Knowledge Management in Railway Industry: A Conceptual Model Based on Open Innovation and online Communities

Majid Babaei Ebrahimabadi[1], Reza Radfar[1*], Abbas Toloie Eshlaghy[1]

[1]Department of Technology Management, Science and Research Branch, Islamic Azad University, Tehran, Iran

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	Organizations need to be capable of attracting external knowledge. This activity is extremely related to innovation process and particularly to open innovation approach. Therefore, this qualitative research is designed to identify the dimensions and components for providing a conceptual model of KM architecture by open innovation approach based on online communities in the grounded theory framework. The initial factors are extracted from the literature and research background. Data are gathered through semi-structured interviews with eight experts of railway transport. The meanings and characteristics of KM architecture with the approach of open innovation based on online communities are presented in three stages of coding, identification and categorization and modeling. The reliability and validity of the interviews are confirmed by the reliability testing methods and the intra-thematic agreement. The results of the data analysis indicate that the various aspects of open innovation and knowledge management are complementary subjects. Organizations can take advantage of existing and global knowledge by incorporating internal and external knowledge and by the knowledge integrity. The internal mechanisms can affect the processes by integrating knowledge via the usage of online communities. Online communities can act as a link between knowledge management and open innovation through public sharing, providing clear and timely information.

1. Introduction

An important part of all countries' economic growth undoubtedly depends on producing knowledge and innovation in different business domains. Hence, knowledge-based economics are also always pioneer in creating innovation and fortune-make ideas as they are dramatically capable to produce science and knowledge [1]. On the other hand innovation is a key form of creating organizational knowledge. Innovation is a process in which organization defines problems and issues and then actively develops new knowledge to solve them [1]. Knowledge management is an interconnected process. Creating knowledge, saving knowledge, publishing and sharing knowledge and finally using knowledge are integral parts of knowledge management. Unlike tangible knowledge which is reachable in a systemic process, tacit knowledge requires individual direct connection and establishing informal organizations inside and outside the organization in order to be gained [2]. Knowledge is traditionally produced inside organizations and their research centers. In this paradigm, R&D sections are working on the key issues of who access to knowledge and use its competitive advantages to create and develop valuable technologies. Yang [3] suggested that it has a positive effect on product innovation to internal sharing knowledge and

gaining external knowledge. One of the consequences of open innovation is that companies should accelerate information flow so that it is possible for them to access, refine and use the knowledge. Companies cannot treat knowledge as a static matter but should basically consider it as dynamic [4].

Open innovation is a paradigm for companies, which requires external and internal idea and also internal and external paths toward markets to develop their business structures [4]. Therefore, open innovation plays an important role in motivating innovation process [5]. For this purpose, it is needed for open innovation to be a part of applied innovation processes in any organizations such as companies, enterprises, universities, governmental organizations and other institutions [6].

Open innovation consists of two parts including outside-in and inside-out [7]. As outside-in part open innovation includes gathering or purchasing different technologies or ideas from external resources such as consumers, suppliers and experts. This type of open innovation has been recently considered by universities and industries. On the other hand, inside-out open innovation needs those organizations to transfer unused and under-used internal ideas to outside the companies to be used by external players. This type of open innovation is less understood and less used [8].

Naturally, what is considered as open innovation in traditional view is any organizational internal and external interaction in limited area. But by development of connection networks which have been quickly extended by internet, there is a significant movement from traditional open innovation to internet based open innovation. Internet is a platform to create a type of network and creative thought around members of those networks.

Online environments can offer new ideas, products and services. An opportunity is also offered to companies to reduce risks, enhance work speed and reach innovative rare resources by the platforms of open innovation.

Generally, as it is shown in Figure 1 web portal structure of open innovation includes two parts: organizational part and innovative part. In a web portal, innovation process is begun by an organization by defining a challenge (in terms of problem or necessity). The company which has introduced the challenge (or rivalry) also should determine who will assess provided recourses, how long it takes to announce and assess rendered solutions, how long the challenge remain open, how much the bonus; then the challenge will be commenced to organize by the organization.

The role of innovators is to see challenges and offer their innovative ideas and solutions. When the best ideas are selected, the providers of the best solution shall receive reward. Consequently, the important question about software systems of online communities is how these systems are effectively managed so that people can productively participate in and the considered issues shall be resulted in being solved.

Iran Railway Transportation industry is generally organized traditionally. A significant part of active companies in railway transformation industry is categorized in small and medium companies. On one hand it is accepted for being loyal to fixed traditional methods of managing transportation by the main body of railway transportation industry. On the other hand it has increased the risk of losing time to apply new technologies. Applying those technologies requires gaining proper knowledge and promotes absorbing capacities in railway transportation companies. However, this knowledge based environment is not detected in these companies. The movement of companies toward changing approaches and applying modern railway transportation system is too slow. It is carried out in a rather passive and interaction-less environment that is due to the occurrence of the lock-in phenomenon. Hence, new approaches are needed to develop in order to revive companies in railway transportation industry.

The so called open innovation is the most popular approach that is introduced as a powerful tool in the interaction between the knowledge and the cross-organizational innovation [4]. The paradigms that exist were formed by the creation of the modern approaches in production/service innovation by information and communication technologies development on one hand and data analysis software in 80 decade on the other hand.
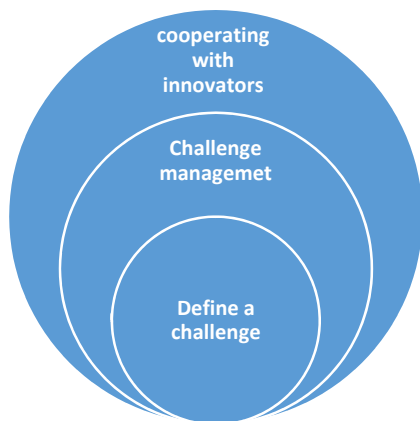
Rodriguse et.al [9] suggested a conceptual model to review moderator effect of cultural

obstacles on the connection between knowledge and innovation strategies in Spain Health & Treatment Organization. The results showed that generally both implicit and explicit knowledge play fundamental role in organizational innovation.

Yang et.al [10] suggests that the leadership is considered as an effective important element on innovation. They proved by several studies that transformational leadership has a positive effect on production of innovation performance, i.e. new products or services cause gaining market share, sale, return on investment, rate of return and interest.

Organizational part

Innovative part

Figure 1. Open innovation process based on web portal

2. The Research Strategy

It is noted that most research works related to open innovation were performed in part of production manufacture and design. This approach was less mattered in service sector. In this case, this research has attempted to make a bilateral connection between internal and external resources of the organization. It is also endeavored to apply open process to produce, publish and use knowledge by identifying most important ongoing challenges of knowledge sharing process. Identifying characteristics of individuals, organizations and online communities is also examined.

Therefore, this research is tending to review those processes through which such effect shall be gained and to determine organizational entrepreneurship and technology orientation effect as intervening factors.

Several researchers indicated that according to social interactions between different individuals, sharing knowledge and controlling organizational regulations, organizational culture affects results of knowledge management process.

To verify how and by which manner both concepts of knowledge management and open innovation are connected as well as the role of cyber space and online communities, the present research tried to identify this link by applying literatures and studies. Some of these findings are categorized in Table 1.

3. The Research Model

- The type of this research is qualitative. Initially, the primary factors are extracted through reviewing background by compounding models of knowledge management and open innovation through online communities. Then a conceptual model is presented by semi-structured interviewing with experts of railway transportation industry and analyzing the data.

- Interviews are formed by using grounded theory (in three steps of open coding, axial coding and selective coding). Grounded theory is a recommended method to review the phenomenon which is not reviewed in details. Even though it has not been fully reviewed as the matter of developing a model based on KM architecture with the open innovation approach based on online communities. So far, this is considered as a general process as most related researches have focused on just certain dimensions of any

Table 1. Connection between two concepts of KM and open innovation

Item	Open innovation	Knowledge management	Link between open innovation and KM
1	Knowledge exploration and exploitation [11];[3];[1]	Mixing people skills to produce knowledge [12]	Companies should exploit exist knowledge while search it globally
2	Focus on internal knowledge and also compounding internal and external knowledge [13]; [3]	Integration of existing and new knowledge [1]; [3]; [2]	Although concepts could be different in both recommendations, nevertheless the main idea is to integrated with internal and external knowledge
3	Powerful and weak relations [14]	Technical systems (Machinery, Lab.) [15]	Relations are also determined by technical systems, as it shows relationship with suppliers, consumers and other shareholders. In this case, these relationships are designed by mentioned technical system to analyze data.
4	Individual level network and organization level network [16]	Integrated capabilities (absorption capacity, ability to share knowledge) [17]	Different compounds include: an individual level network with high or low absorption capacity and corporate level network with high or low absorption capacity (or both)
5	Formal and informal assessment process (transfer from informal assessment to formal one) [20]	Tacit/social knowledge (facilitating product manufacture, for example using regional cultural products) [14]	Within their development, companies trend to move from informal to formal system which could be resulted in creating systems which gather social knowledge by making connection between users, consumers and society
6	Reward system [3]	Managerial systems (i.e. leadership style) [18]; [19]	Reward system is a part of the managerial system, which can be different in terms of leadership styles.
7	Users innovation [20]	External integrity (suppliers and researchers) [12]	This item emphasizes on suppliers, researchers and other players and focuses on innovations and users interested in innovation. User's innovation is an external resource for merging.
8	Using external social network [21]	Internal (solving mutual problems, solving individual problems, overlapping frontiers) [22]	Using external communities can affect internal mechanisms to merge knowledge. Companies can adopt one or both.
9	Public practical community [23]	Knowledge transfer [24]	One way to transfer knowledge is to establish practical communities
10	Technical scanning (make ideas practical to make value) [24]	Flexibility (capability of creating a better innovation) [3]	Companies should have sufficient capability and flexibility to make innovative ideas together with scan technology and individuals' capabilities (absorption capacity)
11	Online communities systems based on open innovation [26]	Mixing organizational knowledge (traditional management from up to down) with social knowledge (from down to up) [27]	Sharing environment to produce creatively and open to maximize interests of both sides

variables of KM and open innovation. Therefore, it was considered as the best choice to apply the grounded theory.

- Data are gathered for making a primary framework of research model. Then dimensions and components were

identified and a conceptual model was offered through interviewing experts of railway transportation industry.

- The population under interview includes experts and senior managers of railway transportation industry. On this basis, 8 experts were interviewed. Repeated data collected from the 6th interview but it was continued to the 8th as a matter of assurance.

- Validity of the completed interviews was assessed by retesting and inter-subject agreement reliability. Then three interviews were selected by retesting and each one of them was coded twice within 10 days by the researcher. The point of reliability was 0.93 and it was considered acceptable as it was more than the recommendation of 0.60 [28]. Then a colleague was asked to participate in this part to the test inter-subject agreement of two coders. After fulfillment of the required test about coding techniques, three interviews were recoded simultaneously by the researcher and the coder. The inter-coder reliability of this research was calculated 0.9 and its reliability was confirmed as it higher than 0.8. Hence, it can be claimed that the reliability of the interview was proper [28].

4. The Results

The steps of conceptualization, reduction, categories determination by using characteristics and dimensions and finally connecting or assignment categories are applied to interpret and organize data. This is performed through coding. Therefore, the data that are resulted from interviewing experts of railway transportation industry including analyzing and interpreting (coding) stressed concepts are analyzed by open, axial and selective coding.

- The First step: Open coding

In this step, the concepts inside interviews are precisely reviewed in terms of being related to KM, open innovation and cyber space. Consequently, the key points and concepts were coded by gathered data from experts' interviews.

- The Second step: Axial coding

In this step, the established categories in previous step are developed and expanded according to a paradigm pattern.

- The Third step: Selective coding

In this step, axial categories are systematically connected to other categories and presented in the framework of a model.

Hence, the arrangement of coding to analyze the qualitative data is as follow:

After introducing the research subject and goals, discussion points and questions of primary interviews, the first set of questions were asked about KM, open innovation and cyber space. The secondary issues were appeared after analyzing the primary interviews. Then the next questions were codified about the emerged issues and further interviews focused on them. This procedure was continued up to theoretical saturation. All interviews were reconsidered word by word to search and extract key points and coding. Any important point was specified with an open code and new codes were assigned by using fixed comparison method. Codes were also compared with open codes in previous and similar versions. This method was performed to check if the new code has been previously created or not. For example, a part of responds to interviews is coded as follows:

'… at this moment, knowledge is created individually. The knowledge, which is reached in process of railway transportation, is not documented, shared and it is not clear that how the processes are recorded …

…. Most knowledge is gained by individual enquiry. It is not recorded, not shared.

… Basically, the principles of KM are not performed. It is required for a KM system to establish a systematic and integrated system to share and document KM …'

This part of interview clearly describes KM system:

'… It is needed for KM system to extract system requirements. For example in loading, tariff code, and types of cargos which are transported by railway, how the railway fleet is and what services can be rendered. These are the information which railway industry can present to KM. On the other hand cargo owners can share the information about cargo's size, type and packaging.'

This part of interview clearly indicates knowledge sharing in railway system based on online communities.

By continuing open coding and repeating fixed comparison, characteristics, dimensions and categories were formed. A higher level of data categorization includes several related concepts. Report of ideas and the theory about real codes and their coding relationship, which are created during data coding, gathering and analyzing are theoretically stressed. When theoretical saturation was realized, theoretical coding or theorizing, that is the last step of data analyzing, is begun in which researcher seeks relationship between main categories.

A summary of the results of open and axial coding according to the opinion of all respondents are shown in following Table 2.

Table 2. Categories and sub-categories frequency of KM

Open and axial code	Frequency
Knowledge management	5
Knowledge socializing	3
Knowledge externalization	4
Generalizability	5
Knowledge sharing	7
Using individuals' experiments	11
CEOs' opinions	7
CEOs' support	5
Criticizability	9
Lack of scientific-based	4
Experiment-based	8
CEOs' resistance against challenges	9
Lack of employees confidence	12
Non-scientific replacement	11
Knowledge management system	7
Thought stream	9
Knowledge indigenization	4
Text translation	5
News criticize	4
Instruction	8

Interview with experts	6
Criticize	5
Hard infrastructure	7
Technological infrastructure	9
Performance assessment system	5
Employees' promotion by KM	4
Soft infrastructure	7
Lack of motivation	5
Soft power of players	4
Participation regulations	5
Culture	8
Not understanding the matter of subject	6

From Table 2 it is clear that 12 categories are identified as the main categories of knowledge management according to the results of open and axial coding of interviews. Some of these categories are knowledge socializing, knowledge externalization, generalizability, knowledge sharing and CEOs' opinion.

From Table 3, it becomes clear that 12 categories are identified as the main categories of open innovation according to the results of open and axial coding of interviews. Some of these categories are compounding cyber and traditional environments, training, patent registration, knowledge transfer and connection between university and industry.

Table 3. Categories and sub-categories frequency of open innovation

Open and axial code	Frequency
Open innovation	12
Compounding cyber and traditional environments	5
Training	3
Patent registration	8
Knowledge transfer	10
Tacit knowledge	9
CEOs' orientation	8
Dependency	7

Cognitive skills	5
Close system	5
Totally traditional organization	9
Transforming hidden knowledge to explicit one	10
Experts' meetings	7
Common task force with related organizations	6
Technical consulting	5
Collecting instructions	8
Making verbal history	4
Connection between university and industry	7

From Table 4, cyber space or using online communities includes establishing expert multimedia groups, public accessibility. It can connect KM and open innovation and provides easy access to knowledge, timely information and clear information.

Hence, according to selective coding the relationship between main categories is presented. Consequently, there is a relationship between KM, cyber space and open innovation. In this case, the research conceptual model is as follow:

Table 4. Categories and sub-categories frequency of cyber space

Open and axial code	Frequency
Cyber space	9
Public accessibility	12
Connection of KM and open innovation	8
Expert multimedia groups	10
Easy access to knowledge	7
Deterrence	3
Providing clear information	6
Timely information	11

In this conceptual model, intervening conditions are emerged from non-expectable situation, which is required to respond by interaction. Intervening conditions explain factors, which are out of the control of knowledge activators and producers in cyber space such as reward for making knowledge and discrepancy with organization values.

The results of selective coding and 12 overlapping effects between categories and subcategories of cyber space, KM and open innovation indicate that there is a significant relationship between these three categories.

5. Discussions

Open innovation is a relatively new concept and a few companies or institutions considered open innovation tools. The most important issue in open innovation approach is how to share knowledge and idea, which produced and maintain out of organization. This approach follows structures, which combine knowledge management inside the organization with existing knowledge outside the organization on hands of experts and/or other companies, as well as offers it integrated to applicants in proper time. Recently, it was increased the number of organizational and individual members of under web portals, but portals are not properly known in industry yet and it has not been efficiently reviewed effectiveness and contribution of these portals.

However, innovative portals have several advantages for innovators and companies but sometimes there are certain problems about them. For example, portals do not promote close cooperation between innovators and companies most of the times.

Also, it cannot just be considered as a portal structure on the internet due to the fact that this cooperation can also be performed through intranet structure between organizations and special beneficiaries, as companies do not want to simply share their intellectual capital through open innovation-based web portal. Another issue is that it is possible to not receive sufficient details about assuring of selecting a solution in some online communities-based solutions .They also cannot make sure that if another person will use a rejected solution in the future. Therefore, the portal should be more
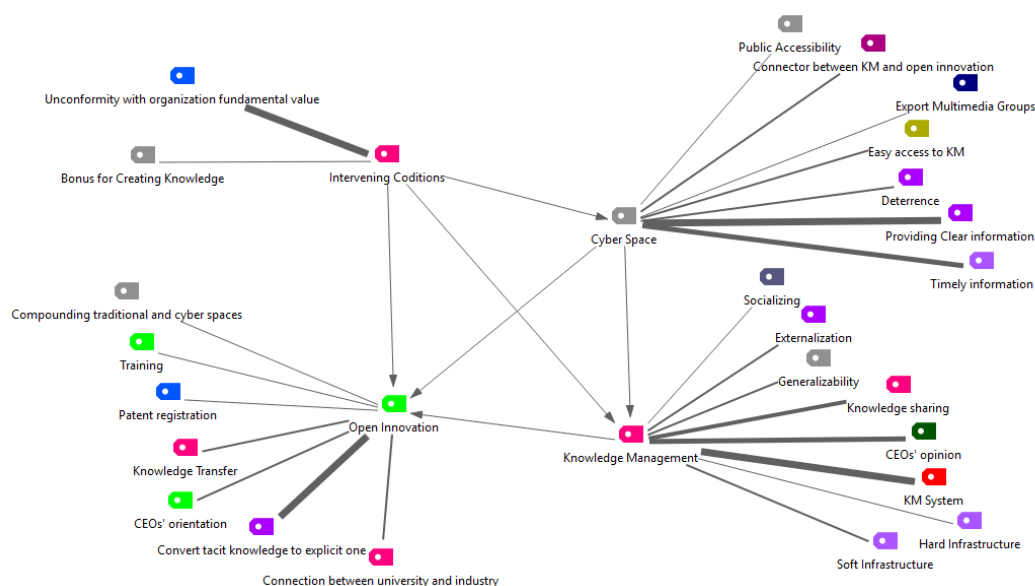
Figure 2. Research conceptual model

qualified and clearer to offer high confidence to beneficiaries.

Then the recommended solutions will be trusted by the industry in this manner. Nevertheless, analyzing current portals and designing a more efficient structure, cannot guarantee that open innovative-based portals, which integrate companies and innovators in an online platform to make innovative solution, are necessarily of most simple ways to promote innovation. Portals can share thousands of external solutions according to company's requirements and expectations of designing platform. However, the results of this research can be applied in all economic and social fields, but the main goal is verifying scales and framework of conceptual model for railway industry. To reach at this target, the opinions of the industry's experts are used to identify standards and criterions.

6. Conclusions

Undoubtedly, railway industry plays a significant role among different transportation options. Countries have especially considered railway development because of specifications such as saving fuel, decreasing environment pollution and acquiring higher levels of security. On one hand, railway is known as a knowledge-based and up to date industry. This claim is totally confirmed by the recent advances in high-speed trains. On the other hand, railway enterprises need to move along with developing knowledge- and innovation-based infrastructures to be able to compete with other companies and other modes of transportation. Traditionally, knowledge management exists inside organizations. However, exchange of inter-organization knowledge and the use of experts' opinions in railway industry are not so common. In Iran railway transportation is generally organized by traditional methods. It is expected to take a while to reasonably adapt to the international norms and standards. To improve their services, companies are required to take new approaches to innovate in their products and services. A major part of active companies in railway transportation is categorized in small and middle size groups. On one hand, companies are highly loyal to continue on traditional methods in railway operation management. On the other hand, it is increasing the risk of losing time in applying new technologies. For applying new technologies, it is required to reach at proper knowledge and promote absorption capacity of railway companies. Such knowledge based environment does not exist in many of these companies. Also, as a result of the lock-in phenomenon, companies' movement to change approaches and to apply modern railway systems is so slow. It is performed in a passive environment without inter-organizational transactions. Therefore, moving

toward open innovation as a bilateral and inter-organizational process in knowledge management structures can facilitate proper access to knowledge inside and outside the organization. This can also avoid repetitive and expensive activities to produce issue-based ideas for managing assets and costs.

Analyzing data showed perfect intermediary role of organizational entrepreneurship in the relationship between CEOs' transformational leadership and product innovation performance. Moreover, technology orientation remarkably adjusts the relationship between CEOs' transformational leadership and organizational entrepreneurship.

The most important result of this research is identifying the effective components on open innovation- and online communities-based knowledge management architectural. These components are identified in two steps. For the first step, a list of consensus scales of previous researchers was collected by studying knowledge management and open innovation fields and relevant past researches. For the second step, an interview was performed with eight railway experts up to saturation point by designing an open questionnaire according to the recognized scales in the first step. Finally, by the opinion of experts, most important scales were identified in three major categories of knowledge management, open innovation and cyberspace by coding those opinions in MaxQDA. Then a conceptual model of the relationships between those categories and sub-categories is shown.

Some of the most important scales of this research are as follows: cyber and traditional environments, training, patent registration, knowledge transfer and connection between university and industry. These can be listed as;

- Managerial trend to exchange knowledge in cyberspace
- Manner of patent registration and protecting intellectual ownership right
- Knowledge transaction transparency in online communities
- Manner of holding experts' meeting in web
- Manner of sharing knowledge
- Managers' resistance against changes
- Lack of confidence between experts and employees

According to the spread of knowledge-based fields in this research, it will be useful to recommend some subjects for further researches, including;

- Security and privacy are the important factors for the users of these kinds of portals. These factors can be effective in bringing success for online communities based KM systems. The manner of providing safety and keeping privacy in web-based mechanisms requires an independent research.

- It is needed for cooperating experts groups with online communities' platforms to explain the culture of cooperating in cyberspace. Designing such structures need to consider cultural environment and promoting methods of experts' participation to maximize knowledge sharing and efficient ideas. It is a proper field for further researches to verify components and scales of maximizing effective participation in web space.

- For sharing innovative ideas to solve a problem in the industrial environment it is needed to design a legal framework to determine manner of performing intellectual ownership right for knowledge and ideas. The framework of this legal mechanism can be a subject of an independent research.

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