# Relationship between Decision Styles and Decision Types for Innovative Opportunities: Empirical Study on Chinese Internet of Things Industry and the Cognitive Decision Support Approach

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Abstract—Internet of things (IoT) has become a strategic industry of China. It is still at the initial stage, which means there are many problems and challenges, such as lack of original innovation, etc. In the dynamic business environment, innovative opportunities play important roles in the rapid growth of a company. How to grasp the innovative opportunities provided by IoT becomes a big challenge for Chinese companies. The applications of IoT in China are still very limited and some listing IoT companies don't behave very well in market. This paper tries to find the reason from the aspect of decision making of those IoT and its related companies' senior executives. Their decision behaviors vary according to decision makers' decision styles. The empirical study on Chinese IoT related companies shows that decision styles have close relationship with decision types when decision makers are facing innovative opportunities. Three decision styles and three decision types were analyzed based on our investigation. 45.8% of the wise and heroic leaders inclined to make radical and risky decisions. 52.2% of the CEOs make decisions in moderate way while 57.6% of the CEOs who prefer to conform to others inclined to make conservative decisions. Chinese traditional culture and the limitation of incentive mechanism may account for the high ratio of conservative decisions and the lack of original innovations in IoT industry. Decision makers can benefit from learning appropriate cases. According to decision makers' decision styles and the characteristics of a decision problem, a decision support approach is proposed to improve their cognition and decision behaviors.

*Index Terms*—decision style, decision type, internet of things, innovative opportunities, cognitive decision support

## I. INTRODUCTION

Internet of things (IoT) is an important part of the next generation of information technology, which has been

in moderate organizational environment. In the past two decades, the speed that companies created competitive advantages and disrupted such advantages was very fast and the time to keep competitive advantages was shortened greatly. The new business environment can be characterized as technological change, high speed of diffusion, intensive information and knowledge.

Innovative opportunities are generated from the interaction between the entrepreneur's objectives and the environment. Theoretically, the more complex and turbulent is the environment, the more valuable is the innovative opportunity. Many evidences prove that innovative opportunity plays a very important role in the success of a firm, especially those hi-tech enterprises. The ability of seizing innovative opportunities has a close relationship with the rapid growth of those successful companies. In the dynamic business environment, innovative opportunities emerge dramatically and

listed as the strategic industry in the report of Chinese

central government. Besides, IoT is hailed by both IT

researchers and practitioners worldwide. How to cope

with the novelty with both opportunity and adventure in

IT industry? Entrepreneurs have different views and

responses based on their characters, cognitive and

According to our rough questionnaire investigation,

53.1% of the IT companies have not decided to invest on

IoT products or service due to their worries on

technological barriers, shortage of funds, market risks,

problems of standards, and even their failure experiences

about innovation. Technological barriers and market risks

globalization, the stable environment of companies has

disappeared. Complexity and dynamics characterize the

Due to the application of internet and economic

rank the top two factors of those entrepreneurs' worries.

decision styles, organizational culture, etc.

premise start-ups for many small and medium-sized enterprises.

Different individuals may have different decisions when they are provided with the same opportunities. The decision skills for innovative opportunities become the critical qualities for those successful entrepreneurs.

This paper studies the relationship between decision styles and decision types when CEOs are facing opportunities in IoT industry. The result is instructive for companies to choose appropriate CEOs in order to grapple IoT business opportunities, and also valuable for those enterprises in dynamic environment.

## **II. INTERNET OF THINGS**

The Internet of Things (IoT) is a novel paradigm that is rapidly gaining ground in the scenario of modern wireless telecommunications [1]. The basic idea of the IoT is that virtually every physical thing in this world can also become a computer that is connected to the Internet [2]. The basic idea of this concept is the pervasive presence around us of a variety of things or objects - such as Radio-Frequency Identification (RFID) tags, sensors, actuators, mobile phones, etc. - which, through unique addressing schemes, are able to interact with each other and cooperate with their neighbors to reach common goals.

Internet of things refers to the ubiquitous devices and facilities connected by internet, including sensors, mobile terminators, industrial systems, building control systems, home intelligent facilities, all assets with RFID, and so on. To be more accurate, things do not means computers, but they can feature tiny computers. They are often called smart things, because they can act smarter than things that have not been tagged. NIC forecasts that by 2025 Internet nodes may reside in everyday things - food packages, furniture, paper documents, etc. It highlights future opportunities that will arise, starting from the idea that popular demand combined with technology advances could drive widespread diffusion of an Internet of Things (IoT) that could, like the present Internet, contribute invaluably to economic development.

The notion of internet of things breaks through the traditional thinking that separates physical infrastructure and IT infrastructure. That is, one side is airports, super highways, buildings, harbors, etc while the other side is data center, personal computer, broad-band network, etc. In the era of internet of things, all facilities will be connected into a whole infrastructure. Such infrastructure is somehow like a new earth, which is called as intelligent earth. The IoT expands the technical Internet building blocks such as DNS, TCP, and IP with identification and addressing schemes, last mile communication technology, and an Internet gateway that matches the IoT

requirements, foremost among them low energy consumption, low cost, and mobility [3].

In China, the development of IoT has become a national strategy. Chinese government will support IoT industry from four aspects which is shown in figure 1.

M2M means machine to machine while RFID means Radio Frequency Identification.

RFID still stands at the forefront of the technologies driving the vision. This is the consequence of the RFID maturity, low cost, and strong support from the business community. RFID is so well-known that for somebody there is a misunderstanding that RFID is equal to IoT.

China is on the way to industrialization. Therefore, it is naturally important to merge industrialization with informationization. China has launched its ambitious plan to support IoT and other related industries. Huge amount of funds will be poured to IoT and its related industries. The US and EU also lay much emphasis on IoT and consider it as a new engine of economy.



Figure 1. Four Aspects of IoT in China

Artzori et al [1] define internet of things from three visions, that is, things oriented vision, internet oriented vision and semantic oriented vision. Things oriented vision contains RFID, UID, spimes, smart items, wireless sensors and actuators, everyday objects, etc. Internet oriented vision includes IP for smart objects, communicating things, web of things, connectivity for anything, etc. Semantic oriented vision consists of semantic technologies, reasoning over data, semantic execution environments, etc.

IoT has great potential of application. Some major applications are shown below.

Transportation and logistics. Intelligent cars, trains, buses as well as bicycles along with roads and rails are equipped with sensors, actuators, and processing power. Roads themselves and transported goods are also equipped with tags and sensors that send important information to traffic control sites and transportation vehicles to better route the traffic, help in the management of the depots, provide the tourist with appropriate transportation information, and monitor the status of the transported goods. It is

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possible to obtain products related information, promptly, timely, and accurately so that enterprises or even the whole supply chain can respond to intricate and changeable markets in the shortest time. Additionally, real-time access to the ERP program helps the shop assistants to better inform customers about availability of products and give them more product information in general [4]. Cars, trains, and buses along with the roads and the rails equipped with sensors, actuators and processing power may provide important information to the driver and passengers of a car to allow better navigation and safety.

- Smart environments. A smart environment is that making its employment easy and comfortable thanks to the intelligent objects, be it an office, a home, an industrial plant, or a leisure environment. Rooms heating can be adapted to our preferences and to the weather; the room lighting can change according to the time of the day. Sensors and actuators distributed in houses and offices can make our life more comfortable. Smart environments also help in improving the automation in factories with a massive deployment of RFID tags associated to the production parts.
- Healthcare. Many people can benefit from the service provided by the IoT technologies. Identification and authentication includes patient identification to reduce incidents harmful to patients (such as wrong drug/dose/time/procedure), comprehensive and current electronic medical record maintenance, and infant identification in hospitals to prevent mismatching. Sensor devices enable function centered on patients, and in particular on diagnosing patient conditions, providing real-time information on patient health indicators.
- Personal and social domain. The applications falling in this domain are those that enable the user to interact with other people to maintain and build social relationships. Indeed, things may automatically trigger the transmission of messages to friends to allow them to know what we are doing or what we have done in the past, such as moving from/to our house/office, travelling, meeting some common mates or playing soccer [5].

The IoT has the potential to add a new value to our lives by enabling communications with and among smart objects, thus leading to the vision of "anytime, anywhere, anymedia, anything" communications. IoT has a great future. However, there is another view which provides doubts and worries. So far Chinese IoT listing companies have not behaved very well. The development speeds of IoT and its relate industries might not be so optimistic. How to make decisions before the big opportunities as well as big risks? Chinese IoT related companies don't have different views.

In such circumstances, innovation is critical for IoT companies to make breakthrough. Some innovations of business model are shown below.

- Customers build all by themselves. Customers should build the whole system, including business platform, reading devices, and rent network for communication. In this model, customers pay the whole fees for the IoT system, which incurs much investment pressure for customers. It is suitable for those companies who have enough funds and have rigorous requirement for privacy. Such companies include power plants, environment protecting organizations, etc.
- Renting platform. Operating companies build public platforms. Customers rent the platforms and pay some relative fees such as readers and communication. Many customers can afford the relatively low costs. This model can be widely applied in the market of GPS for vehicles.
- Advertisement. Platform operating companies build public platforms, readers, tag identifiers, etc and then lease them to advertisement companies, who will pay the rents by their incomes from ads. This is promising market, such as taxis, mobile LED TV on buses, etc.
- Mobile payment model. Customers build platforms, purchase relative devices and rent networks for communication. They take commissions from their end customers who use the platform for payments. This model has been accepted by those banks in their mobile POS business.

Generally speaking, IoT provides us with vast potential market. It also brings us great challenges of innovations both in technologies and business models. How to face the novelty? We investigated some Chinese companies to find the answer.

## III. INNOVATIVE OPPORTUNITIES

The concept of innovative opportunities, put forward by Holmen et al, arises from Schumpeterian theoretical tradition [6]. It argues that innovations, entrepreneurship, creative destruction and opportunities drive capitalist growth. development and economic Schumpeter identified innovation as the critical dimension of economic change. He argued that economic change revolves around innovation, entrepreneurial activities and market power and sought to prove that innovationoriginated market power could provide better results than the invisible hand & price competition. He argues that technological innovation often creates temporary monopolies, allowing abnormal profits that would soon be competed away by rivals and imitators. He said that these temporary monopolies were necessary to provide the incentive necessary for firms to develop new products and processes [7].

There are three types of opportunities, namely "technological opportunities" which is used frequently in evolutionary economics, "entrepreneurial opportunities which derives from entrepreneurship theory and "productive opportunities" which comes from knowledge and resource based theories of the firm.

Holmen defines innovative opportunity as "the possibility to realize a potential economic value inherent in a new combination of resources and market needs, emerging from changes in the scientific or technological knowledge base, customer preferences, or the interrelationships between economic actors". An innovative opportunity must consist of at least three conceptual elements: (1) an economic value for someone: (2) a possibility that the resources needed to realize the opportunity can be mobilized and (3) a possibility that at least some part of the generated economic value can be appropriated by the actor pursuing the opportunity [6]. Generally speaking, innovative opportunitites consist of three conceptual elements, that is, economic value, mobilization of resources and appropriability.

In the light of Holmen's definition, we argue that innovative opportunity can be understood from five aspects. The model of innovative opportunity is shown in figure 1. Targets depend on the entrepreneur's expectation and strategic thinking of his firm. Targets rely on entrepreneur's subjective judgment. Demands reflect the future market trends of the products or service. Resources refer to human resource, money, facilities, information and knowledge, etc. Many companies fail to make full use of innovative opportunities due to the shortage of necessary resources. Capacity is determined by the skills and quality of entrepreneur and the management. High qualified entrepreneurs and the management have the ability to integrate and make full use of the resources they have. Environment includes many aspects, such as technology, economy, law, government policies, culture, etc. Environment can be supporting aspects as well as constraints or barriers to the companies to fulfill their business plans.



Figure 2. Conceptual Model of Innovative Opportunity

Drucker, who was known as the top master of management in 20 century, outlined seven sources for innovative opportunities. The first four are sources of innovation that lie within the industry. The last three arise in the societal environment [8].

• The Unexpected - An unexpected success, an unexpected failure or an unexpected outside event can be a symptom of a unique opportunity.

- The Incongruity A discrepancy between reality and what everyone assumes it to be, or between what is and what ought to be, can create an innovative opportunity.
- Innovation based on process need When a weak link is evident in a particular process, but people work around it instead of doing something about it, an opportunity is available to the person or company willing to supply the "missing link".
- Changes in industry or market structure The opportunity for an innovative product, service or business approach occurs when the underlying foundation of the industry or market shifts.
- Demographics Changes in the population's size, age structure, composition, employment, level of education and income can create innovative opportunities.
- Changes in perception, mood and meaning -Innovative opportunities can develop when a society's general assumptions, attitudes and beliefs change.
- New Knowledge Advances in scientific and nonscientific knowledge can create new products and new markets. To figure axis labels, use words rather than symbols. Do not label axes only with units. Do not label axes with a ratio of quantities and units.

## IV. DECISION TYPES WHEN FACING INNOVATIVE OPPORTUNITIES

Decision for innovative opportunities refers to the process of identification, evaluation, scheme optimization of opportunities and implementation by decision makers to achieve companies' goals and gain extra-profits under specific constraints. It consists of seven elements, that is, decision maker, targets, decision variables, environment, outcomes, evaluation variables and the relationships between those variables.

Decision for innovative opportunities has the following features.

- Active decision. Common decisions are induced by problems and the aim is how to solve the problem where decision makers are passive. Decisions for innovative opportunities, however, are induced by advantageous or profitable events where decision makers are active.
- Psychological dependence. Decisions for innovative opportunities are dependent on decision makers' psychological inclination. Different value orientation of the decision makers, which is influenced by organizational culture, education, experiences and so on, will lead to different behavioral characteristics.
- Abnormal or unstructured decisions. As innovative decision consists of target, demand, resources, capability and environment, there could hardly have two same decision contexts for a decision maker to face. There is no given program or routine for decision maker's reference. Therefore, decisions for innovative opportunities are abnormal or

unstructured decisions, which require decision maker's experience, integration of knowledge, insight and wisdom.

- Dynamic relationship of decision information. Innovative opportunities originate from the appropriate match of objective conditions, subjective targets and capability. There exists relationship between different kinds of information for innovative decision. The match varies according to the change of information. It is important to obtain inner and outer information in time and accurately for decision making.
- Time-sensitive. Innovative opportunities are quite time-sensitive and transient. CEOs should grapple the innovative opportunities and make rapid or just-in-time decisions. Otherwise, such opportunities will disappear.
- Risky. Companies must invest on new products or service to commercialize the innovative opportunities to gain extra-profits. The companies will take the risk of investment failure. Opportunity cost can also be considered as a kind of risk. As a company invests on one product, it could hardly invest on another product due to the limit of fund.

## V. DECISION STYLE

Decision style refers to decision maker's mental models and approaches for decision making. It has nothing to do with the content and targets of a specific decision [9]. Decision style has significant influence on the effectiveness and efficiency of decisions. Generally, individual's risk preference has close relationship with his/her decision style. A decision maker's decision style can be estimated according to his/her risk preference.

Kahneman and Tversky's prospect theory reveals that an individual's behavior is always risk aversion. An individual has the inclination to take a risk when facing losses while avoids risks when facing gains. Gain or loss is related to the so-called "reference point". Therefore, risk is an important factor to be considered for decision making. Besides, other factors, such as individual's age, education, experiences, cognition and value should be considered when he/she makes decisions.

## VI. EMPIRICAL STUDY

The train of thought is as follows. (1) Design questionnaire and collect data. (2) Extract some decision styles. (3) Cluster or group the decision styles. (4) Extract decision types by investigating CEOs' decision behaviors. (5) Cluster or group the decision types (behaviors). (6) Find relationship between decision styles and decision types (behaviors).

## A. Questionnaire Design and Data Collection

As education background, value, experience, personal character, risk preference have impact on an individual's decision for innovative opportunities, the questionnaire consists of two parts that covers the above aspects. The first part tests individuals' identification of innovative The questionnaires were sent to 140 senior executives of IoT related companies in Guangdong province of China. 91 questionnaires were sent back and 83 of them were valid. The data were analyzed by SPSS 16.0.

## B. Result

The basic information is shown in table I.

I ABLE I								
. BASIC INFORMATION								
		number	Percentage (%)					
Gender	Gender male		60.2					
	female	33	39.8					
	21-30	25	30.1					
Age	31-40	42	50.7					
	41-50	8	9.6					
	>51	8	9.6					
	Bachelor's degree	24	28.9					
Education	Master's degree	42	50.6					
	PhD	17	20.5					

Credibility is measured by Cronbach's alpha coefficient. The greater the Cronbach's alpha coefficient is, the higher is the questionnaire's credibility. The Cronbach's alpha coefficient for the questionnaire we used is 0.472. The credibility is acceptable. The result of KMO and Bartlett's test for decision style is shown in table II.

TABLE II	
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CREDIBILITY ANALYSIS						
Kaiser-Meyer-Olkin	.632					
Adeq						
Bartlett's Test of	Approx. Chi-Square	314.355				
Sphericity Df		66				
	Sig.	.000				

The result in table II proves that the data can be processed by factor analysis.

## C. Factor Analysis of Decision Styles

12 aspects have been tested in the questionnaires. The 12 aspects are listed in table III.

After the 12 aspects were processed by principle component analysis, we can extract five factors, which explain 73% of the total variance. The result is shown in Table IV.

The extraction result of principle component analysis is shown in Table V.

The five factors that describe decision styles are showed in table VI.

The five factors were clustered into three decision styles. We named them as (1) style of wise leader (Da), (2) style of democratic centralism (Db) and (3) style of conformity with others (Dc). Classification test was taken via SPSS in order to examine the correctness of the cluster. The results show that the identification correctness of Da is 95.7%, that of Db is 91.3% and that of Dc is 100%. The details are omitted.

### TABLE III

## DESCRIPTION OF 12 ASPECTS IN QUESTIONNAIRE

No.	Description
1	Collect more information as possible as you can and analyze it before making decisions.
2	Discuss with other senior executives to get consensus before making decisions.
3	Trust the results acquired via analytical tools instead of intuition.
4	Appreciate those employees who dare to propose different suggestion.
5	Decide by yourself without regard to other senior executives' contrary suggestion.
6	You like those employees who implement your decision without doubts.
7	Making strategic decisions according to your experiences and intuition.
8	You can accept the risks and uncertainty brought by your decision.
9	You like employees to give suggestion for your company.
10	You prefer to follow the mainstream of the market and industry.
11	You can make decisions without hesitation.
12	Make decisions in reference to the former cases.

## TABLE IV

TOTAL VARIANCE EXPLAINED							
				Extraction Sums of Squared			
	Initial l	Eigenvalues		Loadin	Loadings		
						Cumu	
Comp		% of	Cumul		% of	lative	
onent	Total	Variance	ative %	Total	Variance	%	
1	2.95	24.59	24.59	2.95	24.59	24.59	
2	2.09	17.41	42.00	2.09	17.41	42.00	
3	1.40	12.41	54 42	1.40	12.41	54.42	
	1.49	12.41	34.42	1.49	12.41	4	
4	1.22	10.20	64.63	1.22	10.20	64.63	
5	1.00	8.37	73.00	1.00	8.37	73.00	
6	.86	7.20	80.21				
7	.65	5.48	85.70				
8	.49	4.14	89.84				
9	.43	3.64	93.48				
10	.37	3.13	96.62				
11	.29	2.47	99.09				
12	.10	.90	100.00				
Extraction Method: Principal Component Analysis.							

## TABLE V

## ROTATED COMPONENT MATRIX

	Component						
	1	2	3	4	5		
No.10	903						
No.12	894						
No.11	.852						
No.4		.819					
No.5		.794					
No.2			.798				
No.6			795				
No.1			.602				
No.7				.789			

No.3				.636			
No.8					.841		
No.9					.532		
Extraction Me	Extraction Method: Principal Component Analysis						

Rotation Method: Varimax with Kaiser Normalization. Rotation converged in 7 iterations.

## D. Factor Analysis of Decision Types When Facing Innovative Opportunities

12 aspects of decision types when facing innovative opportunities in IoT industry have been selected from the questionnaire. They are listed in Table VII.

## TABLE VI

FIVE FACTORS OF DECISION ST	YLE
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Factor of Decision Style	Description					
D1	Rational analysis					
D2	Decision by Experience and tradition					
D3	Autocratic decision					
D4	Go with the stream of other opinions					
D5 Willing to follow correct opin						

## TABLE VII

## 12 ASPECTS OF DECISION TYPES WHEN FACING INNOVATIVE

	ORIGNITIES
No.	Description
1	Conform to other large IoT companies' strategies.
2	Avoid loss as possible as you can.
3	Analyze and evaluate all alternatives for innovative
	opportunities and then make decisions.
4	You'll consider the match of company's capability and
	innovative opportunity.
5	Make decisions according to your experiences and intuition.
6	You are willing to accept new ideas and often try some new
	methods in management.
7	Make decisions according to the expected value of every
	alternative.
8	Make rapid decisions instead of waiting for conformity.
9	Concentrate on your core business other than diversification.
10	Trust the results via analytical tools instead of intuition.
11	Pursue big profits and dare to take a risk regardless of
	uncertainty and failure.
12	You like to achieve success with original ideas or make a
	successful surprise raid.

## TABLE VIII.

## ROTATED COMPONENT MATRIX

				Extract	ion Sums of	Squared	
	Initial l	Initial Eigenvalues			Loadings		
						Cumu	
Comp		% of	Cumul		% of	lative	
onent	Total	Variance	ative %	Total	Variance	%	
1	3.10	25.88	25.88	3.10	25.88	25.88	
2	2.40	20.07	45.95	2.40	20.07	45.95	
3	2.23	18.55	64.55	2.23	18.59	64.55	
4	1.13	9.47	74.02	1.13	9.47	74.02	
5	1.05	8.75	82.77	1.05	8.75	82.77	
6	.68	5.73	88.51				
7	.43	3.62	92.14				
8	.37	3.14	95.28				
9	.19	1.60	96.88				
10	.15	1.30	98.19				
11	.12	1.06	99.25				
12	.089	.74	100.00				
Extraction Method: Principal Component Analysis.							

After the 12 aspects were processed by principle component analysis via SPSS, we can extract five factors,

which explain 82.8% of the total variance. The result is shown in Table VIII.

The extraction result of principle component analysis is shown in Table IX.

#### TABLE IX

## ROTATED COMPONENT MATRIX

	Component						
	1	2	3	4	5		
No.1	709	.411	104	.348	.323		
No.1	845	.184	.211	.042	208		
No.3	.314	100	832	151	.245		
No.4	.487	.058	541	.578	168		
No.5	.088	.149	.861	322	.076		
No.6	.046	118	.232	805	307		
No.7	213	262	.091	.805	232		
No.8	.014	.127	071	016	.836		
No.9	.071	734	.102	.286	.312		
No.10	.864	.209	049	013	027		
No.11	054	.676	.325	.164	.394		
No.12	.023	.888	.166	.003	.278		

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. Rotation converged in 13 iterations.

The five factors that describe the decision types when decision makers face to innovative opportunities are shown in Table X.

## TABLE X

FACTORS OF DECISION TYPES			
Factor of Decision Style	description		
T1	Follow mainstream		
T2	Rational analysis		
Т3	Risk-preference		
T4	act with courage and determination		
T5	Loss aversion		

The five factors were clustered into three decision types for innovative opportunities. We named them as (1) type of adventurer (Ta), (2) type of rational or levelheaded man (Tb) and (3) type of conservative or traditional decision maker (Tc). Classification test was taken via SPSS in order to examine the correctness of the cluster. The results show that the identification correctness is satisfactory. The details are omitted.

E. Relationship Between Decision Styles and Decision Types When Facing Innovative Opportunities

TABLE XI

THE RELATIONSHIP BETWEEN DECISION STYLE AND DECISION TYPE

		Decision style		
		Da	Db	Dc
Decision type	Та	45.8%	19.6%	17.6%
for innovative	Tb	31.5%	50.8%	25%
opportunities	Tc	23.7%	29.6%	57.6%
(F test is omitted.)				

Pearson  $\chi^2$  test was taken to examine whether there exists difference between decision styles and decision types for innovative opportunities. The result shows that the decision makers with different decision styles would have significant different decision behaviors for innovative opportunities at the confidence level of 95% (p=0.020).

45.8% of the wise and heroic leaders (Da) incline to make radical and risky decisions when facing innovative opportunities (Ta). Generally in the start-up stage or in hard time, Da type is suitable. Such companies may have great-leap-forward development or turning point. For example, Steve Jobs led Apple to the track of rapid growth by his talent and heroic personality in late 1990s when Apple was in its hard time of bankruptcy. IoT is a novelty and there have many problems in IoT industry. That means opportunities coexist with challenges. In such situation, wise and heroic leaders explore and pioneer IoT products and service to make their companies on the move. Innovation is very critical to IoT industry. Innovations of technology, service, and business model will bring advantages to IoT companies. Otherwise, they will be washed out of IoT market. The dynamic situation calls for wise and heroic leaders to grasp opportunities and take the risks bravely. Therefore, it's very important to hunt appropriate CEOs for IoT companies to reduce opportunity cost. Wise and heroic leaders are suitable for current circumstances.

52.2% of the decision makers who like the type of democratic centralism (Db) incline to make rational or level-headed decisions (Tb). In China, democratic centralism may be the most popular decision mechanism at least nominally. Many Chinese believe in Confucian philosophy that moderation in all things is the best of rules. They don't dare for the world first. In IoT companies, such decision makers study innovative opportunities carefully and then adopt moderate strategies. They take limited risks. At the start-up stage of Chinese IoT industry, the ratio of type Db should not be high. Chinese traditional philosophy that believes in moderate way may be a barrier to the rapid growth of IoT industry. 57.6% of the decision makers who prefer to conform to others (Dc) incline to make conservative decisions (Tc) when facing innovative opportunities. Such decision makers don't have the courage and ability to bring their companies to a new height via radical innovations. The best choice is to avoid mistakes. In the dynamic business environment, no change means declination or death. Surprisingly, the ratio of type Dc is so high in our investigation. In China, some IoT companies have stateowned background more or less. Due to owner absence, top management doesn't care much for the development of their companies. Copying or imitating other innovators brings less risks and lower costs. Therefore, they prefer to pursue stability. This can explain why China is lack of original innovation in IoT industry. More reasons need to be studied to address the abnormal ratio of type Dc in Chinese IoT industry.

## VIII. DECISION SUPPORT APPROACH

Individuals can improve his/her cognition or mental models and hence improve his/her decision behaviors by learning suitable cases. Therefore it is important to find proper cases that can match those individuals with a specific decision style. The decision support strategy is to recommend proper cases to the decision makers according to their decision styles and the characteristics of decision problems aiming at improve decision makers' cognition and decision behaviors. The algorithm is as follows.

**Step 1.** Build up decision information table of cases.

This step consists of three sub-steps. (a) Behavioral experiments will be conducted to find which case can improve an individual's cognition best. Researchers should build up a case base and find the mapping relationship between the cases and the three decision styles based on behavioral experiments. For example, Steve Jobs, the co-founder of Apple, was famous for his magic innovations. His stories could encourage people to think in different ways and behave bravely. Those conservative decision makers will benefit from Jobs' stories and improve their mental models and decision behaviors. This is just an example. We must find the mapping laws between cases and decision styles on the basis of many behavioral experiments. Record the scores

of each decision maker's cognitive improvement  $C_{ki}$ . k

is the order number of decision makers while i is the

order number of cases. All of the variable values of  $C_{ki}$ 

can make a set C. (b) Experts give 5-10 key words  $W_{ij}$  to each case. The key words can describe the specific case appropriately. (c) Fill the decision information table with the key words. Words order is not important.

Step 2. Acquire the decision styles of a decision maker via rating scale, a special questionnaire. American psychologists Katherine C. Briggs and Isabel Briggs Myers published their famous "Myers-Briggs Type Indicator" (MBTI) in 1942. Now it has been modified for more than 10 times and become the most widely used rating scale for cognitive styles and decision styles. For each decision maker, we can employ MBTI to get the

degree of membership to a specific decision style  $M_{kh}$ .

h is the order number of decision styles. Here  $h_{=1,2,3}$ .

All of the variable values of  $M_{kh}$  can make a set M.

Step 3. Establish a model that can reflect the relationship between set M and set C. BP neural networking method can be employed to build up such model.

Step 4. Given a new decision problem. Extract 5-10

keywords of the new decision problem  $W_{ij}^{\dagger}$ . **Step 5.** Calculate the degrees of similarity between each

word of  $W_{ij}^{'}$  and  $W_{ij}^{'}$  by employing the following formula:

$$Sim(S_1, S_2) = \sum_{i=1}^{4} \beta_i \prod_{j=1}^{i} Sim_j(S_1, S_2)$$

where

1)  $Sim_1(S_1, S_2)$  is the description formula of the first independent meaning of original word;

2)  $Sim_2(S_1, S_2)$  is the description formula of other independent meaning of original word;

3)  $Sim_3(S_1,S_2)$  is the description formula of relationship meaning of original word;

4)  $Sim_4(S_1,S_2)$  is the description formula of signal meaning of original word and

 $(1 \le i \le 4)$ adjustable weights. 5) Bi is and  $\beta_1 + \beta_2 + \beta_3 + \beta_4 = 1, \beta_1 \ge \beta_2 \ge \beta_3 \ge \beta_4$ .  $\beta_i$  reflects that the impacts of  $Sim_1$ ,  $Sim_2$ ,  $Sim_3$ , and  $Sim_4$  on the total similarity decrease by order. Because  $Sim_1(S_1, S_2)$  reflects the major characteristics of a concept, its value of weight  $\beta_1$  is relatively high, normally more than 0.5.

Step 6. Use the model established in step 3 to find some

special cases  $(C_{ki})$  that can match a decision maker's decision style. Then select the case with the highest value of  $Sim(S_1, S_2)$  which reflects the similarity of between the

new decision problem and  $C_{ki}$ . Recommend the selected case to the decision maker. It will result in greatly improving the decision maker's cognition and decision behaviors.

## IX. CONCLUSION

Although decision behaviors vary according to different decision styles, there exists relationship between decision styles and decision types when facing innovative opportunities. Therefore, it's absolutely important to select appropriate senior decision makers for a company. A large portion of the wise and heroic leaders (Da) incline to make radical and risky decisions when facing

innovative opportunities (Ta). At the start-up stage, Chinese IoT industry calls for those wise and heroic CEOs who can bring more innovations and hence establish more prosperous IoT market. Making decisions in moderate way is many CEOs of Chinese IoT companies decision style. It is connected with Chinese traditional culture and oriental philosophy. Unfortunately, the ratio that decision makers always try to conform to others seems too high. They make decisions conservatively and dare not take risks even facing big opportunities. It is an obstacle for the development of Chinese IoT industry. Individual's cognition and decision behaviors can be improved by learning suitable cases. According to his/her decision style and the characteristics of a special decision problem, an appropriate decision support approach can recommend the most suitable case for the improvement of his/her cognition and hence decision behaviors.

According to the above result, we suggest that (1) board of directors should take CEO's decision style, personality and risk preference into account besides his/her capability; (2) companies should make incentive mechanism for top management, especially senior decision makers; (3) companies should encourage decision makers' practice and bear their failure on the way to innovation. (4) Cognitive decision support system should be developed to improve decision makers' cognition and decision behaviors.

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