The Frontier of Linearity in the Intellectual Capital Metaphor

Constantin Bratianu
Academy of Economic Studies, Bucharest, Romania
cbratianu@yahoo.com

Abstract: The purpose of this paper is to demonstrate that *linearity* is a major limitation of the metaphor *Knowledge as Capital*. This metaphor proposed by Daniel Andriessen as a challenging debate for ECIC 2009 has been extremely fruitful in promoting knowledge as a new field of interest in economic research and praxis. Since *Capital* is a core concept of any economic activity, using it as a semantic source for the newly coined expression, Intellectual Capital, proved to be a winning idea. However, any metaphor highlights certain things and hides others. There are some semantic frontiers in the source domain which constitute its limitations. The purpose of this paper is to analyse the *linearity* property of the source domain, and to demonstrate that it constitutes a major limitation of the IC metaphor. We begin with the mathematical definition of a *linear space*, and then we analyse how this definition requirements, which are fulfilled within the source domain, cannot be fulfilled within the target domain. We are interested especially in the following requirements of the linear space: *commutativity, associativity, distributivity* and the application of the *principle of superposition*. The *Knowledge* domain does not satisfy any of these requirements which means that the target domain is strongly nonlinear. Although many authors have used these concepts of *linearity* and *nonlinearity* in connection with knowledge and intellectual capital, none of them undertook a systematic analysis of the basic properties of linear spaces and how they fit within the knowledge field. Linearity is strongly related to the measurable property of the source domain, and this operational connection explains why many methods proposed to measure knowledge and intellectual capital failed to produce good results. We shall extend our analysis to *linear* and *nonlinear thinking* patterns, showing how the frontier of linearity can impair managerial decisions. We hope that our work will stimulate new research aiming at using properly the nonlinearity property of the *Knowledge* field.

Keyword: capital, knowledge, linearity, linear space, linear thinking, nonlinearity

1. Introduction

Metaphors play a vital role in developing our knowledge field by initiating new perspectives of meaning associations and of using them in the decision making process. Andriessen (Andriessen, 2006; 2008; Andriessen and Boom, 2007) have shown that knowledge management and intellectual capital theories developed in these last years have been based primarily on using metaphors. “Knowledge is an abstract concept. It has no referent in the real world. We use metaphor to map elements of things we are familiar with in the real world (organisms, resources, products) onto the concept of knowledge to make it comprehensible. Knowledge is not a concept that has a clearly delineated structure. Whatever structure it has it gets through metaphor” (Andriessen, 2006, p.96). However, metaphors depend on the cultural value and cultural semantic systems of different countries or regions. In the Western culture the source domain of most such metaphors has been a tangible object, while in the Eastern culture the source domain has been an intangible one. Nonaka and Takeuchi (1995) claim that Japanese companies have a very specific understanding of knowledge, meaning the emphasis is on *tacit knowledge*. This type of knowledge is highly personal and difficult to define and clearly express. “Furthermore, tacit knowledge is deeply rooted in an individual’s action and experience, as well as in the ideals, values, or emotions he or she embraces” (Nonaka & Takeuchi, 1995, p.8).

In the metaphor *Knowledge as Capital*, the source semantic domain is *Capital*, and the target semantic domain is *Knowledge*. The source domain is coming from the Western culture. Thus, it incorporates a dominant tangible meaning, although its definition is rather fuzzy. In classical economics, *capital* is one of the three factors used in the production of other goods. The others being land and labour. In finance, capital is related to: investment, cash flow, credit, debt, funding, interest, risk, real estate, securities, trusts, mutual funds, commodities, futures etc. Regardless of its specific form of manifestation, capital is measurable. Since we use linear metrics for measuring the capital, we may consider *linearity* as a dominant characteristic of the source domain. Thinking about the new metaphor, *Knowledge as Capital*, let us remind that the metaphorical semantic kernel is given by the intersection of the two semantic domains. The larger this semantic intersection, the better cognitive approximation we get by using this metaphor. At the same time, there will always be some characteristics of the source domain not used by metaphor, as well as some characteristics of the

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target domain not covered by the source domain (Andriessen 2006; 2008). An illustration of this metaphorical analysis is shown in figure 1.

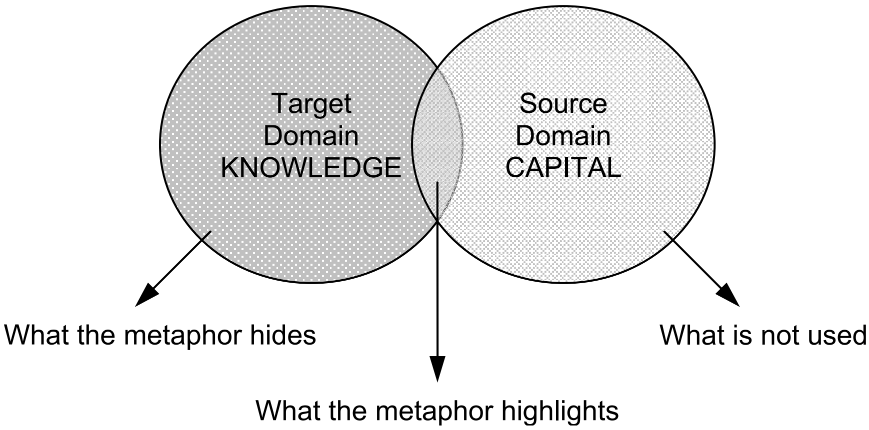

Figure 1: Source and target domains of the *Knowledge as Capital* metaphor

In the remainder of this paper we will explore the meaning of a *linear space,* and how the *linearity* characteristic of the source domain becomes a frontier toward the target domain. In other words, what this new metaphor hides is the *nonlinearity* of the knowledge field, among other things.

2. Linear space

The *linear space* concept has been developed in mathematics, both in geometry and in algebra. In geometry a linear space is defined by the rectangular system of reference (X, Y, Z) conceived by Descartes. It can be one-dimensional, bi-dimensional or three-dimensional space. In Algebra, there is a whole field of theory and research developed as Linear Algebra. One of the most frequently used definitions for the concept of *linear space* is the following: “A vector (linear) space is where all linear combinations of elements are also elements of the space. This is easy for spaces of numbers but not for a space of functions. Roughly, this is to say that multiplication by numbers, and addition of elements is defined in the space” (The Free Online Dictionary of Computing, 2003). Thus, a vector (linear) space is a set V together with two operations, + and x. The following are the mathematical requirements for a space to be a linear vector space:

- If $\boldsymbol{u}$ and $\boldsymbol{v}$ are vectors in V, then $\boldsymbol{u} + \boldsymbol{v}$ is also a vector in V.
- If c is a scalar, then $c\boldsymbol{v}$ is a vector in V.
- The vector addition is *commutative*: $\boldsymbol{u} + \boldsymbol{v} = \boldsymbol{v} + \boldsymbol{u}$.
- The vector addition is *associative*: $(\boldsymbol{u} + \boldsymbol{v}) + \boldsymbol{w} = \boldsymbol{u} + (\boldsymbol{v} + \boldsymbol{w})$.
- There is *an identity element* such that: $\boldsymbol{u} + 0 = 0 + \boldsymbol{u}$.
- There is *an inverse element* such that: $\boldsymbol{u} + (- \boldsymbol{u}) = 0$.
- There is *distributivity* over scalar addition: $(a + b)\, \boldsymbol{u} = a\boldsymbol{u} + b\boldsymbol{u}$.
- There is *distributivity* over vector addition: $(\boldsymbol{u} + \boldsymbol{v})\, a = \boldsymbol{u}a + \boldsymbol{v}a$.

If we consider a field of *scalars* representing simple numbers, these above requirements are all satisfied, as follows:

- If a and b are scalars in S, then $a + b$ is also a scalar in S.
- If c is a scalar in S, then ca is also a scalar in S.
- The scalar addition is *commutative*: $a + b = b + a$.
- The scalar addition is *associative*: $(a + b) + c = a + (b + c)$.
- There is *an identity element* such that: $a + 0 = 0 + a$.
- There is *an inverse element* such that: $a + (- a) = 0$.
- There is *distributivity* over scalar addition: $(a + b)c = ac + bc$.

3. Capital domain

The economic *Capital* is a measurable concept, and it can be expressed in numbers. The easy way to evaluate the source domain is to consider the *money* metric, which means to play with simple numbers. Let us consider three arbitrary numbers representing money: a = 5; b = 10; c = 100. Let *N* be the set of all natural numbers. Then, let us apply the scalar requirements:

- If 5 and 10 are numbers in N, then 5 + 10 is also a number in N.
- If 100 is a number in N, then 100x5 is also a number in N.
- The number addition is *commutative*: 5 + 10 = 10 + 5.
- The number addition is *associative*: (5 + 10) + 100 = 5 + (10 + 100).
- There is *an identity element* such that: 5 + 0 = 0 + 5*.*
- There is *an inverse element* such that: 5 + (- 5) = 0.
- There is *distributivity* over number addition: (5 + 10)x100 = 5x100 + 10x100.

In this case, all of the above requirements are satisfied, and the *linearity property* can be defined. Linearity can also be discovered as a dominant property for the thinking pattern used to handle problems in the *Capital* domain (Bratianu, 2007). Linear thinking patterns are used as cognitive approximations for real complex situations. It is like using linear segments to approximate curves of different shapes. The *linear thinking pattern* is a conceptual construct representing linear processes, which are based on linear equations of the form: $y = kx$. Here, we consider x to represents the process input, k – a process constant, and y – the process output. In simple words, a process is linear when the output or the final result is proportional with the input. It is such an easy way of thinking that our everyday life is full of linear thinking examples. All measurements systems are based on this thinking pattern. Let us consider temperature measurements, by using thermometers. Regardless of the temperature scale used (i.e. Celsius or Fahrenheit) the mercury dilation is proportional to the measured temperature. Let us consider the process of heating the water contained in a small tea kettle put on a gas stove. We introduce a thermometer inside the water and watch carefully its indication. Due to heat received the water temperature is increasing linearly up to 100 degree Celsius, and then stops. It is the saturation temperature when water is transformed into steam. This is a phase transformation, and from physical point of view it is a nonlinear process. Thus, the linear property of heating the water is not transferred to the phase change. The temperature of 100 degree Celsius becomes a frontier for the water heating, although the gas stove has not been put off. It is an interesting phenomenon to keep in mind for the metaphorical analysis of *Knowledge* as *Capital*.

Purchasing goods by measuring their mass it is also a linear process. The money we have to pay is proportional to the mass of goods we put on the electronic scale. The price per kilogram is the process constant. There are many other fields of activities where people use the linear thinking pattern without even questioning its validity. For instance, budgetary salaries are paid based on the time metric, and not on the value creation metric. Time is linear and it is very easy to consider it as a reference framework. The more time one works the more money makes. However, there is a physical, as well as a legal limit of such a procedure to increase his income. Changing the perspective, think about the way streets are divided into several traffic bands. When they are equally measured, then there is a linear geometry solution, although traffic is nonlinear. Thus, *linearity* is a dominant property of the *Capital* domain, and we are interested to see if it can be transferred to the *Knowledge* domain.

4. Knowledge domain

Bratianu and Andriessen (2008), performing a metaphorical analysis of *Knowledge* as *Energy* showed that knowledge can be considered as a *field*: ”The first characteristic from the source domain we point out in the target domain is the *field* manifestation of the energy. Thus, *knowledge should be considered as a field.* A field of forces is by its nature mass free and spread in space as a continuous domain” (p. 76). This field contains both explicit knowledge and tacit knowledge. According to Nonaka and Takeuchi (1995) “Highly subjective insights, intuitions, and hunches are an integral part of knowledge. Knowledge also embraces ideals, values and emotions as well as images and symbols. These soft and qualitative elements are crucial to an understanding of the Japanese view of knowledge” (p. 9). Considering *tacit knowledge* and *explicit knowledge* as the two major components of any *knowledge* concept, we may construct knowledge vectors as shown in figure 2.

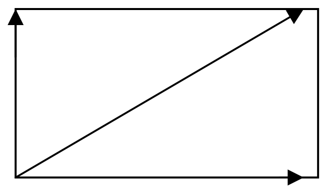

Figure 2: A graphical illustration of the vector **snow**

The vector **snow** can be decomposed into two components: (snow)-**e** which is the rational part of the concept learned in school (i.e. characteristics from physical point of view), and (snow)-**t** which is the experiential part of the concept learned through a direct experience by seeing, touching, smelling and tasting the real snow. Here, we introduced **t** as the unit vector on the **tacit** axis, and **e** as the unit vector on the **explicit** axis. These two components may have different magnitudes according to the degree of abstractness of each concept, and the level of direct experience of each individual. For instance, somebody who lives in a northern country with heavy winters and lots of snow will have a larger (snow)-**t** component than an individual who lives in a tropical country, where hardly there is any snow. Using this approach we can define each concept as a vector, and the knowledge field becomes a field of vectors. Now, we would like to investigate if the knowledge vector field is *linear* or *nonlinear*.

The first requirement is given by the *composition* rule. If two vectors ***u*** and ***v*** belongs to the defined space V, then their composition yields a new vector ***u*** + ***v*** which also belongs to this field. This rule applies to the source domain, and we want to see if it applies also to the target domain. Let us consider two vectors **snow** and **white.** The composed vector **snow** + **white** has meaning and it is a component of the knowledge field. We shall recall from vector algebra that two vectors can be added by adding each type of components separately, and then perform their aggregation into the vector form. For the two vectors just considered we have:

(snow)-**t** + (white)-**t** = (snow + white)-**t**

(snow)-**e** + (white)-**e** = (snow + white)-**e**

snow + **white** = (snow + white)-**t** + (snow + white)-**e**

In these above relations we use the mathematical symbol + with the meaning of *aggregating* concepts, and not to add them in a pure mathematical way. Thus, by aggregating these two concepts **snow** and **white** we get the meaning that snow is white, which is a part of the knowledge field. However, we can construct many combinations of the concept of **snow** with other concepts without getting any meaningful new concept. For instance, (snow + fire), (snow + bread), (snow + laptop) etc. are meaningless aggregations. Their resulting vectors *do not belong to the knowledge field, and thus the composition rule is not fully satisfied.*

However, we have considered so far only the *rational* part of the *Knowledge* domain. The *emotional* part of this domain is even more important since “Emotions drives reason more than reason drives emotion” (Hill, 2008, p.17). In business we have been educated to think with our heads and not with our hearts. Breakthrough research in neuroscience demonstrated the importance of emotions in the *Knowledge* domain. According to Hill (2008), people’s faces reveal seven core emotions: fear, anger, sadness, disgust, contempt, surprise, and happiness. The first five are negative emotions, the fourth is neutral and the last one is a positive emotion. Let us consider now two emotions placed in the knowledge vector field: **disgust** and **happiness**. Then, applying the composition rule we get:

disgust + **happiness** ≠ (disgust + happiness)-**t +** (disgust + happiness)-**e**

There is no way to co-exist these two emotions simultaneously in our heart, and thus the result of such a composition rule does not belong to the *Knowledge* domain, which means that the linearity property does not apply to such a situation. Demonstrations can be made also with ideas, insights, values and other constituents of the target domain. Sometimes, experience is measured in number of years spent in a specific job. The more years spent in a specific job, the larger the working experience of a given individual is to be considered. This is not true, because experience can be enriched by the variety of jobs and activities and not by repeating the same type of activity over and over again. This is a clear limitation of using a linear thinking model for a nonlinear process. Linearity has always been a limitation in the decision making process by eliminating emotions and oversimplifying the process itself. Even the consumer behaviour models have been developed by using concepts based on rational choice, and limited rationality. The composition rule can also be illustrated by exchange of goods. If A has one apple and B has also one apple, together they have two apples. A gives his apple to B. In the end, A has got zero apples and B has got two apples. Together, they still have two apples. This is valid in the *Capital* domain. In the *Knowledge* domain, the composition rule does not apply anymore to the sharing of knowledge.

The second requirement is a nonsense for the knowledge field, since meanings cannot be enlarged just by multiplication with a scalar. Since an operation of the form 5 x **intelligence** yields something outside of the knowledge field, *the scalar multiplication* requirement is not satisfied within the target domain.

Let us consider now the *commutative* rule of addition. In order to better illustrate this rule for the knowledge field we shall consider three knowledge entities:

(John) + (drinks) + (milk) ≠ (milk) + (drinks) + (John)

(professors) + (teach) + (students) ≠ (students) + (teach) + (professors)

We learn from school that there are certain grammar rules to construct sentences and phrases, and that word order in any such construction is vital. Thus, a sentence is an oriented semantic construction and *commutativity* is highly restricted. This might be sometimes a real difficulty in translating texts from one language into another language, due to these different sentence structures. Also, in the decision making process there are clear defined sequences of knowledge aggregation which cannot be reversed like in a linear space (Baron, 2003; Goodwin & Wright, 2004). Management is also a highly oriented structural process which cannot accommodate the commutativity requirement. Moreover, real processes are irreversible processes oriented along the time axis. Just think of the irreversibility of our biological life, and we will see immediately how commutativity cannot be applied anymore. The *Knowledge* domain is a highly nonlinear field.

Let us consider now the *associativity* requirement. In team management association process is quite natural. The way in which individuals associate together in order to perform different jobs is unique with respect to their knowledge fields (Katzenbach & Smith, 2003). Assuming that by working together two or more individuals yields new knowledge fields at the team level, the following relation can be proved easily in practice:

(John + Dan) + Mike ≠ John + (Dan + Mike)

In any organization, associativity is based on compatibility of knowledge and skills, on motivation and work requirements. Thus, the rule applied to linear systems cannot be applied in the same way to the nonlinear organizational knowledge field. Actually, teamwork and team management is based on two knowledge compatibilities: cognitive and emotional. Rarely these two compatibilities can be satisfied simultaneously, and almost never the associativity property can be satisfied for both of them. Team management places an important role on emotional compatibility, and personal development, which means a clear departure from the industrial linear management. Much of Google's success is due to this new type of team management. "Roughly half of Google's 10,000 employees - all those involved in product development – work in small teams, with an average of three engineers per team" (Hamel & Bren 2007, pp.111-112).

In the knowledge field there is no such *identity element* like 0 in a linear space. Even the no-thing-ness has got an interesting interpretation in Buddhism as "the spirit of the thing itself". According to Musashi, the legendary Japanese warrior in marshal arts, the whole strategy of a warrior should be based on no-thing-ness: "You can come close to understanding no-thing by realizing that there is nothing outside of yourself that can ever enable you to get better, stronger, richer, quicker, or smarter. Everything is within. Everything exists. Seek nothing outside of yourself" (Kaufman, 1994, p.105).

In the knowledge field the rule of *the inverse element* cannot apply, for the main reason that there is no such identity element like 0 in the linear space. We may find concepts or ideas of opposite meaning, but bringing them together does not end up with nothing. It ends up with a state of uncertainty, or even a paradox. Consider the following examples, and try to think of the possible semantic result:

(Ted is tall) + (Ted is not tall) = ?

(Helen has a car) + (Helen has not a car) = ?

This is a very interesting property of the knowledge field, with many implications in management and hard times in decision making. One information or a knowledge concept cannot reduce to zero another information or knowledge concept of an opposite meaning, since zero does not exists in the knowledge field! Putting together the two conflicting semantic entities creates a state of uncertainty, which can be reduce only by getting new knowledge from a different source with respect to the same topic or example. From another perspective, we may say that zero is important in the linear metric for an one dimensional process. In the knowledge field we currently operate with multidimensional processes for which zero element loses its meaning. The inverse element property creates a clear interface between the *Capital* domain and the *Knowledge* domain.

The *distributivity* rule does not apply to the knowledge field since the scalar multiplication in the knowledge field cannot be defined. Let us consider the knowledge associated to the concept of **wisdom**. A multiplication of the form 3 x **wisdom,** which means to multiply the scalar 3 with the knowledge vector **wisdom,** does not yield a meaningful result since:

3x**wisdom** = **wisdom** + **wisdom** + **wisdom** = **wisdom**

5. The superposition principle

The superposition principle is a direct consequence of the linear space properties. It is applied everywhere there is a linear field. In Physics, the superposition principle is applied especially in the electric field theory, and in the wave theory. For instance, in the electric field theory the superposition principle can be formulated as follows: the electric field due to a collection of particles is the sum of the fields produced by each particle separately. In the theory of light waves, the superposition principle states that when two or more waves overlap in space, the resultant disturbance is equal to the algebraic sum of the individual disturbances (Encyclopaedia Britannica, 2008). In other words, the superposition principle is an extension of the addition property to field entities, or effects of some linear transformations. Using mathematical generic equations, the superposition principle can be expressed as follows:

$L\varphi(1) = F(1)$ & $L\varphi(2) = F(2) \Rightarrow L(\varphi(1) + \varphi(2)) = F(1) + F(2)$,

where L is a linear operator, and $\varphi(1)$, $\varphi(2)$, $F(1)$, $F(2)$ are some given functions.

The superposition principle can be applied in the source domain since linear metrics are frequently used here. It is interesting to see such kind of argumentation in the famous work “Wealth of Nations” of Adam Smith: “As the capital of an individual can be increased only by what he saves from his annual revenue or his annual gains, so the capital of a society, *which is the same with that of all the individuals who compose it*, can be increased only in the same manner” (Smith, 1998, p.199). Considering that this work has been written about three hundred years ago, we have to acknowledge that applying the superposition principle to explaining the capital composition was quite advanced for that period of time. The superposition principle can be applied also in the *reverse* order, i.e. de-composing a complex linear problem into several simpler linear problems and finding their solutions; then, assembling these solutions based on the superposition principle and getting the complex solution for the initial problem. In this perspective Adam Smith conceived the division of labour, which sometimes may go down to single simple operations. To illustrate how this division works he considered the case of a pin-maker: “One man draws out the wire, another straights it, a third cuts it, a fourth points it, a fifth grinds it at the top for receiving the head; to make the head requires two or three distinct operations; to put it on, is a peculiar business, to whiten the pins is another; it is even a trade by itself to put them into the paper; and the important business of making a pin is, in this manner, divided into about eighteen distinct operations, which, in some manufactories, are all performed by distinct hands, though in others the same man will sometimes perform two or three of them"(Smith, 1998, p.12). This division of labour is an excellent illustration of the linear thinking and of the superposition principle applied to the source domain. Thus, linearity proves to be a winning perspective of thinking and of structuring the industrial activities (Drucker, 1993).

In the new knowledge companies, this division of labour cannot yield high productivity anymore. Hamel & Breen (2007) consider these principles of division of labour and specialization to be insufficient and often toxic, since they limit the liberty of people and inhibit their creativity. When the initial problem is defined within a nonlinear field, like that of knowledge, this method does not work anymore. However, many managers consider as a general rule breaking down any complex problem into smaller problems and finding first these simple solutions, and then adding them up. If the field is strongly nonlinear, the method will yield wrong solutions. "Phenomena and events in the real world do not always fit a *linear model*. Hence the most reliable means of dissecting situation into its constituent parts and reassembling them in the desired pattern is not a step by step methodology such as system analysis. Rather, it is that ultimate *nonlinear thinking* tool, the human brain. True strategic thinking thus contrasts sharply with the conventional mechanical systems approach based on *linear thinking* " (Ohmae, 1982). Linear composition or decomposition used in the industrial management is not anymore adequate for complex processes like strategy elaboration, change implementation, innovation and leadership. Meanwhile a new cohesive organizational culture has been developed: "to offset the risk of isolation, successful leaders don't just read the situation around them in emotional terms, they also foster a cohesive culture in which employees feel invited to participate and collaborate. To that end, they seek to surround themselves with talent. Thus, people will be as smart or smarter than themselves (both rationally and emotionally), and they will be recognized for their abilities and promoted for their good work" (Hill, 2008, p.258).

Intuitively, this superposition principle has been used in the pioneering research of the intellectual capital (Andriessen, 2004; Stewart, 1997). According to this incipient literature the intellectual capital is considered as a given potential composed of: human capital, structural capital and customer or relational capital. There are some variations of this structuring, but the main ideas are the same. For instance, in the Skandia navigator the intellectual capital is decomposed into human capital and structural capital; the structural capital is split into customer capital and organizational capital, and finally the organizational capital is split up into innovation and process capital. However, the three component entities designed as human capital, structural capital and relational capital are not independent entities. They overlap substantially since the intellectual capital is highly nonlinear and the superposition principle does not apply at all in this analysis. For instance, each component contains knowledge, intelligence and values, and their aggregation into intellectual capital means finally to count twice each of these basic constituents (Bratianu, 2008).

Applying the superposition principle to the organizational knowledge, as it is described in linear systems, someone may end up with the Albrecht's Law: "Intelligent people, when assembled into organization, will tend toward collective stupidity" (Albrecht 2003, p.4). This is not a compulsory phenomenon in any group of people. It is an optional one to the extent to which group members allow it to happen. However, it does happen frequently since it follows the entropy law (Bratianu 2007). The superposition principle is very close to the *static* interpretation of the organizational intellectual capital, since the *static model* has been developed based on the tangible assets experience (Edvinsson & Malone, 1997; Stewart, 1997; Sveiby, 1997). Organizational experience demonstrates every day that knowledge undertakes a continuous transformation process at both individual and organizational levels. In this new dynamic perspective "knowledge is understood as emerging from the ongoing interactions between the organizational members, and the focus is not on the intangible assets per se but on the organizational capabilities to leverage, develop and change intangible assets for value creation" (Kianto, 2007, p.3). Performing a literature search and critically assessing the dynamic models, Kianto (2007) came out with three main dynamic interpretations of the intellectual capital: 1) value creation dynamic; 2) organizational activities, and 3) change capabilities. The first dimension shows how different resources interact to create value for organization. The second dimension shows how different activities interact in knowledge creation, acquisition, sharing, dissemination, combination. The third dimension demonstrates the organizational capability for change and strategy implementation (Carpenter & Sanders, 2007). This change is necessary for continuous adaptation of organization to the turbulent external business environment. Innovation, learning and renewal are the major topics related to this third dynamic dimension of the intellectual capital (Kianto, 2007; Roos et al, 1997; Sveiby, 1997). However, in these above dynamic models the basic structure of the intellectual capital does not change, which is a severe limitation to further investigation.

Organizational knowledge is not a result of summing up the individual contributions of all the employees, like in Physics. It is a result of their integration and of the synergy effect: "An integrator is a powerful field of forces capable of combining two or more elements into a new entity, based on interdependence and synergy. These elements may have a physical or virtual nature, and they must poses the capacity of interacting in a controlled way" (Bratianu, Jianu & Vasilache 2007). The synergy effect makes actually the difference between a linear and a nonlinear system. Thus, the linearity frontier cannot go beyond the static interpretation of the intellectual capital, interpretation based on the conception that knowledge is like any other tangible assets. The dynamic knowledge field is strongly nonlinear, and the intellectual capital is a synergetic effect of the organizational integrators work. The most important integrators are: vision and mission of the company, management and leadership, technology and processes, and organizational culture (De Geus, 2002; Hamel & Breen, 2007; Warren, 2008).)

6. Conclusions

The purpose of this paper is to show how *linearity* is a major limitation in using the metaphor *Knowledge as Capital*, a metaphor suggested by Daniel Andriessen as a challenging debate for ECIC2009. In this metaphor *Capital* represents the source semantic domain, and *Knowledge* represents the target semantic domain. One of the most important characteristics of the source domain with respect to management and organizations is that of *linearity*, since it dominated for about one hundred years the managerial thinking. In order to understand if this property can be projected into the target domain we performed a theoretical investigation of the necessary mathematical conditions for a given field to be considered a linear space. We considered step by step the rules for addition and multiplication required by a linear space, and analyzed the way in which they are satisfied or not in the target domain. Our analysis shows that these rules cannot be satisfied by the *Knowledge* domain, which means that the knowledge field is strongly nonlinear. In other words, *linearity* is like a frontier in the metaphor *Knowledge as Capital.* Understanding *Knowledge* means to break away with the classical linear thinking, and to embrace the new nonlinear thinking. In the same time, knowledge contains both cognitive knowledge and emotional knowledge. There is a permanent dynamics between these two main forms of knowledge that leads to complex transformations of tacit into explicit knowledge and vice versa, as well as cognitive knowledge into emotional knowledge and vice versa. Due to all these complex processes, organizational knowledge, management and leadership, intellectual capital, creativity and innovation, learning organizations, cognitive and emotional intelligences, strategy and change are all concepts well beyond the frontier of linearity.

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