. When it comes to 3G era, Nokia neglected the change of customers' preference and missed the great opportunity of developing touchscreen smartphones.

In addition to having the ability to discover the needs and desires in the potential domains or reachable domains, corporations also need to have the capabilities of developing, producing and delivering the product, providing after-sale service and further releasing the pain and frustration of target customers in the potential domains. Therefore, the activity in this link is closely related to R&D, production management, inventory management, logistics management, customer relationship management,

service management, etc. in the management fields. Important issues and topics in these fields are the parameters worth noticing and exploring in this part of Innovation Dynamics. (see Chen and Yu (2009); Yu and Chen (2010b); Yu and Chianglin (2006) and Yu and Lai (2005))

4.3. Creating charge and releasing charge (see Figure 9 (iv))

In addition to releasing the charge of target customers, corporations can also create charges to them. Through advertising or marketing techniques, corporations create charge and further induce their desires in the potential domains for the product/service the corporations offer.

Take the quick barber shop for an example (refer to Example 4). Outside the quick barber shop, there is a red, green and yellow signal lamp in place of a barber pole. Green means no wait; yellow, a wait of five to ten minutes; red, a wait of 15 minutes or longer. When people see a green light on, they would be more willing to enter the barber shop. The signals create charge to customers and just as the quick barber shop motto says, they "unlocking the potential of time."

In contrast, the target customers can also create charge or release charge for corporations through similar ways. For example, consumers will team up to shop and ask the company to provide a discount (wholesale price); if the seller is willing to accept it, the buyer will make an order (to release seller's charge). This is a common way of creating and releasing charge directly from customers to corporations.

To effectively apply strategies and create charges, corporations must utilize marketing techniques and have in-depth understanding of the target customers. Hence,

the activities in this link are closely related to marketing management and customer relationship management.

4.4. Creating values (see Figure 9 (v) and (A))

The products or services create value when target customers buy the products or services as to release their pains, problems and frustrations (Chen, 2010; Chen & Yu, 2009; Chen, Huang, & Yu, 2012; Yu, 2002; Yu & Chen, 2010a, 2010b). When customers are satisfactorily discharged, they could come back for more and which create more profit and value. Value can be estimated in two parts, tangible and intangible. Tangible value is easily to be measured by numbers or the amount of money, but the intangible value comes from the satisfaction and happiness resulted from the release of charge or pains in the potential domains. Tangible value provides direct contribution to corporate profit; intangible value contributes to the customers first, then the corporation (when customers want and buy more). People often tend to pay attention to things they can see, so only tangible value will be noticed, and intangible value is often neglected. However, the power created and the impact brought by intangible value is usually greater than the specific money value. If the charge and needs in the potential domains are released and satisfied, customers will be willing to buy and consume more, which will bring more tangible value. Through sharing their happiness and satisfaction with others, the tangible value will be increased due to the creation of intangible value.

In Example 3, when Nokia's products satisfy customer's (especially young generation) hidden desire of showing off and being apt to change, it created huge value and surpassed Motorola as to became the leader in mobile industry. If the corporation cannot explore the hidden needs or desire of targeted customers, it may

lose the opportunity to create value, or even worse, it may lead to failure.

Similarly, in Example 4, the quick barber shop observes people's busy life style and provides quick but neat services, without extra frills. They discover that not all people need a whole set of hair-doing process, including massaging, shampooing, cutting, blowing, etc. They may simply want a haircut. The "cheap and quick" services which costs less than one third price of ordinary barbering may not create huge tangible value at the beginning. But the intangible value resulted from the satisfaction of meeting people's need for efficiency and effectiveness surely leads it to big success when such new service and its benefits spread out.

In this link, both tangible and intangible values have to be taken into account. In the creation of tangible value, corporations will need to pay attention to related issues of financial management; and for the operating and creation of intangible value, it will be important to take care of issues regarding to customer relationship management and service management, etc. In each issue related potential domains need be explored.

4.5. Value distribution and reinvestment (see Figure 9 (vi) and (D)-(E))

The tangible value described in the previous session is the profit created when a corporation innovates successfully. It may be distributed in many ways to the stakeholders, including employees, investors, customers, the society in forms of salary, bonus, reduction of prices, taxes, etc. Value may also be reinvested to the corporation itself to enlarge and enrich its CSs, and allow it to start a new value creation process. For instance, QB House, the first quick barber shop in Example 4 has been extending its business to many other Asian countries as to release more pains and frustrations for

more people and create more values.

The activities in this link are closely related to the concept of value chain analysis, which can be applied to whole supply chains and distribution networks. The delivery of a mix of products and services to the end customer will mobilize different economic factors, each managing its own value chain (Poter, 1985). Capturing the value generated along the chain, distributing and re-investing it to the related stakeholders or the corporation itself become important issues for management strategists.

4.6. Clockwise and counter clockwise versions of innovation dynamics

The innovation dynamics can be interpreted step by step clockwise and counter clockwise. According to the indices of Figure 9, let us briefly discuss it clock-wise as follows:

(i) According to HD Theory, when there exists unfavorable discrepancies between the current states and the ideal goals of individuals or organizations (for instance, the corporations are losing money instead of making money, or they are technologically behind, instead of ahead of the competitors), it will create charges which can prompt the individuals or corporations to work harder to reach their ideal goals;

(ii) The transformation of CSs will be presented in visible or invisible ways, which results in a new set of the products or services produced by the corporations;

(iii) The products or services produced by corporations must carry the capability to relieve or release the pains and frustrations of targeted customers. Note that there are actual domains, reachable domains, and potential domains for the targeted

customers, and for their pains, frustrations, and problems;

(iv) Besides discharge, corporations or organizations can create charges to the targeted customers by means of marketing, advertisement or promotion, and vice versa;

(v) The targeted customers will experience the change of charges. When their pains and frustrations are relieved, the customers become happy. By their buying the products or services, the products and services create their value;

(vi) The value will be distributed to the participants such as employees, stakeholders, suppliers, society, etc. In addition, to gain the competitive edge, products and services have to be continuously upgraded and improved. The reinvestment therefore is needed in order to develop and produce new products and services.

In contrast to the clockwise cycle, the Innovation Dynamics can be interpreted counter-clockwise, according to the indexing of Figure 9, as follows:

(A) To create values, the corporations must consider who will be the targeted customers, and what kind of pain and frustration they have, both in actual and potential domains;

(B) In order to ease the pains and frustrations for the targeted customers, what products or services, in actual and potential domains, are needed? Competitiveness becomes an important issue in the final selection of the products and services to produce;

(C) How do the corporations transform their internal and external competence and resource through supply chains to develop or provide the selected products and services effectively and efficiently?

(D) When the transformation of CSs succeeds, the corporation's internal and external charge will be released, at least partially;

(E) New goals as to create new values can be reestablished. The innovation cycle: (A) → (B) → (C) → (D) → (E) → (A) will go round and round.

Note that the above discussion, including (i)—(vi) and (A)—(E) of section 4.6 and section 4.2.—4.5, provides us a systematic check list. If we thoroughly go through each questions or point raised, we can reduce decision blinds and possibility of decision shocks.

4.7. Related challenging decision makings in innovation dynamics

Note that activities over each link of the Innovation Dynamics, in Figure 9, involve decision makings in changeable spaces. Let us sketch them in the following Table 3. The related fields of management are also provided (Chen, 2010). The list of Table 3 may serve as a set of new directions for the various fields of managements to develop and research, as well as a possible checking list for reducing decision blinds and possibility of decision shocks.

Table 3. Innovation dynamics and fields of management

Processes in Innovation Dynamics	Descriptions	Related Management Fields
Transforming of competence sets (refer to (i) and (D) in Figure 9)	• Acquiring, adjusting and allocating resources (human resources, skills, technologies, etc.); transforming resources into products/services • The corporation's internal and external charge will be released when the transformation of CSs succeeds.	• Human resource management • Organization management • Production management • Research and development (R&D) • Procurement management • Logistics management • …
Producing of products/services (refer to (ii) and (C) in Figure 9)	• The outcomes of CS transformation and expansion • How to transform the internal and external competence and resource to develop or provide the selected products and services effectively and efficiently?	• R&D • Production management • Inventory management • Logistics management • Value chain analysis • …
Releasing pains and frustrations of target customers (refer to (iii) and (B) in Figure 9)	• Discovering of target group and exploring their needs in actual and potential domains • What products or services are needed in order to ease the pain and frustrations of customers?	• Marketing management • Services management • Customer relationship management (CRM) • …
Creating charge / releasing charge (refer to (iv) in Figure 9)	Besides discharge, corporations or organizations can create charges for the targeted customers by means of marketing, advertising or promotion, and vice versa.	• Marketing management • CRM • …
Creating / distributing values and reinvestment (refer to (v) and (vi) ; (A) and (E) in Figure 9)	• Releasing the charges of the target customers and creating values; how to distribute and share the created value effectively as to keep the stakeholders in unity for growth, prosperity and competitiveness. • To create values, the corporations must consider who will be the targeted customers, and what kind of pain and frustration they have, both in actual and potential domains.	• Financial management • Compensation management • Investment management • Public relation management • Value chain analysis • …

From "Habitual domain, decision making in changeable spaces, and innovation dynamics" by Chen, Y. C., 2010, p.37. Taiwan: NCTU press.


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Chapter 5. Empower Decision Making Capability by HD Tools

If we are equipped with a set of tool to enrich our mind as to get into the depth of potential domains of our self and other people, we could have more capability to deal with challenging problems. As a consequence, we could reduce the possibility of decision trap, blind, and shock, be more able to identify challenging problem before its occurrence, be more able to solve the challenging problem more effectively, and be more capable to release the pains and frustrations of our own and others. In Example 3, Nokia could lead the 2G mobile telephony market because it could see through people's charge structure in their potential domains. To be able to do so, the decision maker's HD must be very broad, rich and flexible as to find the solution that could release the charges of all people concerned. Thus, it is important to expand and enrich our HD. By doing so, we can understand the problems better, and make decisions more effectively and efficiently. Without doing so, we might unwittingly get stuck and trapped in the process, felt powerless and frustrated.

There are three tool boxes coined by Yu (1990, 1995, 2002, 2009) to help us to enrich and expand our potential domain and actual domain:

(1) Tool box 1: Eight basic methods for expanding and enriching HDs (see Table 4);

(2) Tool box 2: Nine principles of deep knowledge (see Table 5); and

(3) Tool box 3: Seven empowering operators (see Table 6).

Table 4. Eight methods for expanding and enriching HDs

1. Learning Actively
2. Projecting from a Higher Position
3. Active Association
4. Changing the Relevant Parameters
5. Changing the Environment
6. Brainstorming
7. Retreating in Order to Advance
8. Praying or Meditating

From “Habitual domains and forming winning strategies” by Yu, P. L., 2002. Taiwan: NCTU Press.

Table 5. Nine principles of deep knowledge

1. The Deep and Down Principle
2. The Alternating Principle
3. The Contrasting and Complementing Principle
4. The Revolving and Cycling Principle
5. The Inner Connection Principle
6. The Changing and Transforming Principle
7. The Contradiction Principle
8. The Cracking and Ripping Principle
9. The Void Principle

From “Habitual domains and forming winning strategies” by Yu, P. L., 2002. Taiwan: NCTU Press.

Table 6. Seven empowering operators

1. Everyone is a priceless living entity. We are all unique creations who carry the spark of the divine.

2. Clear, specific and challenging goals produce energy for our lives. I am totally committed to doing and learning with confidence. This is the only way I can reach the goals.

3. There are reasons for everything that occurs. One major reason is to help us grow and develop.

4. Every task is part of my life mission. I have the enthusiasm and confidence to accomplish this mission.

5. I am the master of my living domain. I take responsibility for everything that happens in it.

6. Be appreciative and grateful and don't forget to give back to society.

7. Our remaining lifetime is our most valuable asset. I will enjoy it fully and make a 100 percent contribution to society in each moment of my remaining life.

From "Habitual domains and forming winning strategies" by Yu, P. L., 2002. Taiwan: NCTU Press.

Note that all the HD tools in all three boxes are not afraid of being used and depreciated. In fact, the more we use them, the more powerful they will be in our brain and more readily to help us to solve challenging problems. Here we discuss only three methods in the following sections and list the definition of tool box 1 and 2 in Appendix 5 and 6. The interested reader is referred to Yu (1990, 1995, 2002, 2006, 2009) for more details.

5.1. Deep and down principle (of tool box 2)

This principle has two meanings. First, one needs to periodically reduce his/her charges to as low as possible. When we are very busy and deeply concentrating, only

ideas carrying high activation probability will occupy our mind. We will be too preoccupied with those situations to consider anything else. By reducing our charges, we can pay attention to those ideas with low activation probability. Thus, our actual domain will be expanded, and we will be able to observe related parameters hidden in potential domains. For instance, the dog food company in Example 1 only focused on the pet owners in AD_t but not the dogs in the potential domain (PD_t), so they falsely conducted statistics on buyers, not on the final users (dogs). If the company can reduce its charge by following this principle, it may discover the preference of the key player, the dogs, hidden in potential domain and avoid making wrong decisions.

The second meaning of this principle is to take "the humble position" when dealing with others. By being sincerely humble, we could make other people to offer their ideas and operators to us more willingly and absorb new ideas more easily and effectively. Consequently our HDs will be expanded and enriched. In Example 3, Nokia lost 3G market because it underestimate and misjudge iPhone's power. If it would be humble, it may be able to appreciate what iPhone has offered; as a result it could reach into the depth of potential domain and observe the change of trend and preference of users.

5.2. Changing the relevant parameters (of tool box 1)

There are many parameters which are involved in a particular problem or event. If we are willing to change the parameters, we may be able to obtain new ideas. Recall Example 4, the way of charging fees, cutting hair, cleaning hair, etc. are the parameters. Quick barber shop made good use of them and develop a new procedure and style of barbering. Its service not only releases target customers' charge but also creates huge value for itself. Many of us have a habitual way of looking at a particular

problem with a fixed parameter value (for instance, our assumption that the recovery time of an investment is seven years), which can fix our mind, perhaps unconsciously, in dealing with our problems. Being willing to search for the parameters and change their values can usually help us expand our view of the problem. In many important decision problems, our criteria, alternatives, possible outcomes and preferences can all be changed over time. Allowing the parameters to change in our thinking process will allow us to reconsider what a good decision should be and to construct better strategies for the problems.

5.3. The alternating principle (of tool box 2)

Sometimes we have to omit or change our combined assumptions so that we can create new ideas from different sets of assumptions. For example, by combining 0 and 1 in different orders, mathematicians can create numerical systems and digital systems upon which electronic devices and computers are based. Different combinations of the three primary colors (red, blue and yellow) can create an unlimited variety of colors and patterns. In challenging decision making, the decision maker can alternate the parameters (as combining with the "***Changing the relevant parameters***" we mentioned above) or assumptions to see if new ideas or solutions are produced. By doing so, the HD will be expanded and enriched, and the decision makers can make better decisions. In Example 3, Nokia's famous product design of changeable mobile phone covers was also an application of the alternating principle. Nevertheless, if Nokia could alternate the parameter of people's phone using habit, it might grab the chance to develop touchscreen products and keep its leading position.


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Chapter 6. Quantification of Identification Spheres

As mentioned in chapter 1 and section 2.2, identification spheres plays a vital role in knowing the HDs of ourselves, other people, and/or organizations in solving nontrivial decision problems. In this chapter, we illustrate the formation and the model of quantification of identification spheres.

6.1. The formation of identification spheres

Recall section 2.1, Yu (2002) stated that each human being has a set of goals[2] to reach and maintain. This process or function will be called goal setting. Parallel to goal setting, (goal) state evaluation is constantly performed in the brain. Our brain continuously monitors, consciously or subconsciously, to detect any and all current deviations from ideal goal states. Each event is related to a set of goal functions. When there is an unfavorable deviation of the perceived value from the ideal, each goal function will produce various levels of charge. The totality of the charges by all goal functions is called the charge structure and it can change dynamically over time.

Generally, when the actions of another person or group can relieve or reduce our charge, we gradually, tangibly and intangibly, grow close to and identify with this person or group, even coming to love him or her. For example, if you were a Canadian, in watching international football games or any sport, do you want Canada team to win? If so, you are already identified with Canada team. When Canada team wins a game, you are ecstatic. Why you show such a high level of support and identification with Canada team is because deep inside you have goals relating to feelings of self-importance and social approval. When Canada team wins a game, the charge generated by these goals is relieved or reduced, and you thus feel a sense of identification with Canada team (Yu, 2002). The more of our charge another person can relieve or reduce, the greater and stronger our sense of identification with him/her.

Conversely, when the actions of another person increase the charge in our charge structure, we will gradually, tangibly and intangibly, avoid and fail to identify with this person, perhaps even reject him or her. For example, if you were a Canadian, you

[2] Regarding a structure of human goal functions, see appendix 4 and Yu (2002) for more details.

would dislike a football team from another country, fail to identify with it, and perhaps even hate it, especially if this team regularly defeated Canada team. This is because this football team increases the charge on you regarding the feelings of self-importance and social approval (Yu, 2002). The greater the charge placed on us by another person, the greater our sense of dis-identification with him/her.

The identification sphere is the projection of the habitual domain's identification with people, objects, and events under certain conditions and in specific temporal and spatial environments. The identification sphere has the same characteristics as the habitual domain. Over a period of time, the identification sphere gradually stabilizes and remains within a fixed range. We have a varying degree of identification with different people and events in various circumstances. Figure 1 shows the general identification sphere based on the characteristics described above.

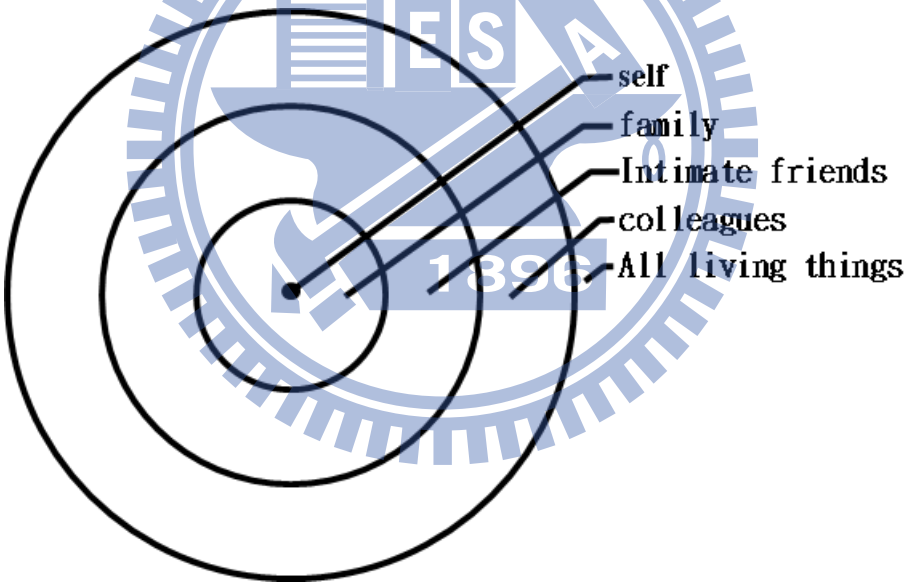

Figure 10. Identification sphere.
From "Habitual domains and forming winning strategies" by Yu, P. L., 2002, p315. Taiwan: NCTU Press.

Generally, people identify most strongly with themselves; therefore, the self is part of the core of the identification sphere. The sphere then expands outward according to different degrees of identification. After the self comes family, close friends, colleagues, and finally, all living things.

6.2. Identification sphere model

6.2.1. The structure of the identification spheres

A person's identification sphere refers to the people, objects, and events that he/she can identify with under certain conditions and in certain spatial and temporal environments. Each individual has an identification sphere.

To quantify and facilitate concrete application of the concept of identification, this study developed the following formula. The identification function $d_e^t(i, j)$ indicates the degree of identification of person *i* with *j*[3] at a certain point in time *t* and under specific event *e*. This study assumes the range of $d_e^t(i, j)$ as [-1, 1]; $0 < d_e^t(i, j) \leq 1$ indicates that *i* positively identifies with *j*. The greater this value, the higher the level of identification. If the value of the identification function approaches 0, the degree of identification is extremely low; conversely, if the function approaches 1, the degree of identification is extremely high.

If $-1 \leq d_e^t(i, j) < 0$, this indicates that at the point in time *t*, *i* has a different opinion compared to *j* regarding event *e*, or that *i* does not identify with *j* to a certain degree.

Throughout this article, we assume that there are *n*-person involved in our study. We can use the formula below to define the identification sphere of *i* (at level α or higher) regarding event *e* at the point in time *t*:

$$\mathbf{I}_e^t(i, \alpha) = \left\{ j \,\middle|\, d_e^t(i, j) \geq \alpha > 0, 1 \leq j \leq n \right\} \quad (1)$$

The range of the identification sphere defined above changes according to alterations in the parameters, such as the spatial and temporal environment, people and events. If parameters *t* and *e* are fixed, then $\mathbf{I}_e^t(i, \alpha)$ can be simplified to $\mathbf{I}_i(\alpha)$. Notably, α is the identification threshold of *i*. When $d_e^t(i, j) > \alpha$, the identification

[3] *j* can be a person, event, or object; the focus of this study is on investigating the identification sphere formed between individuals regarding a specific matter.

degree of *i* with *j* has exceeded the identification threshold α. Using an election as an example, $d_e^t(i, j) > 0$ indicates that voter *i* identifies with candidate *j* to a certain degree; $d_e^t(i, j) > \alpha$ indicates that not only does voter *i* identify with candidate *j*, but also the degree of identification has reached the threshold (α) of voting for him/her.

When α is 1 or close to 1, then the corresponding identification sphere is known as the core of identification sphere. If a person is inside the core of your identification sphere, he or she has a great influence on you. Likewise, if someone makes you a core person in his/her identification sphere, you have a significant influence on that individual.

Because the range of identification degrees is fixed at [-1, 1], the range of α is also from -1 to 1. Assuming that we establish a value of α for a specific situation, when the identification level of *i* with *j* equals or exceeds α, then *j* falls within the identification sphere ($\mathbf{I}_i(\alpha)$) of *i*. $\mathbf{I}_i(\alpha)$ changes according to changes in the identification threshold α. As the value of α increases, the number of members in the identification sphere typically decreases.

When $d_e^t(i, j) < 0$, there is a certain degree of dis-identification of *i* with *j* regarding event *e*. When the function approaches 0, the degree of dis-identification is extremely low; when the function approaches -1, a high degree of dis-identification is indicated.

When $d_e^t(i, j) < \beta, -1 < \beta < 0$, the degree of dis-identification of *i* with *j* regarding event *e* has exceeded the dis-identification threshold of *i*. Using an election as an example, $d_e^t(i, j) < 0$ indicates that voter *i* does not identify with candidate *j*. Furthermore, $d_e^t(i, j) < \beta$ indicates that not only voter *i* does not identify with candidate *j*, but also the degree of dis-identification is extremely high, even reaching the threshold of rejection. When $d_e^t(i, j) = 0$, there is neither identification nor dis-identification of *i* with *j*.

Using the identification function $d_e^t(i, j)$ and the identification threshold α, we can construct the identification sphere $\mathbf{I}_i(\alpha)$ of *i* at the time point *t* regarding event *e*,

as shown in (1). Using the identification function $d_e^t(i, j)$ and the dis-identification threshold β, we can also construct the dis-identification sphere $D_i(\beta)$ of i at time point t regarding event e, as shown in (2)

$$\mathbf{D}_i(\beta) = \left\{ j \,\middle|\, d_e^t(i, j) \le \beta < 0,\ 1 < j \le n \right\} \tag{2}$$

We can classify the degree of identification into the following categories: high degree of identification, moderate degree of identification, low degree of identification, neutral/low degree of dis-identification, and moderate/high degree of dis-identification. Additionally, we can define the categories as follows: a high degree of identification refers to an identification degree greater than 0.7 but equal to or less than 1; a moderate degree of identification refers to an identification degree greater than 0.3 but less than or equal to 0.7; and a low degree of identification refers to an identification level greater than 0 but less than or equal to 0.3.

Similarly, a high degree of dis-identification refers to a level where the dis-identification degree is greater than or equal to -1 and less than -0.7. A moderate degree of dis-identification refers to a level where the dis-identification degree is greater than or equal to -0.7 and less than -0.3. While a low degree of dis-identification refers to a value of dis-identification degree greater than or equal to -0.3 and less than 0.

6.2.2. Matrix of identification degrees

Assume there are n-person, from $\{d_e^t(i, j) \,|\, i, j = 1, ..., n\}$, we can construct a matrix of the degrees of identification among there n-person, as shown below:

$$\mathbf{D}_e^t = \left[d_e^t(i, j) \right], \quad 1 \le i, j \le n \tag{3}$$

where t indicates a specific time point, e indicates a specific event, and $i, j = 1,2,..., n$ individuals. Notably, the degree of identification of i with j does not necessarily equal the identification degree of j with i; in other words, one may

have $d_e^t(i, j) \neq d_e^t(j, i)$. For example, a class is electing a class representative and student *i* strongly identifies with student *j* and feels that he/she can win this position; therefore, the degree of identification of *i* with *j* is, for example, 0.8. However, *j* may not necessarily feel that *i* can win the position; thus, the identification degree of *j* with *i* may be only 0.2 or lower. Students *i* and *j* each have a different degree of identification with respect to the issue of whether the other can win the position of class representative.

Under general circumstances, we can probably assume $d_e^t(i, i) = 1$, indicating that *i* completely identifies with himself/herself regarding a specific event *e*. $d_e^t(i, i)$ can be appropriately adjusted according to the issue at hand.

6.2.3. Example: Electing a class representative

This hypothetical class consists of five students. Table 7 shows the results of a hypothetical survey conducted on the degrees of identification among students at a certain time point *t* regarding the specific matter of electing a class representative *e*.

According to the previously defined degrees of identification, $d_e^t(i, j) > 0$ indicates at least a low degree of identification; $d_e^t(i, j) > 0.3$ indicates at least a moderate degree of identification, and $d_e^t(i, j) > 0.7$ indicates a high level of identification. According to the formulas for identification sphere (1) and dis-identification sphere (2), when the identification threshold α and dis-identification threshold β change, the members within these spheres also change, as shown in Table 8.

Table 7. Degrees of identification among students ($d_e^t(i, j)$)

$d_e^t(i, j)$	1	2	3	4	5
1	1	0.9	0.4	-0.6	-0.4
2	0.7	1	0.3	-0.8	-0.3
3	0.4	0.8	1	-0.9	-0.5
4	0.4	0.7	0.1	1	0.2
5	0.5	0.7	0.2	-0.3	1

Table 8. α-identification sphere and β-dis-identification sphere

$\mathbf{I}_i(\alpha)$, $\mathbf{D}_i(\beta)$	$\mathbf{I}_i(0.3)$	$\mathbf{I}_i(0.7)$	$\mathbf{D}_i(-0.3)$	$\mathbf{D}_i(-0.8)$
i =1	{1,2,3}	{1,2}	{4,5}	ø
i =2	{1,2,3}	{1,2}	{4,5}	{4}
i =3	{1,2,3}	{2,3}	{4,5}	{4}
i =4	{1,2,4}	{2,4}	ø	ø
i =5	{1,2,5}	{2,5}	{4}	ø
$L(\alpha) = \bigcap_{i\in\{1,\ldots,5\}} I_i(\alpha)$	{1,2}	{2}	-	-
$K_4(\beta) = \bigcap_{i\in\{1,\ldots,5\}, i\neq 4} D_i(\beta)$ (Note, if $j \neq 4, K_j(\beta) = \phi$)	-	-	{4}	ø

Each row in Table 8 indicates the identification sphere or dis-identification sphere formed by student i under different thresholds of identification/dis-identification. For example, when the threshold of identification α with classmate 1 is 0.3, the identification sphere formed is {1,2,3}. When α=0.7, the identification sphere of 1 formed is {1,2}. When the identification threshold for classmate 2 is 0.7, the identification sphere formed is {1,2}. When the threshold of dis-identification β with classmate 3 is -0.3, the dis-identification sphere formed is {4,5}. When β=-0.8 for classmate 4, the dis-identification sphere is an empty set.

Generally, people identify most strongly with themselves, and not dis-identify themselves with respect to events. When α and β are given, the intersection of the corresponding identification spheres and dis-identification spheres (excluding the self) can be defined as follows:

$$\mathrm{L}(\alpha) = \bigcap_{i\in\{1,\ldots,5\}} \mathrm{I}_i(\alpha) \tag{4}$$

$$\mathrm{K}_j(\beta) = \bigcap_{i\in\{1,\ldots,5\},i\neq j} \mathrm{D}_i(\beta) \tag{5}$$

when α=0.3, according to the intersection of the five students' identification spheres shown in (4), we can obtain the following: **L**(0.3)={1,2}. This indicates that under a low degree of identification, classmates 1 and 2 will both receive the full support of the class. If α=0.7, then **L**(0.7)={2}, indicating that under a high degree of identification, only classmate 2 will receive the support of the entire class. If the self were not included, according to the intersection of the five students' dis-identification spheres shown in (5), then $\mathbf{K}_4(-0.3)=\{4\}$. That indicates that classmate 4 has the least support as a candidate for the position, and $\mathbf{K}_4(-0.8)$ is an empty set. It can be verified that if $j \neq 4$, $\mathbf{K}_j(-0.3) = \mathbf{K}_j(-0.8) = \text{ø}$

The result of the above example (**L**(0.7)={2}) shows that there is only one candidate whom everyone identifies highly with: classmate 2. This is the student that will be elected as class representative. However, if the identification threshold is fixed at α=0.3 or α=0.9, then **L**(0.3)={1,2} and **L**(0.9)=ø. The result is that there will be either two or zero candidates with whom everyone identifies. How this situation should be handled remains to be determined. Additionally, the above example included only five participants, making analysis easy. The question of how we can use the concept of identification to select the most influenial individual or group of individuals when there are hundreds or thousands of participants is addressed in the sections below.

Chapter 7. Application of Identification Spheres

7.1. Application 1: Using and applying the concept of identification degree, identification spheres and dis-identification spheres in electing a group leader

The basic principle of voting in election is "one equal vote for each person," and the candidate who receives the most votes is elected. Though the purpose of voting is sound, the mechanism allows numerous public representatives with dubious backgrounds to manipulate the conventional electoral system and become elected. These candidates only need to control the votes of a portion of supporters (basic support) to practically control the election outcome; therefore, they will strive hard to please certain voters (political vote buying, vote lobbying), and neglect the needs of the remainder of the electorate (Lijphart, 1991; Lijphart & Grofman, 1984; Norris, 1997).

With respect to identification degree, there are a number of ways to select a winner. In the following 2 subsections, we introduce 5 different methods of election.

7.1.1. Election based on the degree of identification

If voting follows the concept of identification, conventional electoral methods could change, and candidates would perhaps be forced to consider the needs of the entire electorate.

Let us explain this by the following hypothetical scenario: In an election, there are 3 candidates, (J_1, J_2, J_3), to be chosen by 9 committee members, denoted by I_1, I_2,$\cdots$,I_9. The members are asked to indicate their degree of identification with each of the candidates in place of the conventional voting method. Hypothesized statistics on

the 9 voters' degree of satisfaction with each of the 3 candidates are shown in Table 9 below.

Table 9 shows the calculation of the identification degree $d_e^t(i, j)$, and its relation to conventional voting methods (a voter *i* choose the candidate with whom he/she identifies most over all possible *j* that is $\max_j\{d_e^t(i, j)\}$). For example, the first row shows that the degree of identification of voter I_1 with the 3 candidates is 0.2, 1, and 0.1. Because I_1 identifies most strongly with J_2 (0.1<0.2<1), I_1 would vote for J_2, according to conventional election methods. The 6th row shows that the degree of identification of voter I_6 with the 3 candidates is 0.8, -1, and 0.6. Because I_6 identifies most strongly with J_1 (-1<0.6<0.8), I_6 would vote for J_1. Based on these data, the final election outcome would be as follows: J_1: 3 votes; J_2: 5 votes; and J_3: 1 vote. Though the feelings of voters toward candidate J_2 are extreme (five people completely identified with the candidate, while three others did not identify with him at all), if there were no other factors of influence, the winner of the election would be J_2 (5 votes>3votes>1 vote), according to conventional election methods.

Table 9. Degree of identification of *I* with candidate *J* and resulting votes

$d_e^t(i, j)$	J_1	J_2	J_3	$\max_j\{d_e^t(i, j)\}$
I_1	0.2	1	0.1	J_2
I_2	0.3	1	0.3	J_2
I_3	0.2	1	0.3	J_2
I_4	0.2	1	-0.6	J_2
I_5	0.3	1	0.2	J_2
I_6	0.8	-1	0.6	J_1
I_7	1	-1	0.5	J_1
I_8	0.8	-1	0.5	J_1
I_9	0.5	0.2	0.6	J_3
$\sum_i d_e^t(i, j)$	**4.3**	**2.2**	**2.5**	

The second column of Table 9 shows that the 9 voters' degrees of identification with candidate J_1 are as follows: 0.2, 0.3, 0.2, 0.2, 0.3, 0.8, 1, 0.8, and 0.5. The total degree of identification ($\sum_i d_e^t(i, j)$) is 4.3. Likewise, the total degree of identification of J_2 and J_3 are 2.2 and 2.5 respectively. If the election outcome hinged on the highest total degree of identification, the winner of the election would be J_1 because he had the highest total degree of identification (4.3>2.5>2.2). If J_2 were elected via conventional electoral methods, his total degree of identification would be lower than that of J_1 and J_3. This method can be likened to voter I_i grading candidate J_j: A score of 1 indicates that the voter feels the candidate is completely suited to the position. A score of -1 means the voter feels that the candidate is entirely unsuited to the position. While a score ranging between 1 and -1 indicates differences in the degree of support (identification). This scoring method is similar to that of beauty pageants or other contests, in which judges grade contestants without using names and the winner is the contestant with the highest total score.

Compared to the conventional method of voting in elections, the greatest advantage of the identification-based election system is that it considers not only the identification of voters with candidates, but also different degrees of identification and dis-identification. A candidate must then strive to increase the number of voters that identify with him/her, and reduce the number of voters that reject or dis-identify with him/her. The result is that seeking the support of only a portion of voters or provoking opposition from voters are both unsuccessful tactics; instead, candidates must be more thoughtful and observant, and widely solicit public support.

In the conventional electoral system, the candidate with the highest final number of votes wins the election. Because there cannot be a negative vote, the election results simply show the support (identification) of voters for the candidate. This type of system can be likened to choosing the best candidate from good candidates; regardless of how the selection proceeds, the candidate selected will be a good candidate. This election system does not reflect the actual condition of society or the dissatisfaction of voters with dishonest or questionable candidates.

By contrast, in the election system based on the range [-1,1] of $d_e^t(i,j)$, the successful candidate is the one with whom voters identify most strongly. Because the degree of identification can be negative (dis-identification), this electoral system does not only include selecting the best candidate from good candidates (the sum total of identification ratings for all candidates is positive), but also selecting the least bad candidate from bad candidates (the sum total of identification ratings for all candidates is negative).

If the sum total of the identification ratings received by the winning candidate is negative, then even though he/she has won the election, he/she will be very cautious

and careful because he/she knows that he/she will need to work hard to win the trust and support of voters.

7.1.2. Election based on the concept of the identification sphere

From $d_e^t(i, j)$ in Table 9 and the identification sphere formula (1), we can derive α-identification sphere and β-dis-identification sphere, as shown in Table 10 below.

L(0.8) = ø, which indicates that under a high degree of identification, none of the candidates receives the support of the entire electorate. The votes are distributed as follows: J_1 : 3; J_2 : 5; J_3 : 0; and **L**(0.6)= ø. This shows that under a moderate degree of identification, none of the candidates receives the support of all voters. The vote distribution is J_1 : 3; J_2 : 5; J_3 : 2; and **L**(0.2)={J_1}. This subsequently indicates that under a low degree of identification, candidate J_1 receives the support of the full electorate; the vote distribution is J_1 : 9; J_2 : 6; and J_3 : 7.

If the criterion for winning the election is that the successful candidate must receive the support (identification) of all voters, then the successful candidate would be J_1 because this candidate was the only one included in the identification sphere of every voter (**L**(0.2)={J_1}). Therefore, if the premise is that the successful candidate must be identified with by every *i*, we can adjust the identification threshold α to determine the most suitable *j*.

If α is set to 0.8, a high threshold of identification, then **L**(0.8) = ø , that is no candidate can be identified by all other people. In this case, we have to choose the candidate who has the highest number of identification by the voter. In Table 4, we can see J_1, J_2, and J_3 respectively received 3, 5, and 0 identification by the voter,

hence J_2 will be the winner. Therefore, once the threshold α is fixed, the candidate whith the largest number of voters identifying with him/her will be the winner.

If we must consider both identification and dis-identification in the criteria for winning in the election, then $d_e^t(i,j) > \alpha$ indicates that i has given j one vote of identification and $d_e^t(i,j) < \beta$ indicates that i has given j one vote of dis-identification. Assuming that votes of identification and dis-identification cancel each other out, if α=0.8 and β=-0.6 (referring back to Table 4), then J_1 receives 3 identification votes and 0 dis-identification votes, resulting in a score of 3-0=3. Candidate J_2 receives 5 identification votes and 3 dis-identification votes, resulting in a score of 5-3=2. Candidate J_3 receives 0 identification votes and 1 dis-identification vote, resulting in a score of 0-1=-1. Therefore, the successful candidate is J_1 because 3>2>-1.

Table 10. α-identification sphere and β-dis-identification sphere

$\mathbf{I}_i(\alpha)$, $\mathbf{D}_i(\beta)$	$\mathbf{I}_i(0.2)$	$\mathbf{I}_i(0.6)$	$\mathbf{I}_i(0.8)$	$\mathbf{D}_i(-0.2)$	$\mathbf{D}_i(-0.6)$	$\mathbf{D}_i(-0.8)$
i =1	{J_1,J_2}	{J_2}	{J_2}	ø	ø	ø
i =2	{J_1,J_2,J_3}	{J_2}	{J_2}	ø	ø	ø
i =3	{J_1,J_2,J_3}	{J_2}	{J_2}	ø	ø	ø
i =4	{J_1,J_2}	{J_2}	{J_2}	{J_3}	{J_3}	ø
i =5	{J_1,J_2,J_3}	{J_2}	{J_2}	ø	ø	ø
i =6	{J_1,J_3}	{J_1,J_3}	{J_1}	{J_2}	{J_2}	{J_2}
i =7	{J_1,J_3}	{J_1}	{J_1}	{J_2}	{J_2}	{J_2}
i =8	{J_1,J_3}	{J_1}	{J_1}	{J_2}	{J_2}	{J_2}
i =9	{J_1,J_2,J_3}	{J_3}	ø	ø	ø	ø
$L(\alpha) = \bigcap_{i\in\{1,\ldots,9\}} I_i(\alpha)$,	{J_1}	ø	ø	-	-	-
$K_j(\beta) = \bigcap_{i\in\{1,\ldots,9\},i\neq j} D_i(\beta)$	-	-	-	ø	ø	ø
Number of votes gained (lost) by candidates under different α and β level	J_1 : 9 J_2 : 6 J_3 : 7	J_1 : 3 J_2 : 5 J_3 : 2	J_1 : 3 J_2 : 5 J_3 : 0	J_1 : 0 J_2 : 3 J_3 : 1	J_1 : 0 J_2 : 3 J_3 : 1	J_1 : 0 J_2 : 3 J_3 : 0

Compared to a conventional electoral system, the identification-based election described in this study not only has the attributes listed in Section 3.1, but also allows organziations to adjust α and β according to their organizational requirements and characteristics to develop an election system suited to their needs.

In this section, we just list 5 possible methods of eclection which are classified and summarized as follows:

Method 1: voter *i* votes for candidate *j* with whom he/she identifies most over all possible *j* ($\max_j\{d_e^t(i, j)\}$), and the winner is the candidate who receives most votes.

Method 2: voter *i* grading candidate *j*, and the winner is the candidate who has the highest total degree of identification ($\sum_i d_e^t(i, j)$).

Method 3: adjust the identification threshold α, until some candidate *j* receives the support of the full electorate ($\mathrm{L}(\alpha) = \bigcap_{i\in\{1,\ldots,n\}} \mathrm{I}_i(\alpha) = j$), and this candidate would be the winner.

Method 4: if identification threshold α is fixed, and no any candidate *j* receives the support of the full electorate ($\mathbf{L}(\alpha)$ = ø), then the winner is the candidate who receives the highest number of votes ($d_e^t(i, j) > \alpha$).

Method 5: given the identification threshold α and dis-identification threshold β, if candidate *j* is inside the identification shpere of voter *i* ($\mathbf{I}_i(\alpha)$), he/she gains one vote; if candidate *j* is inside the dis-identification shpere of

voter i ($D_i(\beta)$), he/she loses one vote. The winner is the candidate who receives the highest number of votes.

Indeed, this is a multiple criteria decision problem. There are different criteria of election listed in above 2 exapmles. Regarding multiple criteria decision problem, please refer to (Yu, 1985; Zeleny, 1982). In the future, we will try to integrate the selection and election with multiple criteria problem.

7.2. Application 2: Optimization models for selecting the key persons that influence the community

7.2.1. Community identification matrix and opinion leadership

Word of mouth (WOM) has a great influence on consumers in product determination (Dellarocas, 2003; Herr, Kardes & Kim, 1991). In the purchase of a new product or service (such as an automobile, PC, or cosmetics), the power of WOM influence is especially common (Brown & Reingen, 1987; Scott, 2003). Opinion leadership is generated in a community after it has been established for a duration of time whether it is a conventional community organization or one of the recently emerged virtual Internet communities[4]. In the community, the behavior and perspectives of opinion leaders (key persons) have a relatively strong influence on other community members (Brown, Broderick & Lee, 2007; Webster, 1970). Different communities have different opinion leaders who use different methods and channels to influence the decisions of community members.

[4] Virtual communities are also called Internet communities, e-communities, or computer communities; they are a type of social group that forms from interaction among Internet users.

We often see similar scenarios in society. For example, if a person is considering the purchase of an automobile, no matter how well the salesman explains the attributes of a car, it is not as significant as a critical opinion of the car offered by a friend with whom the person identifies (the friend may work in the automobile industry or have experience using the car). Why the friend's opinion has such a significant influence on the decision is because the friend is within the person's identification sphere regarding an automobile purchase. Because the person strongly identifies with the friend, the friend's opinions can easily influence the decision. In community organizations, the viewpoints or behavior of opinion leaders have a strong influence on the community.

When corporations wish to market new products or new concepts, if they can communicate the new concepts to opinion leaders (core individuals) in a community organization or make them try the new products and then share the information with community members (through endorsement or marketing), members' acceptance of the new product or concept would be greatly enhanced.

The optimization method for expanding the transmission of information from a small number of community members to the entire community is explained below. Table 11 shows the degrees of identification among the 9 members regarding a specific event or matter.This study used a hypothetical community of 9 members.

Remark 7.1. If there are large numbers of members in the community, one may first identify a reduced group of potential opinion leaders (from the artists, sport stars, well known politicians, journalists, etc.) Then use statistical methods such as survey and divide the community into subgroups (like market segmentation) to study how the members of subgroups identify with the potential opinion leaders to obtain the data of

Table 11. Here some aggregation operators may be used to define the degree of identification of a group with an opinion leader.

Table 11. Degrees of identification among community members ($d_e^t(i, j)$)

$d_e^t(i, j)$	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9
I_1	1	0.3	0.45	0.6	0.55	0.7	0.8	0.2	0.25
I_2	0.6	1	0.6	0.6	0.6	0.6	0.5	0.6	0.5
I_3	0.4	0.4	1	0.5	0.5	0.6	0.65	0.6	0.6
I_4	-0.2	-0.37	-0.6	1	-0.5	0.5	0.03	0.4	-0.2
I_5	0.58	0.5	0.42	0.55	1	0.42	0.42	0.58	0.7
I_6	0.7	0.6	0.6	0.9	0.7	1	0.8	0.75	0.8
I_7	0.7	0.55	0.75	0.55	0.75	0.95	1	0.6	0.8
I_8	0.6	0.8	0.5	0.8	0.7	0.6	0.8	1	0.6
I_9	0.29	0.09	0.29	0.4	0.8	0.29	0.29	0.7	1

In Table 11, I_i and J_j are interpreted as follows. For example, considering I_2 and J_2, I is an identifier and J is the person with whom I identifies. The subscript 2 is the community member index.

The α-identification matrix of Table 12 is derived from Table 11 by setting $d_e^t(i, j)$ to 1 when $d_e^t(i, j) \geq \alpha = 0.7$ and $d_e^t(i, j)$ to 0 when $d_e^t(i, j) < \alpha = 0.7$.

Setting $d_e^t(i, j) \geq \alpha = 0.7$ to 1 indicates that *i* strongly identifies with (supports) j regarding a specific event or matter, and *j* has a strong influence on *i*. Setting $d_e^t(i, j) < \alpha = 0.7$ to 0 indicates that regarding this event, the identification of *i* with *j* did not reach α=0.7, and *j* does not have a notable influence on *i*.

Table 12. Matrix and relative identification sphere of community member *i* when $\alpha \geq 0.7$

$\alpha \geq 0.7$	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	Identification sphere of community member I_i	Which members identify with community member J_i
I_1	1	0	0	0	0	1	1	0	0	$\{J_1,J_6,J_7\}$	$\{I_1,I_6,I_7\}$
I_2	0	1	0	0	0	0	0	0	0	$\{J_2\}$	$\{I_2,I_8\}$
I_3	0	0	1	0	0	0	0	0	0	$\{J_3\}$	$\{I_3,I_7\}$
I_4	0	0	0	1	0	0	0	0	0	$\{J_4\}$	$\{I_4,I_6,I_8\}$
I_5	0	0	0	0	1	0	0	0	1	$\{J_5,J_9\}$	$\{I_5,I_6,I_7,I_8,I_9\}$
I_6	1	0	0	1	1	1	1	1	1	$\{J_1,J_4,J_5,J_6,J_7,J_8,J_9\}$	$\{I_1,I_6,I_7\}$
I_7	1	0	1	0	1	1	1	0	1	$\{J_1,J_3,J_5,J_6,J_7,J_9\}$	$\{I_1,I_6,I_7,I_8\}$
I_8	0	1	0	1	1	0	1	1	0	$\{J_2,J_4,J_5,J_7,J_8\}$	$\{I_6,I_8,I_9\}$
I_9	0	0	0	0	1	0	0	1	1	$\{J_5,J_8,J_9\}$	$\{I_5,I_6,I_7,I_9\}$

Next, we explain the optimization method for effectively transmitting messages from a small number of community members (opinion leaders) to the entire community. "Effective transmission" in this sense refers to a high degree of identification regarding a specific

event between *i and j*, so that when *j* gives *i* opinions, *i* is extremely receptive to the extent that the opinions of *j* influence the decisions making and behavior of *i*.

The first row in Table 12 shows that regarding a specific event, I_1 highly identifies with $\{J_1,J_6,J_7\}$; therefore, $\{J_1,J_6,J_7\}$ has a strong influence on I_1. From the first to the last row of the column entitled "Identification sphere of community member I_i" of the table shows the nine groups of people that have a significant influence on each person in $\{I_1,I_2 \ldots I_9\}$ respectively: $\{J_1,J_6,J_7\}$, $\{J_2\}$, $\{J_3\}$, $\{J_4\}$, $\{J_5,J_9\}$, $\{J_1,J_4,J_5,J_6,J_7,J_8,J_9\}$,$\{J_1,J_3,J_5,J_6,J_7,J_9\}$,$\{J_2,J_4,J_5,J_7,J_8\}$, and $\{J_5,J_8,J_9\}$. The last column of Table 6 shows the groups of people that have a significant influence on each person in $\{J_1,J_2 \ldots J_9\}$ respectively.

7.2.2. Mathematical programming to select the key persons that influence the community

After obtaining the community identification matrix $[d_e^t(i,j)]_{n\times n}$, we can use mathematical programming to determine the most effective (lowest cost) combination of key persons to communicate specific messages to the community. These methods are shown in Model (6):

$$
\begin{aligned}
&Min \sum_{j=1}^{n} c_j x_j \\
&s.t. \sum_{j=1}^{n} a_{ij} x_j \geq 1, \ for\ i = 1,2,\cdots,n \\
&\quad x_j \in \{0,1\} \quad for\ j = 1,2,\cdots,n \\
&\quad a_{ij} = \begin{cases} 1, & if\ d_{ij} \geq \alpha \\ 0, & d_{ij} < \alpha \end{cases}
\end{aligned}
\tag{6}
$$

where x_j is the variable for the jth person in the community, x_j=0 means jth person is not chosen to be an opinion leader; x_j=1 means jth person is chosen to be an opinion leader. c_i indicates the cost required to arrange for jth person to communicate messages (endorsement or marketing); $d_{ij} = d_e^t(i,j)$ is the identification degree of i with j, while α is the given identification threshold. According to Tables 5 and 6, and assuming that the cost required to arrange for each member to communicate messages is 1 unit (c_i=1), then the mathematical programming in relation to (6) is as follows:

$$
\begin{aligned}
&Min\ z = x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 + x_9 \\
&s.t.\ \ x_1 + x_6 + x_7 \geq 1 \\
&\quad x_2 \geq 1 \\
&\quad x_3 \geq 1 \\
&\quad x_4 \geq 1 \\
&\quad x_5 + x_9 \geq 1 \\
&\quad x_1 + x_4 + x_5 + x_6 + x_7 + x_8 + x_9 \geq 1 \\
&\quad x_1 + x_3 + x_5 + x_6 + x_7 + x_9 \geq 1 \\
&\quad x_2 + x_4 + x_5 + x_7 + x_8 \geq 1 \\
&\quad x_5 + x_8 + x_9 \geq 1 \\
&\quad x_j \in \{0,1\} \qquad (7)
\end{aligned}
$$

where $x_1 + x_6 + x_7 \geq 1$ indicates that among {1,6,7}, 3 people, at least one person must be selected to effectively influence I_1. From this we can infer that if there are 9 members, at least 9 constraints are required to ensure that each member is influenced by the person with whom he/she strongly identifies ($d_{ij} \geq \alpha$).

Next, the branch-and-bound method (Hillier & Lieberman, 2005) is used to obtain the optimal solution to this integer linear programming problem. The optimal solution is

$$
\begin{aligned}
&z = 5 \\
&x_1 = 0,\ x_2 = 1,\ x_3 = 1,\ x_4 = 1,\ x_5 = 0,\ x_6 = 0,\ x_7 = 1,\ x_8 = 0,\ x_9 = 1
\end{aligned}
$$

5 people J_2,J_3,J_4,J_7, and J_9 ({2,3,4,7,9}) must be selected at a cost of 5 units. This result shows that regarding this specific event, as long as these 5 opinion leaders are willing to provide assistance (endorsement or marketing), they can effectively influence the entire community.

The last column in Table 12 shows that J_5, J_7, and J_9 ({5,7,9}) are the more influential members of the community (highest number of members who strongly identified with them). These individuals can respectively influence 5, 4, and 4 individuals. Assume that the cost involved in their endorsment or marketing of a product is 3 times that of the others. The constraints in Model (6) do not need to be changed; however, the objective function must be adjusted as follows:

$$Min\ z = x_1 + x_2 + x_3 + x_4 + 3\times x_5 + x_6 + 3\times x_7 + x_8 + 3\times x_9$$

According to the branch-and-bound method, if the other conditions remain unchanged, the optimal solution to the integer linear programming is

$$z = 7$$
$$x_1 = 0,\ x_2 = 1,\ x_3 = 1,\ x_4 = 1,\ x_5 = 0,\ x_6 = 1,\ x_7 = 0,\ x_8 = 0,\ x_9 = 1$$

(selection of 5 people J_2,J_3,J_4,J_6, and J_9 ({2,3,4,6,9}) at a cost of 7 units (the cost of J_2,J_3,J_4, and J_6 is 1 unit each; the cost of J_9 is 3 units). This result shows that regarding this specific event, as long as these 5 opinion leaders are willing to provide assistance (endorsement or marketing), they can effectively influence the entire community.

The above example shows that if other conditions remain unchanged, the optimal solution changes as the cost parameters change (c_i; see Model 6). It is worth noting that the number of constraints of the problem (6) increases with the number of the members in the community, it may become very difficult to solve, even impossible with available computers. The comments of Remark 4.1 are also valid for the problem (6) when the community is very large.

Due to the rapid development of information technology and the spread of internet use, numerous virtual communities have recently formed online. Well-known online communities include Facebook, Myspace, and Twitter. Opinion leaders (such as technical, travel, food, online auctioning experts) emerge in these online communities over time, just as they do in traditional communities (Fingar, Kumar & Sharma, 2000; McWilliam, 2000). When companies wish to market a new product or concept, the identification sphere model introduced in this study can be used to identify the opinion leaders (core individuals) in community organziations. Companies can communciate the new concepts to these individuals or have them trial the new products, and through them share information with the community (through endorsement or marketing). Using this approach, companies can effectively enhance community members' acceptance of a new product or concept.

Chapter 8. Conclusions and Further Research

8.1. Conclusions

Decision problems, such as those of human beings, have HDs. A number of related parameters, such as alternative sets, criteria sets, and outcome sets, are observable and quite often occur in the actual domain; however, a number of parameters are invisible and hidden in the reachable and potential domains. The interaction of these visible or invisible parameters forms a changeable space. By introducing the concepts of HD theory and CS, and analysis of decision problems, this study enabled us to understand that, to obtain "optimal solutions" for challenging problems in changeable spaces, decision makers must investigate the depth of potential domains to acquire and master their required CSs.

Based on HD theory and CS analysis, a framework to solve challenging decision problems is provided, that is, Innovation Dynamics. It systematically describes processes of dynamic decision making in changeable spaces. This framework is closely related to studies in management fields. Furthermore, because it is based on HD, CS, psychology, and behavioral science, it is more suitable to discover hidden parameters, including the actual needs and desires of humans, and the technical trends to solve the challenging problems more effectively. The introduction of three HD tool boxes is beneficial for decision makers to identify and explore the hidden parameters and their dynamic changes to solve challenging problems in changeable spaces.

In addition, this dissertation also focused on the identification sphere theory of habitual domains, and proposed a quantitative method to analyze the concept of identification, including the function, degree, and matrix of identification, and the

identification and dis-identification spheres. The election of class representatives was used as an example to describe the mathematical model of identification spheres, and to clearly and numerically express interpersonal relationships.

This study subsequently used two applications to explain the identification sphere that forms among individuals regarding a specific event, and the influence of this sphere. Application 1 in Section 7.1 presented the use of the concepts of degree of identification and identification sphere to form electoral guidelines. The unique attribute of this electoral system is that voters can express both their degree of identification and dis-identification with candidates. Additionally, the identification threshold α and the dis-identification threshold β can be adjusted according to the specific requirements and characteristics of the organization, thereby allowing the organization to build an electoral system that is suited to its requirements. Application 2 in Section 7.2 presented the use of the identification matrix to establish an identification threshold, and to select the most effective (lowest cost) combinations of opinion leaders (key persons) in the community. This section provides a description of the mathematical programming problem for finding the group that covers (influences) all community members, and the optimization method for expanding the transmission of information from a small number of community members to the entire community.

8.2. Further research

Quantification of decision making in changeable spaces will be explored further. For example, the objective of effectively identifying and quantifying the relevant and/or key parameters and their potential change in decision making will be addressed. A number of results on the manner in which to restructure the relevant parameters to enable each participant in the decision problem to declare a victory and form a

"win-win" strategy can be found in the reference (Larbani & Yu, 2009, 2011; Yu, 1990, 2002; Yu & Larbani, 2009). We will also address the problem of the manner in which to systematically analyze the invisible potential domains to find an effective method to acquire, adjust, and allocate required competences in potential domains. Mathematical analysis for specific decision problems in each link of Innovation Dynamics is beneficial to this study. Solving these problems will benefit both practical decision making in changeable spaces and academic research in decision science.

Future research may use the identification function and identification matrix to investigate the identification spheres that form between people and objects. For example, when companies develop new products, the concept of the identification sphere can be used to express the identification level of *i* with the attribute combinations *j* of the product (for example. automobile attributes include speed, appearance, comfort, safety, and stereo setup). The identification threshold (α) can subsequently be adjusted to determine the identification sphere of *i* regarding the product attributes. By performing calculations using Model (6) in Section 7.2, the optimal combination of product attributes with which a majority of target customers can identify can be determined, and the customers' degree of acceptance regarding the new product and its attributes can be understood. Because the cost of product attributes differ, businesses can use these results to select the appropriate combination of product attributes, and (with limited resources) create a product that is suited to target customers.

Future research can also use the identification function and identification matrix to investigate the identification spheres that form between people and various events.

For example, when companies advertise or promote products, they can use the concept of the identification degree ($d_e^t(i, j)$) to determine the identification degree of *i* with advertisement medium *j* (such as television, newspaper, and Internet). The identification threshold (α) can subsequently be adjusted to determine the identification sphere of *i* regarding the advertisement medium. By performing calculations using Model (6) in Section 7.2, the optimal combination of advertisement media with which the target customers identify most strongly can be determined. Therefore, businesses can gain a clearer understanding of the media that produces the optimal advertisement or promotional effects. Because various media incur various advertising costs, businesses can select the most appropriate combination of advertisement media according to customers' degree of acceptance of various media, and (with limited resources) achieve optimal promotional effects.

In addition, the identification function and identification sphere can also be applied to analyze alliances and cooperation in *n*-person game theory. For more details, please refer to Larbani and Yu (2011).

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Appendix 1: Mathematical Presentation for the Evolution of MCDM

To more precisely delineate the main differences among the models of boxes (1)－(4) in Figure 1, we use mathematical symbols and describe them as follows.
Models in box (1) can be specified as

$$v - Max \quad f(x)$$
$$x \in X = \{x \mid g(x) \le 0\} \qquad (1)$$

where f and g are vectors, both can be specified by static functions or dynamically by differential, integral or difference equations.

Models in box (2):
In (1), some or all components of f or g can be probabilistically or fuzzily defined.

Models in box (3):
In (1)

$f(x)$ is decomposed as $f(x, \tilde{Z}_1)$

$g(x)$ is decomposed as $g(x, \tilde{Z}_2)$

where $\tilde{Z}_1$ and $\tilde{Z}_2$ are aggregated unknowns. The form and dimensions of f and g are well specified.

Models in box (4):

In (1), $f(x, \tilde{Z}_1)$ and $g(x, \tilde{Z}_2)$ including the form and dimensions of f and g, $\tilde{Z}_1$ and $\tilde{Z}_2$ are not well specified. They are all to be explored, discovered and/or changed as to find a great, not the best, solution for the challenging problems.

Appendix 2: **Industry Attractiveness Parameters**

(1) Market Parameters

- *Type*: Size of the market, volume, region served, degree of vertical integration, volatility of market sales, cyclical nature of sales, diversity of available products.
- *Growth Prospects*: Stage of product life cycle, projected future growth rate, past growth.
- *Characteristics*: Distribution system, brand differentiation, price sensitivity, captive customers, necessity/luxury product.

(2) Competitive Parameters

- *Industry concentration*: Current concentration index, projected change in concentration.
- *Entry barrier/exit barrier*: Capital requirements, product differentiation, economies of scale, distribution channels, brand identity, switching costs, access to raw material.
- *Buyer power*: Number of buyers, switching costs, dependence on industry.
- *Supplier power*: Number of suppliers, dependence on industry, switching costs.
- *Threats of substitutes*: Price/performance tradeoff.
- *Overseas competitors*: Number of major foreign players, cost factors (factor costs differences), technology availability in other countries.
- *Rivalry among competitors*: Number of competitors, industry capacity vs. demand, diversity of competition, degree of product differentiation.

(3) Financial Parameters

- *Cost factors*: Raw materials, wages and salaries, fixed vs. variable costs, selling expenses.
- *Efficiency factors*: Learning curve effects, economies of scale, average inventory levels, productivity, capacity utilization.
- *Capital structure*: Industry average leverage ratio, average P/E (Price/earning) ratio and trends.
- *Financial results*: Past profitability, future profit potential, share price trends.

(4) Socio Political Parameters

- *Government & legal*: Consistency of Government policies, antitrust laws, regulation/deregulation, EPA requirements, equal opportunity requirements, fair trade decisions, consumer protection, trade laws.

♦*Social attitude and trends*: Changes in consumer preferences, demographics shifts, changes in population mix.

♦*Outside stakeholders influence*: Relationship and support, impact on decision making.

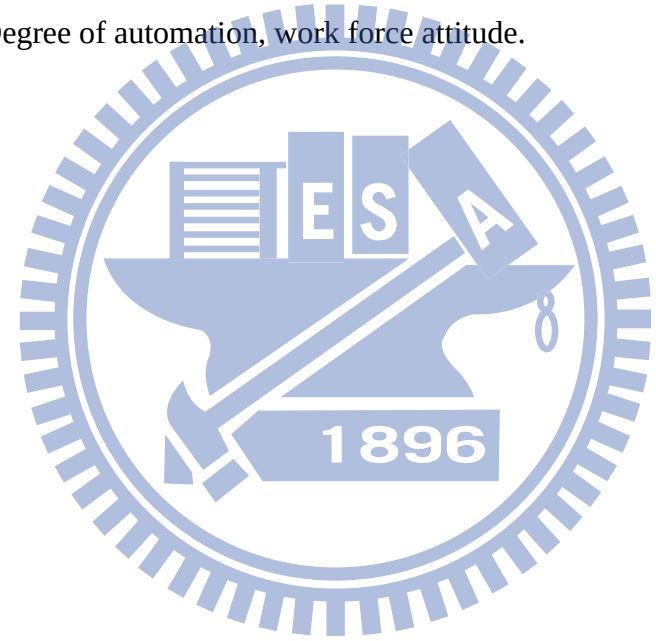
♦*Labor issues*: Availability of skills, degree of unionization, attitude and motivation level.

(5) Technological Parameters

♦*Complexity*: Skills required, investment intensity, volatility, availability, changes in technology.

♦*Product innovation and development*: Basic R&D requirements, applied R&D requirements, importance of patent position, rate of technological advancement.

♦*Productivity*: Degree of automation, work force attitude.



Appendix 3: **Firm Strengths Parameters**

(1) Markets Parameters

- *Company type*: Geographical area serve, degree of vertical integration, volatility and cyclical firm sales, breadth of product line, location of plants.
- *Prospects*: Size, growth rate relative to industry.
- *Company characteristics*: Effectiveness of distribution network, relationship with dealers, brand differentiation, advertising and promotional skills, sales force effectiveness, captive customer, vulnerability to changes in demand, perceived quality of products.

(2) Competitive Parameters

- *Company dominance*: Market share (domestic), market shares (overseas), changes in market share.
- *Exit barriers*: Capital investment, resale value of equipments/assets, number of employees involved, community pressure.
- *Bargaining power of buyer on firm*: Number of buyers, fragmented/concentrated, buyer switching costs.
- *Bargaining power of supplier on firm*: Number of suppliers, size relative to suppliers, dependence of suppliers on firm.
- *Vulnerability to competition*: Number of major domestic competitors, number of foreign competitors, basis of competition.

(3) Organization and Management Parameters

- *Management quality*: Top management, leadership, quality of strategic decisions, middle/functional management, availability of general management skills.
- *Management style*: Proactive/reactive, risk taking propensity, participative/autocratic, aggressive/passive, flexible/inflexible, external/internal focus.
- *Management loyalty/morale*: Turnover, tenure in the organization, commitment to the organization.
- *Organizational culture:* Shared values and norms, company policies, procedures, attitudes.
- *Systems*: Information & control systems, organization structure, reward and evaluation systems.
- *Personnel*: Background, skills.

(4) Financial Parameters

- *Cost structure*: Overhead/total cost, cost of raw materials, wages and salaries, sales cost/total sales.

♦*Achieved efficiency*: Decrease in cost/unit achieved, collection period-receivables.

♦*Capital structure*: Debt/equity, ability to raise equity, borrowing capacity, distribution of shares.

♦*Financial performance*: Stock price and changes, P/E ratio, profitability (return on investment or return on equity), stability of profits, reserves, cash flows.

(5) Socio Political Parameters

♦*Government & legal*: Firm's ability to adapt/cope with change, firm's ability to influence, compliance with regulatory bodies, impact of regulations, position adopted on important issues.

♦*Social Attitudes and trends*: Impact of social changes on firm, adaptability to change, proactive actions to take advantage of opportunities.

♦*Outside stakeholders*: Influence of outside stakeholders on strategies and decisions, extent of stake holder support, relationship with stakeholders.

♦*Labor issues*: Influence of organized labor, hostility of labor, attitude of labor.

(6) Technological Parameters

♦*Technological complexity*: Size of investment, skills availability, available technological know-how, technological follower/leader.

♦*Products innovation and development*: Patents available, new product capabilities, research and development facilities.

♦*Productivity*: Work force attitude, degree of automation of the firm, output/employee ratio, inventory turnover ratio, capacity utilization, economies of scale, inventory levels compared to industry average, capacity utilization, age of plant and equipment.

Appendix 4: A Structure of Goal Functions

(1) **Survival and Security:** physiological health (correct blood pressure, body temperature and balance of biochemical states); right level and quality of air, water, food, heat, clothes, shelter and mobility; safety; acquisition of money and other economic goods;

(2) **Perpetuation of the Species:** sexual activities; giving birth to the next generation; family love; health and welfare;

(3) **Feelings of Self-Importance:** self-respect and self-esteem; esteem and respect from others; power and dominance; recognition and prestige; achievement; creativity; superiority; accumulation of money and wealth; giving and accepting sympathy and protectiveness;

(4) **Social Approval:** esteem and respect from others; friendship; affiliation with (desired) groups; conformity with group ideology, beliefs, attitudes and behaviors; giving and accepting sympathy and protectiveness;

(5) **Sensuous Gratification:** sexual; visual; auditory; smell; taste; tactile;

(6) **Cognitive Consistency and Curiosity:** consistency in thinking and opinions; exploring and acquiring knowledge, truth, beauty and religion;

(7) **Self-Actualization:** ability to accept and depend on the self, to cease from identifying with others, to rely on one's own standard, to aspire to the ego-ideal and to detach oneself from social demands and customs when desirable.

Appendix 5: Eight Methods for Expansion of Habitual Domains

(1) Learning actively: By active learning we mean obtaining those concepts, ideas and thoughts from various channels including consultations with experts, reading relevant books and following the radio, television, journals, etc.

(2) Take the higher position: There is a tendency in all of us to view the world from a very limited, even selfish perspective. By taking the higher position we are, in fact, expanding our habitual domains.

(3) Active association: There are many different events, subjects, objects and problems in our daily lives. They all have different features, but common properties. By actively associating them, we may be able to discover the unique features of problems, events, subjects and objects. Once the unique features are discovered, our habitual domains may be expanded.

(4) Changing the relative parameter: Make a habit of looking for connections between seemingly disparate objects and events.

(5) Changing the environment: Every event or problem has a number of parameters of characteristic elements. By tinkering with these parameters, changing their values, we can produce new concepts and ideas.

(6) Brainstorming: Brainstorming is nothing more than effective group thinking. Presented with a particular problem, each member of the group is asked to freely report what comes to mind regarding various aspects of the situation. It can be an enormously creative process, not only to meet a challenge the group faces, but also to encourage individual growth.

(7) Retreat in order to advance: Sometimes taking a time-out from the matter can be the most effective mind-expanding technique you can use. By retreating, we change the actual domain and, consequently, the reachable domains.

(8) Praying or meditation: Some of the most effective ways to lower our overall charge are through prayer, meditation, relaxation exercises or through a conscious effort to put aside our unfulfilled wishes. The practice can let the ideas of low activation probability to catch our attention and change our actual domain and reachable domain.

Appendix 6: Nine Principles of Deep Knowledge

(1) **The deep and down principle:** This can also be remembered as the ocean principle. The idea is to empty your mind of desires and to insulate oneself from external bombardment of ideas. By doing so, you create an atmosphere conductive to deep thinking. When one is relaxing, his overall charge level is lower, and "hidden" thoughts with much lower charges come bubbling up. Relaxation can also make one more sensitive to emerging problems, allowing one to solve them when they are at a fairly simple stage.

(2) **The alternative principle:** This can be remembered as the door principle. An assumption which is always imposed or always left out will lose its value as an assumption. Sometimes we have to omit or change our combined assumptions so that we can create new ideas from different sets of assumptions.

(3) **The contrast and complementing principle:** This can be remembered as the house principle. A house offers barriers – a roof and walls against the weather – and also, contrasting with and complementing this quality, it has open space within. Even what we see as existing can be contrasted with that which doesn't exist, and these two things complement each other in their functions.

(4) **The revolving and cycling principle:** This principle can be remembered as falling flower seeds. When a flower fades in the autumn and falls to the ground, it carries with it the seeds for renewal in the following spring. Just as each success contains the seeds of failure, so each failure contains the seeds of success.

(5) **The inner connection principle:** This is the blood is thicker than water principle. It means, simply, that a close connection will be honored over simple acquaintance. The idea is to build as many strong channels as possible connecting us to the inner core of another individual's habitual domain. Making inner connections is the real goal of what is sometimes called "networking".

(6) **The changing and transforming principle:** This is the ice and stream principle. The world is constantly changing, and so are the habitual domains of the individuals and organizations that inhabit it. They change when circumstances (or parameters) make them. People who are willing to change are people with a better chance for happiness and success. We must all be on the alert for changes and their implications and be willing to change ourselves. If we do not, we will never tap our potential.

(7) **Contradiction principle:** This is the stand on your head principle. Sometimes it is worth seeing the world upside down, or at least from a different angle, it can clear your mind. If there is an event or information that contradicts our conclusions, then we must revise our assumptions or change our conclusions. Applying this principle to our daily thinking can sharpen our thought processes.

(8) **The cracking and ripping principle:** This is the broken teacup principle. Cracks are the weak point of any structure. If you want to destroy a mighty fortress, we can do so by working on its crack lines and ripping them open.

(9) **The void principle:** This might be called the empty space principle. This principle simply states that the outside of our habitual domains is not empty. Just because we don't perceive it or recognize it doesn't mean it isn't there. And whether we acknowledge it or not, those other HDs can have a profound effect on us.