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Abstract

The present paper proposes a new way of thinking regarding the relation between innovation and knowledge using a Physics-borrowed model, trying to prove whether knowledge resources can „flow" (be percolated) in a network or a grid, in order to be transformed in technological innovation. In the Knowledge Flow Percolation Model centre, human beings are seen as thinking electrons, both consuming and generating knowledge flow. Through the inter-dependent actions of individuals, knowledge circulates inside different types of organisations, allowing functioning and innovating in order to obtain competitive advantages. The model can be extended also at a national level, and some assumptions of self similarity appear in this process of extension. The model must be seen as a proposal for the research community and as a basis for future observations regarding the importance of knowledge flows in innovation.

Keywords: technological innovation, knowledge, knowledge flows, knowledge flows percolation model

1. Introduction

Technology is mainly knowledge, whereas innovation represents new and applied knowledge. The success of innovation depends on the way the knowledge it relies on is obtained and administered – in other words, it depends on an efficient knowledge management. This relation has been noticed and supported by various authors – see Alavi and Leidner (2001), Malik (2004), Du Plessis (2007), White and Bruton (2007), Nahar (2011), Hurmelinna-Laukkanen (2011), Popescul (2011).

As previously shown in Popescul (2011), the conventional vision according to which organizations are regarded as input – processing – output systems is not enough when it comes to describing knowledge processes. Modern organizations' characteristics, highly based on knowledge – that is, the intangible character of input and output, the constant interaction with customers and various types of partners, the strong independence of experts and of their individual judgment, innovation meaning a constant renewal and a continuous amplification of the products and services portfolio, the informational asymmetry – all these increased both the needs and possibilities for a rapid informational and knowledge transfer, both representing the essential success factors in the dynamic and global business environment nowadays. Therefore, the knowledge flow problem seems to become accessible using the means of the complexity theory. Although the knowledge flow regarded separately can be considered a linear element, from a transmitter to a receiver, the complexity at the system (organizational) level appears due to the connectivity and multiple transfer relations. In this paper, or intention is to decipher this complex relation by proposing a new model for the transformation of knowledge flows in innovation.

2. Knowledge Flows Percolation Model

Our Knowledge Flows Percolation Model (KFPM) is based on a cumulating model firstly used in Physics in order to prove whether resources can „flow" (be percolated) in a network or a grid. In engineering, percolation models are used in order to analyse if fluids can flow through a solid material (such as water through absorbent soil, for example).

Graphically, the model is built starting from a grid with vertical and horizontal lines. The grid will be seen as a network where each intersection between two lines will be called knot (node), and each line between the knots is an edge. The edges are assimilated, in this model, to channels each having two stages: close or open. „Water" can flow through the opened channels but not through the closed ones. The grid can be filled if open channels connect the upper to the lower part. In figure 1, the opened pipes are drawn with thick lines and the closed one using thin lines. The percolation takes place when a certain percentage of the total channels is opened – a value which is called accumulation or tipping point. It shall be observed that in the first grid the percolation phenomenon is shown.

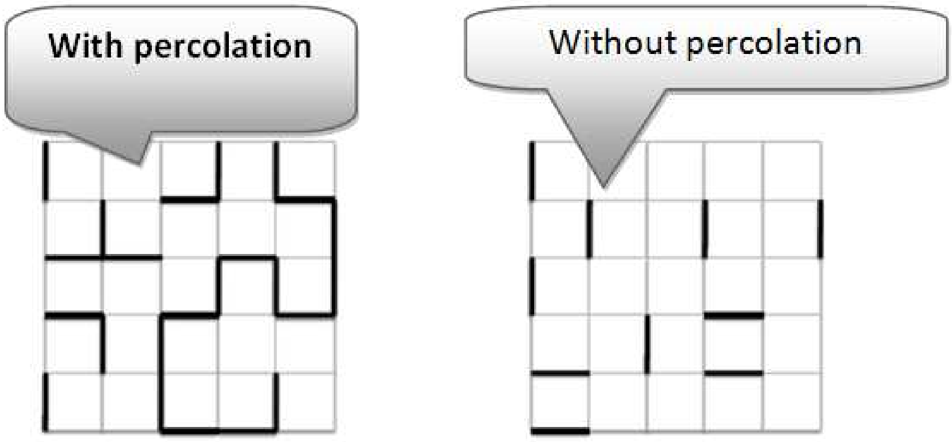

Fig 1. General percolation model (Page, S., 2012, Model thinking class, online course offered by Michigan university, at https://www.coursera.org/modelthinking/lecture/index, Tipping points)

In our opinion, we can associate those individuals generating and consuming knowledge to the knots of this model. The more persons transferring knowledge among them, the more channels are opened and the system the persons belong to may pass to another innovation level. Moreover, we can also use the model at the national level, substituting individuals with organisations and keeping the same hypotheses. Another interesting aspect is that more opened channels represent more possible paths for knowledge – the grid entirely becomes more fertile. The KFPM is, without doubt, a dynamic model, where the configuration of the knowledge flow is permanently changing. The results of these flows are accumulated inside the system, making it more robust and more capable to support further knowledge development.

2.1 The individual level

In the KFPM centre, **human beings** are seen as thinking electrons, both consuming and generating knowledge flow. These encapsulate knowledge (a fluid mixture of assumed experiences, values, contextual data, understanding and expertise), building therefore a framework for the evaluation, inclusion and creation of new experiences and information. The receiver associates the received knowledge to his/her own mental model creating a unique personal interpretation of the knowledge received, each time generating, in ascertain measure, new knowledge as personal interpretations according to the personal level of understanding. Nonaka, together with Toyama and Konno (2000, p. 7) state that people know as a result of a dynamic process, based on the interaction with other individuals, in a certain context in space and time the importance of which should not be neglected. According to Jennex (2007, pp. 2-3), the transfer of knowledge in an organisation takes place when its members pass from one to another implicit and explicit knowledge whereas an invention takes place when a person succeeds in transforming an undiscovered part of his-her implicit knowledge into explicit knowledge. The innovation capacity of an organisation should be based on obtaining, using and sharing implicit knowledge by individuals.

In the KFPM, the green dots represent individuals – knots in the knowledge flows, their transmitters and active receivers. The red dots represent the temporary inactive individuals, who are not involved in receiving and emitting knowledge.

Even if the individual agents are essential elements in every knowledge flow, they rarely operate by themselves in nowadays environment. We should not forget that, in certain activities, they are replaced by automated agents, who cannot interact with the implicit knowledge. For most of the analysts, individual agents who are in the centre of every knowledge flow, represent the prototypical force capable of change. The human agents are capable of working with artefacts of knowledge in any stage of abstractisation, performing without help any operation regarding the creation, retention, transfer and use of knowledge.

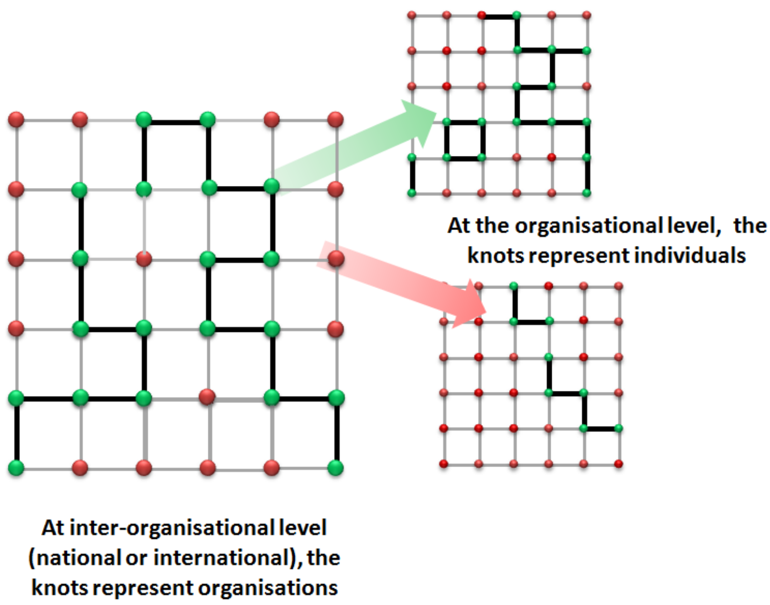

Fig. 2. Knowledge Flows Percolation Model (KFPM)

2.2 The organisational level

Through the inter-dependent actions of individuals, knowledge circulates inside different types of **organisations**, allowing functioning and innovating in order to obtain competitive advantages. The relevant model for the description of dynamic knowledge creation inside the organisation and their use are shown by the SECI model (Nonaka and Takeuchi, 1995), as synthetically presented in the image below.

In the SECI model, **socialisation** represents the process of sharing implicit knowledge from one individual to another, according to common experiences. In this case the primary knowledge flow is one-to-one. The accuracy and intensity of the knowledge flow depend on the relationship between the giver and the receiver as well as on the environment where the transfer takes place. The parameters mentioned above are hard to measure since the results of the flow are not correct but represent the accumulation of implicit knowledge. In the KFPM model, socialising is the equivalent of an open channel between two agents.

The **externalization** refers to the expression of implicit knowledge as explicit knowledge. In this stage the knowledge creation takes place and once expressed and crystallised in shaped that can be communicated to other people as well, turn into the basis for new knowledge. These is the very moment when groups are formed and the knowledge flows between individuals multiply and become more complicated, are created and disrupted sometimes with major speed – the cloth of knowledge flows is now quite sophisticated, the component flows are impossible to distinguish, as in the paintings of Jackson Pollock. In other words, the KFPM model describes externalisation as a set of open channels between various individuals forming a group.

In the **combination** process, different fragments of explicit knowledge are gathered together in order to obtain systematic explicit knowledge, more complex and more substantial. This is also a flow generating new knowledge resulting from the reconfiguration of existing knowledge which is sorted, added, combined and classified. The combination process leaves valuable „marks" in the organisation, generates the acquisition of knowledge as documents, manuals, knowledge bases etc. The individuals are connected to groups and together they filter knowledge combining it with new ones.

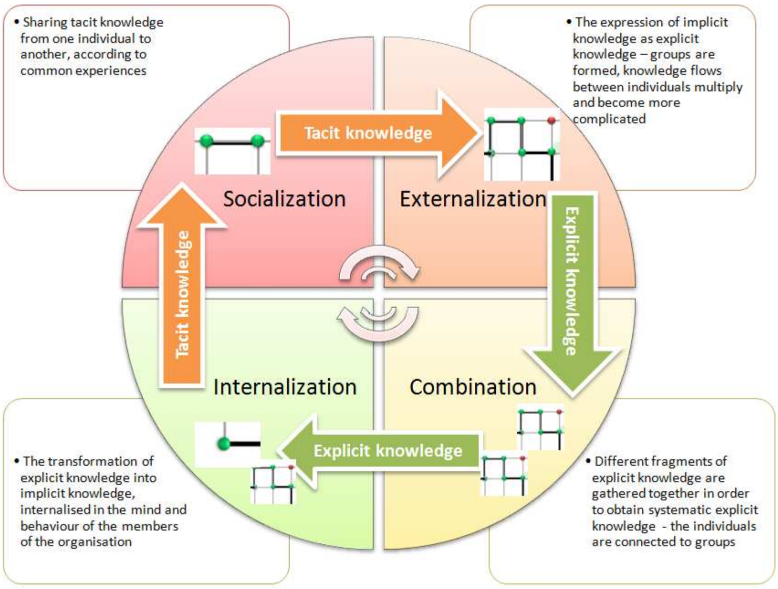

Fig. 3. The correspondence between SECI and KFPM models (Nonaka, I., Toyama, R., Konno, N., SECI, "Ba and leadership: a unified model of dynamic knowledge creation", Long Rage Planning, vol. 33, adapted from Neştian, 2007, p. 30)

The **internalization** represents the transformation of explicit knowledge into implicit knowledge, internalised in the mind and behaviour of the members of the organisation. It is accomplished by including explicit knowledge into actions, practices or simulations of real life situations. Therefore the process called „learning-by-doing" is produced. The individual is now the receiver of the knowledge flow. By internalisation, the explicit knowledge is spread throughout the entire organisation, thus creating a new set of implicit knowledge leading to the takeover of the entire production cycle of knowledge. Consequently the centre of the model has a spiral suggesting the continual SECI cycle having as an effect the continual growth of knowledge held by the organisation.

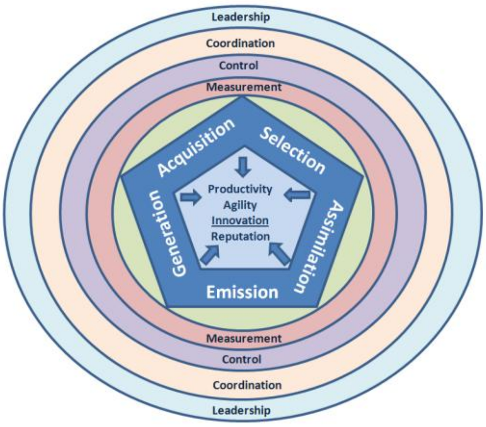

Fig. 4. Knowledge management value chain – primary and secondary activities (Holsapple, C., Jones, K., Singh, M., "Linking Knowledge to Competitiveness: Knowledge Chain Evidence and Extensions", in Jennex, M., "Knowledge Management in Modern Organizations", Idea Group Publishing, Hershey, London, 2007, p. 54)

A different perspective on knowledge circulation in an organisation belongs to Holsapple et al. (2007) represented in the figure above. Apart from the stages shown in the centre of the figure, which can be associated with the stages of the Nonaka model (although, from our perspective, the Holsapple model is not sufficiently focused on implicit knowledge), the authors also propose a set of processes which are specific to knowledge management – measuring, control, coordination and leadership actions. These processes stimulate the knowledge flows taking place during knowledge acquisition – selection – assimilation – emission – generation (also seen as primary activities).

The significance of the primary and secondary activities is presented in table no. 1

Table 1 Primary and secondary activities in the knowledge management value chain (Holsapple, C., Jones, K., Singh, M., "Linking Knowledge to Competitiveness: Knowledge Chain Evidence and Extensions", in Jennex, M., "Knowledge Management in Modern Organizations", Idea Group Publishing, Hershey, London, 2007, p. 55)

Knowledge acquisition	Knowledge acquisition from external sources and its transformation for future use
Knowledge selection	Knowledge selection from internal sources and its transformation for future use
Knowledge generation	Knowledge generation by discovering or derivation through available knowledge
Knowledge assimilation	Change of organisational knowledge through the distribution and storage of acquired, selected or generated knowledge
Knowledge emission	Incorporate knowledge into the organisational outputs in order to be released in the environment
Knowledge leadership	Set the right condition for the successful leadership of the KM
Knowledge coordination	Management of dependencies between knowledge management in order to ensure fast and proper resources
Knowledge control	Ensure that both knowledge processors and resources are available at the desired quality in at he desired quantity, observing the desired security request
Knowledge measurement	Estimate the value of knowledge resources, processors and implementation

In accordance with the observations made by Holsapple et al. (2007), we can update the KFPM also with these helping flows - measuring, control, coordination and leadership actions, destined to help individuals in creating valuable knowledge flows.

From Nonaka, the knowledge creation is supported by a foundation called Ba. The concept, of Japanese origins, can be translated approximately as „place", representing in fact the context for the creation, sharing and use of knowledge. As a notion, Ba is slightly correlated to a physical space and more to an ideational space of knowledge. The creation of knowledge is performed within the limits of this Ba, which are permanently redefined by the created knowledge. The limits of Ba determine the framework where knowledge is considered to be active resource. Consequently, each of the four stages of knowledge creation takes place in a specific Ba (place): originating Ba, the dialoguing Ba, Bathe systemizing Ba and the exercising Ba – see Neştian (2007). The importance of environment in the knowledge flow creation is also pointed out in this paper. Hence, we will focus in our model on grid, which we can see as a fertile soil, capable of stimulating the opening of knowledge circulation channels or, on the contrary, as an inhibiting, impermeable environment, closing any intention of an individual to communicate and share knowledge.

According to Newman (2004, p. 313), when talking about collective agents, we should not forget that they are not homogenous and therefore cannot be granted a certain behaviour on artefacts. One of their main features is the ability to transcend the ontological differences between the constituting agents, forming new sharing values and new implicit visions on the world. The relationship between the individual agents may be regarded as a form of storage of implicit knowledge. A collective agent can include billions of knowledge flows, whereas there is a high temptation to simplify them focusing on analysis only on the individual or automated agents. Such a perspective is dangerous, though, since such elements as cultural norms, organisational paradigms and shared systems of values are ignored.

2.3 The national (international) level

The knowledge circulation between organisations generates new national or international flows. These flows belong to the technological transfer – but they do not appear to be treated fairly according to their rightful importance. In this sense, Howells (2000) shows that the technological transfer relates more to technologies which are incorporated into factories and equipments or existing knowledge transposed into plans, technical drawings and manuals (applied, explicit). What he observes is that only the results of the innovation are transferred and not the „envelope" or the larger mechanism allowing the understanding and acquisition of the innovation process itself. In this paper we will approach, starting from Huţu's definition (1999, p. 47), the technological transfer as a communication process involving the knowledge transmission associated or not with a flow of material elements between a source (the owner of technology) and a receiver – which we associate with explicit knowledge but also as the integration and adaptation of a system (technology), previously created and developed in a certain context, to another context – the second part also refers to an important transfer of implicit knowledge between the participants to the technological transfer. During the technological transfer, knowledge moves iteratively through communication channels between pairs of agents structured as groups or organisation. The transferability rate, which reflects the transfer ability of the organisation owning the technology as well as the integration ability belonging to the receiving organisation, is the measure of the efficiency of the technological transfer. We will therefore associate with Malik's opinion (2004, p. 65), who thinks that technological transfer promotes technological innovation by transferring ideas, knowledge, devices and artefacts from top companies, research and innovation organisations and academic research for a wider and more efficient application in the industrial and commercial fields. The technological transfer can take place, according to the position of the source and of the receiver in terms of field of activity, on a vertical basis – from scientific resources to society, by passing from one stage to another belonging to the same technical creation process (for example, fundamental research – applicative research or design - production) or on a horizontal basis – at the same level; the transit from certain levels of the process, from one application field to another, or from one organisation (scientific, industrial, commercial) to another – see also Huţu (1999, p. 47).

The knowledge flows inter-organisations were discussed by Nonaka in a development of the SECI model (Neştian, 2007), referring to the knowledge creation through external collaborations, the perspective focussing on partnerships between organisations. In this extension it shall be considered that knowledge creation has to be built on a common foundation by means of experience sharing and mutual understanding. The people from both organisations must work together - socialize, within the context of the initial SECI model. The needs, mental patterns and the knowledge of organisations will be communicated and known implicitly by the organisations involved. In order to improve this mutual knowledge the explicit knowledge must be shared as paperwork, norms or basic rules with the collaboration. Nevertheless, it should be all supported by implicit knowledge exchange ensuring the right decoding and the understanding of the shared explicit knowledge. The partnership between the two organizations, performed according to the SECI model, will therefore lead to an ascendant spiral of their development. Furthermore, by forming a common foundation of implicit knowledge it also covers the inconveniences related to the „post" transfer of equipment and the corresponding documents referred to by Howells (2000) and mentioned above as well, but fails to mention that a certain technology can be old for the sender but at the same time new for the recipient who lacks the technical and organisational abilities necessary to successfully adopt the technology.

When speaking about the relationship between the organisations it seems to be quite hard to create such spaces which are similar to the Ba mentioned above, where all the essential actors of the innovation process – universities, research units, public administration and private companies – find the stimulating resources for the knowledge flows they need. The most „discovered", in this case, is the „originating Ba", the main reason being the lack of collaboration between such actors who lock themselves up in the traditional ivory towers.

3. Conclusions and future research directions

Our intention, in this paper, was to create a new model of innovation based on knowledge flows, the Knowledge Flow Percolation Model, as a basis for future observation in this very important and attractive domain of study. We added, in this sense, a new perspective more focused on the complexity of knowledge flows and more particular interested in innovation as their output, in comparison with Nonaka and Holsapple models. We treated the knowledge flows at the individual, organisational and inter-organisational levels, underlining the importance of knowledge communication, collaboration and accumulation in assuring the percolation of knowledge and making the grid more and more fertile and able to support innovation.

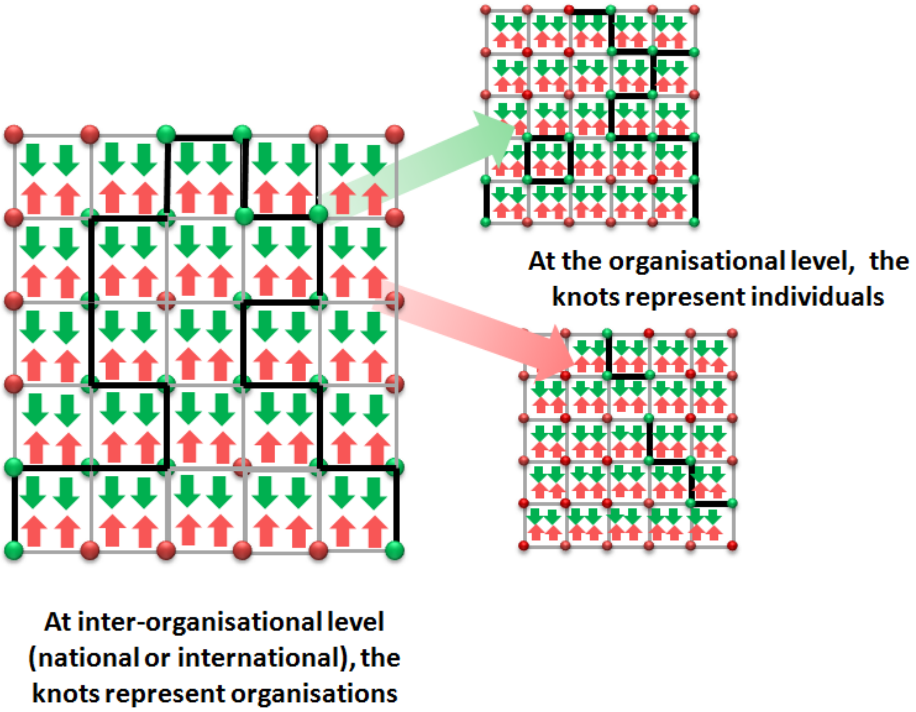

Fig. 5 Refined Knowledge Flows Percolation Model (KFPM)

Analysing the models above we can intuitively state that barriers against the individual and composite flows drives them away from the context exposed by this paper, namely innovation. In other words, the more fractured the spiral in the centre of the Nonaka model and the more unequal the flow intensity, the more impermeable the grid within the KFPM, the more difficult the transformation of knowledge into innovation and furthermore into competitive advantage. We are now capable of refining the model, adding red arrows downwards on the grid signifying barriers, the stops against the flow of knowledge on innovation and as a counter point, green upside-down arrows signifying the actions to be taken by the decision factors at the organisational, national or international level to remove those barriers, taking the grid to the desired permeability level. If the network represented by the grid becomes sufficiently liquid, it will be able to facilitate innovations. The liquid environments contribute to the re-contextualization of individuals' problems, reduce individuals' problems, reduce reasoning errors, help good ideas appearing sometimes as intuition be disseminated and completed. These barriers and solutions are to be addressed in a future paper.

Another observation based on this model is the apparent self similarity of knowledge flows at the three-analyzed levels (individual, organizational, national). This self similarity remains to be proved in another future paper, maybe with the help of a more mathematical, fractal model.

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