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The Thermodynamics of Innovation Culture Management

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Abstract
Thermodynamics is one of the science and engineering branch that deals with the transformation of heat energy to other forms of energies (mechanical, electrical, chemical or etc). The laws of thermodynamics help to explain how the universe works. In the universe, endless innovations are being made by all creatures. As an intelligent, wise and curious species, human endeavor every day to understand the excellence in design and innovativeness of the universe.

This study claims that the laws of thermodynamics rules and sustains the culture of innovation in organizations. Innovation, commercialize or creates value from inventions. In other words, invention brings out the energy in human intelligence and mind. This energy is converted to other forms of energy by value adding; from idea generation to technology transfer (commercialization). Innovation process manages the energy inside and outside of organizations. Thus, in this study, the hypothesis is set that the laws of thermodynamics rules innovation as it rules the universe.

Keywords: Innovation culture, thermodynamics, law, open innovation, closed innovation.

Introduction

Energy is everywhere and its conversion governs the universe. It has been the input of all processes and work done in life, starting from breathing to photosynthesis, machining, casting, purchasing, R&D and innovation, etc.

Energy can not be created from nothing or it can not be annihilated. It is converted or transferred to another form. The potential energy is related with the position and structure of matters/materials/objects. Kinetic energy is associated with the motion of matters. For example, the bond energy among atoms or molecules depends on the structure of bonds as well as atoms. When the bond is broken, the bond energy (potential) is transformed to electric or thermal energy (kinetic) and motion (work) starts. One could associate this, as the potential energy in smart minds is transformed to ideas (Rao, 2010, p.1-7; Atkins, 2010, p.1-80) (Figure 1).

Figure 1. The schematic of potential energy transformation to other forms.

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The laws of thermodynamics have been defined in 19th century to explain how a system can function, change and produce useful energy. Thermodynamics studies how heat is transformed to a useful energy in the form of work. Innovation deals with how ideas are transformed to a valuable work. The age of the innovation could go back to the creation of the universe. Since the beginning, innovation has been the center of life for all creatures. Necessities have triggered them to become innovative in order to stay alive. Every creature has developed new processes and products to be alive. For example, one of the first innovation made by human was a knife made by volcanic stones 2 million years ago (Toth & Schick, 2006, p.20-21).

Nowadays, there has been a great expectation from individuals and organizations to become innovative. As individuals, the energy needed for innovation has always been there. However, for organizations (governments, small, medium or big companies, corporates and etc.) to stay in the market, a collective energy is needed to sustain corporate innovations. Therefore, there has been a tremendous effort made to focus on innovation management for last two decades. It is believed that, in order to be innovative, the organizations have to focus on innovation culture management rather than innovation management. Since, the culture in the organizations asks for a smart management system and smart minds (Keles & Battal, 2017).

Building innovative culture in organizations is all about understanding and managing the energy in and around. Human and their minds are the potential energy sources for smart idea generation in organizations. Governing these energies and transforming to other forms to produce value is considered to be the philosophy of the innovation culture management. In this study, the hypothesis is set on that, the laws of thermodynamics rules and sustains the culture of innovation in organizations. Thus, innovation culture management is re-invented with the help of the law of thermodynamics.

Conceptual Design

In thermodynamics, the universe is assumed to be composed of a system (organization) and its surroundings having an imaginary boundary (Atkins, 2010, p.1-80). In our study, the universe is proposed to be composed of organizations and their surroundings. Systems/organizations could be isolated, closed or open depending on the transfer of energy and matter. None, both and only energy is transferred in isolated, open and closed systems, respectively. Energy transformation governs the innovation culture in organizations and the laws of thermodynamics valid in the management of innovation culture. The isolated, closed and open innovative cultures could be designed and managed depending on the inventory of smart minds and inventions made in organizations.

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Zeroth Law of Innovation

If two organizations are in each in innovative equilibrium with some third organization (Atkins, 2010, p.1-15), all these organizations will be in innovative equilibrium (Figure 2). In order words, if two organizations have the same innovative collective minds, intelligence and technological intelligence with each other, they are assumed to have the same innovative level. And, if one of which is in equilibrium to another third organization as far as innovation is concerned, it would not be wrong to say that all three organizations are in innovative equilibrium. When these organizations have attempted to get together for innovative solutions, the ideas generated will be similar. Therefore, it is very unlikely to expect radical or disruptive innovations from their collaborations. Because, collective innovative assets (minds, intellectual property, management systems, technological property and know-how inventory) are the same so, the zeroth law of innovation governs the innovation for these organizations. Thus, no innovation transfer is made to one another.

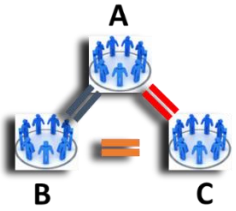

Figure 2. Zeroth law of innovation.

First Law of Innovation

The first law of thermodynamics is based on a total energy conservation. In an isolated system, the energy is transformed to another form, it is not destroyed or created. In a closed system, energy change (ΔU) depends on heat (Q) and work done (W) on the system (Figure 3 a) (Atkins, 2010, p.16-36).

The principle in the first law of innovation is the conservation of the smart energy of a human in an organization. Smart energy is equal to smart mind plus invention capital. In other words, smart energy is the collection of net smart minds and net inventions made. In some cases, the inventions made in organizations add to the smart energy. In others, inventions made by organizations take from the smart energy. In an organization, if the smart minds are put in making inventions, innovative technologies/smart energies will be developed in house by the people in the organization. This is considered as smart energy made in organizations (Figure 3 b). However, if the smart minds in the organizations are directed to put their energy for improving suppliers' work under the name of "Supplier Development", this is called inventions is made by the organization. Unless, there is win-win protocol between the organizations, the smart energy will decrease for the organizations which work for others.

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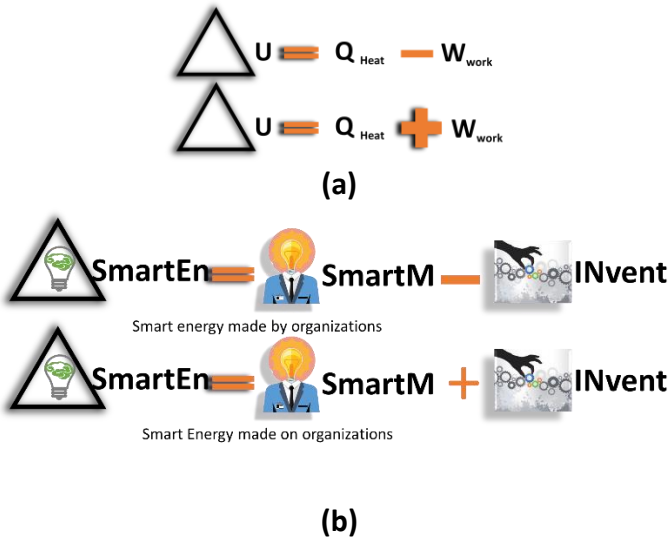

Figure 3. The first of thermodynamics (a), and smart mind energy (b).

ΔSmartEn denotes the change in the internal smart mind energy of organizations. Positive SmartM is the human minds devoted to organizations as collective smart minds. Inventions made on the organizations increases energy but invention (INvent) made by organizations decreases smart energy. Because, the smart minds with the help of the motivated smart management system create highly energetic innovative culture. Without smart management system the energy of organizations goes down.

Second Law of Innovation

The second law of thermodynamics introduces entropy (Atkins, 2010, p.37-62). Entropy is disorder, randomness or chaos. Nature runs for being in a low energy state, so disorder could be easy. Staying in order would need energy. Low energy state for organizations could be considered as tranquility and happiness.

It is known that entropy/chaos never decrease over time, it may reach to an equilibrium, may stay the same or increase. And, energy spontaneously travels from hot to cold. In an organization, smart minds who are eager to innovate have high motivation and creative energy/kinetic energy. So, they penetrate into the organizations and try to influence other people. If there is a resistivity in the organization to be motivated for creativity, most of the times due to the friction/disagreement among people, the entropy will increase making the organization unhappy. The chaos in the organization will increase and the smart energy in the organization will be less useable and no work is done. One could assert that, chaos sometimes stimulates other smart solutions resulting in spontaneous innovation. But living always in chaotic environment will eventually erode the organizations.

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In order to manage the entropy in the organizations, a creative organizational culture is needed. Therefore, it would be better to design the human capital to help and sustain creative culture. Plus, a management system is needed to build a sustainable motivation and creativity. Because, unfair systems will hurt and decrease trust in organizations creating a highly chaotic atmosphere, eventually.

Third law of innovation

The third law of thermodynamics brings the concept of zero Kelvin temperature into life (Atkins, 2010, p.80-96). The entropy becomes zero when it is reached to absolute zero Kelvin. For an organization, the disorder in the organization would be zero when absolute perfect culture is built. However, both for the universe and any organization, it is almost impossible to have zero entropy. Because, in the universe there is always thermal motion and in organizations there is always a probability of disagreement among people.

Spontaneity of Innovation

In thermodynamics, the spontaneity of reactions can be calculated by considering the change in enthalpy (ΔH), temperature (T) and change in entropy (ΔS). Enthalpy is the internal energy plus the product of its pressure and volume or work done (see Figure 4). When the pressure is constant the change in enthalpy becomes equal to heat. If enthalpy is more than zero, the reaction needs heat otherwise it releases energy (Atkins, 2010, p.63-79).

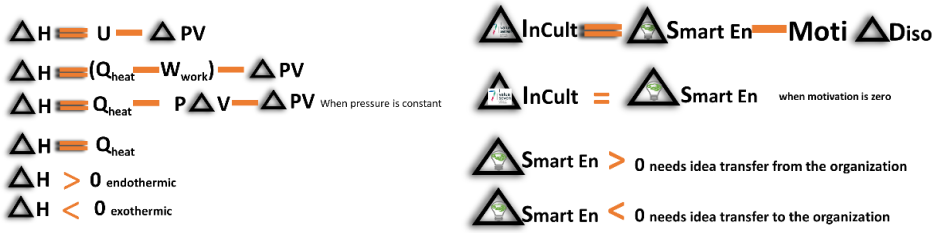

Figure 4. The Gibbs free energy in thermodynamics (a), the free energy of the organizations (b).

In an organization, the enthalpy refers the smart energy (ΔSmartEn). If the motivation of an organization is constant (Moti), the belief of human to the organization controls the smart energy. If the change in the smart energy is more than zero (ΔSmartEn>0), idea transfer is needed from outside/surroundings for the organizations to be innovative. Otherwise, ideas are transferred from the surroundings (ΔSmartEn<0) (Figure 4).

For an organization, innovation must be spontaneous. The change in the culture of innovation shows whether or not that organizations are innovative. The innovative culture energy (ΔInCult) depends on the innovativeness of human (ΔSmartEn), organizational motivation (Moti) and the level of disagreement in the organization (ΔDiso). For a spontaneity in innovation, the change in the

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innovation culture energy has to be less than zero (ΔInCult<0). So, the free energy of organizations (ΔInCult) has to be spent for work so called innovation. In Table 1 limits are given for the spontaneity of the innovation culture.

Table 1. Spontaneity in innovation culture.

	ΔSmartEn<0 Idea is transferred from the organization (smart minds are able to generate smart idea)	**ΔSmartEn>0 Idea is transferred to the organization (smart minds needed for smart idea generation)**
ΔDiso>0 high disagreement in the organization (chaotic)	**ΔInCult INNOVATION CULTURE** spontaneous innovation at all motivational (Moti) status even under chaotic medium smart ideas are able to make innovation spontaneous but not sustainable	**ΔInCult INNOVATION CULTURE** spontaneous innovation only at high motivations (Moti) chaotic medium and not enough smart ideas, high motivations are needed for spontaneous innovation
ΔDiso<0 Low disagreement in the organization (less chaotic)	**ΔInCult INNOVATION CULTURE** spontaneous innovation even at low motivational (Moti) status smart ideas are generated more than enough making the organization innovative	**ΔInCult INNOVATION CULTURE** non-spontaneous innovation at all motivational (Moti)status not enough smart ideas, the organization could not be innovative even at less chaotic environment

Isolated-Closed and Open Organizations and Innovation

The law of thermodynamics extends to isolated, closed and open system (Figure 5). No, energy and both mass and energy are transferred in isolated, closed and open systems, respectively. When the laws of thermodynamics adopted to innovation, organization could also be classified as isolated, closed and open. In isolated organization, invention capital is limited and innovation stays inside. In a closed organization, in order to increase the value of the organization in the market, some part of invention capital is transferred outside. In open organization, along with the invention capital, the organization may transfer smart minds/energy as well.

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Open Innovation is defined by Chesbrough as the use of knowledge transfer from and to organizations to speed internal and external innovation (Chesbrough, 2006; Hoegl, Lichtenthaler&Muethel, 2011). In open innovation, diffusion is considered to be in both directions from and to the organizations. It is worth to note that, transferring smart minds or knowledge/technology from outside may become enemy if the innovation culture in the organization is not managed well. Due to the entropy increase as a result of bad innovation culture management, the organizations may lose smart minds and face with knowledge-technology pilferage. Therefore, smart strategies for organizations are needed to manage dynamic innovation culture rather than being totally isolated, closed and open. For all types of organizations, sustainable, smart and win to win innovation management should consider IVALUE7 system which includes innovative strategy, smart mind, idea-design and technology, collaboration, intellectual property, infrastructure, and finance management. It is believed that by this way threats in all systems may be eliminated (Keles & Battal, 2017; Hoegl et al., 2011).

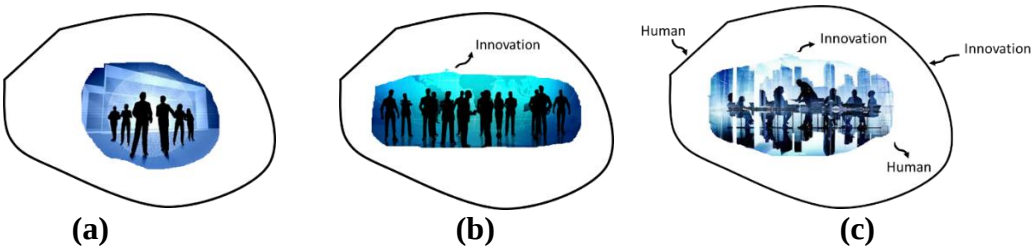

Figure 5. Organizations, isolated (a), closed (b), open (c).

Conclusions

The nature has already a lot of solutions, every product or processes are ruled by its innovative being. In this study, a hypothesis is made whether or not an innovation culture energy in an organization is governed by the rule of thermodynamics.

If energy conversion runs the universe, an innovative idea could be considered to be another form of brain energy of smart minds. Therefore, organizations which make an innovative organizational energy management will rule and win. This paper has shed a light that, as in life, there is a thermodynamic understanding in the management of innovation culture.

In order to create and manage innovative culture in the organizations, one has to explore followings;

- whether or not the organization is isolated, closed or open and decide the boundaries of innovation culture.
- be aware of smart minds and/or create smart minds (SmartM) to increase the potential energy of the organization,
- built a rich innovative ecosystem together with employees, suppliers,

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customers, other collaborators (universities, institutes, etc.). It is worth to note that an organization is as innovative as its ecosystem (Zeroth law of innovation),

- Smart Energy (Smart En) is a result of smart minds and invention. The smart minds put in inventions has to be valued/commercialized. Otherwise smart energy is released without benefit (First Law of Innovation).
- SmartMinds (SmartM) is hard to find and keep motivated. By eliminating friction, it is likely to decrease entropy. Chaos in the organizations tires and loses Smart Minds (Second Law of Innovation).
- Innovation culture (InCult) could be sustainable if motivated smart minds live in a constructive ecosystem.

Guidelines for Applying Research to Practice

1. Define your organization;
    a. Isolated; no turnover in human capital and limited invention
    b. Closed; some invention capital is transferred to the organization
    c. Open; both human and invention capital are exchanged
2. Determine the management style for culture of innovation,
3. Search to locate your smart minds,
    a. Spend some time with your employee, supplier, customer, etc to know their potential,
    b. Design a process to make smart and collaborations,
    c. Design a training programme and find smart collaborators for creating smart energy (ideas).
4. Motivate the organization
    a. Determine and eliminate the source of frictions,
    b. Built and sustain constructive ecosystem,
    c. Design platforms to acknowledge smart minds,

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