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Complex system technologies as an adequate synergy tool of knowledge and innovation functions projecting sustainability of the development

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Abstract

In this paper the authors are trying to answer how to structure the cluster of knowledge, innovation and technology when the object of analysis is the country's universally sustainable development problems. The authors synthesize the existing ideas about the possibilities and give an opinion on the possibility to reveal the interaction between knowledge, innovation and technologies in the context of value creation. The paper presents also the possibility of stochastically informative expertizes optimizing the structure of the mentioned cluster.

Keywords: universally sustainable development; integral knowledge, innovations and technologies cluster; technology of the complex system.

1. Introduction. Rational knowledge, innovation and structure of technology integral cluster riddle

Integral Knowledge, Innovation and Technology (KNIT) cluster comes to the proscenium of development solutions and as a significant source of development factors and as option of complex adaptive systems technology. In fact, the understanding of technologies increasingly is coming to define the profile of its unique character: the nuclear technologies, nanotechnologies, internet technologies. On the other hand, more and more express the whole of the actions and processes, principles, methods, criteria, expressing the whole of the original sources e.g. the transformation of knowledge and innovations to the value product such as management system, monitoring and

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development strategy (Antonelli, 2009; Boehm. & Fredericks, 2010; Camic, Gross & Lamont, 2012; De Noronha Vaz & Nijkamp, 2009).

This apparently is a natural changes of the thinking logic, since even a not particularly sophisticated manufacturing and supply of product is formed the net of organization of manufacturing, supply, formation of the market, marketing, finance etc. which perception becomes the problem. Therefore, it is necessary to think that sometimes there is no better to choose the complex networks or the ideology of system organization and management, without hesitation that it was formally named the object of a complex system and the instrumentation of research, remained the adequate to emerging systems in the reality as well as their interaction of subsystems or components.

Apparently, it is appropriate to use an already professionally prepared model of complex system that has the ability to cover and reveal the whole of broadly complex system class characterized by the functions and look up the system of concrete case in the variety of functions of the model. There is no doubt that we will always be in case that the choice of a particular system has its own characteristics and it triggers the need to develop a general model. However, always it is need to remember that an adequate model of the wide class of complex systems – is long and costly job.

It is formed the view that the technologies, innovation or technological discoveries can come from the managerial side of the effort. This sends a positive signal from multiple service providers, since, by the stencil way of thinking, they just stayed near the technology (Luke, Verreynne & Kearins, 2010; Naštase, 2013; Noor Al-Jedaiah, 2010).

Now, among the titles of the technologies, more frequently appear those that appeal to the organizational side or to the properties of used solutions. Near the information technology are attempting to win their place in complex system, the technologies, which is focused on the object, their mutual relations, the processes of changes and the criteria and especially the complexity.

Looking at the large number of countries, especially without abundant national resources, development projects, quite unambiguously reveals the idea that the major and inexhaustible resource for their development becomes an integral knowledge, innovation and technology cluster. Individual attention at the last sentence requires the concept of an inexhaustible. Since this factor is naturally evolving and purposefully educated, so about its abundance maybe even having to speak. But, on the other hand, recognizing that the future problems are becoming more sophisticated the while the negative processes in many areas of human existence becomes catastrophic speeds, we must understand that the minimum resources can survive his everlasting but for many subjects etc. individual countries may become unreachable. There is no doubt, that the integral KNIT performance evaluation problem should be referred to the country and the world of science and object of exceptional attention. Unfortunately, for the latest problem decision making is only a few works. What should be an integral KNIT structure of the recognition that categories of knowledge, innovation and technology mean different functions and different paths, formed need for financial resources.

2. Knowledge, innovation and technology cluster as a complex adaptive system

In order to explain that this is a complex adaptive system, there can take advantage of that detract from the content of the text, it is taken from the Internet the drawing, voiced complex adaptive systems model (see Figure 1).

Designing the self-organizing system which could be the sustainable development of the country in general, it is important to adequately grasp the knowledge, innovation and technologies cluster value. Naturally, during the formation of the cluster, it is important to distinguish the value of each component and the basic functions that could be based on expert evaluation of financial resources. In turn, it is necessary to focused on the performing role of each of the components to achieve the country‘s objectives of the sustainable development (see Figure 1) (Alam & Kabir, 2013).

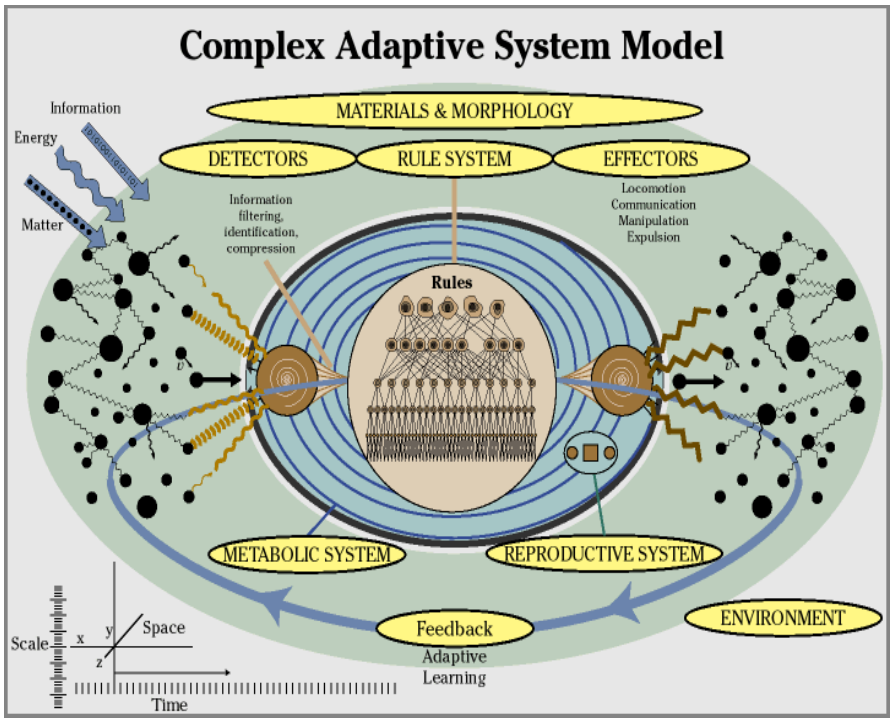

Fig. 1. Complex adaptive system model (Source. The Wild Peak, 2013)

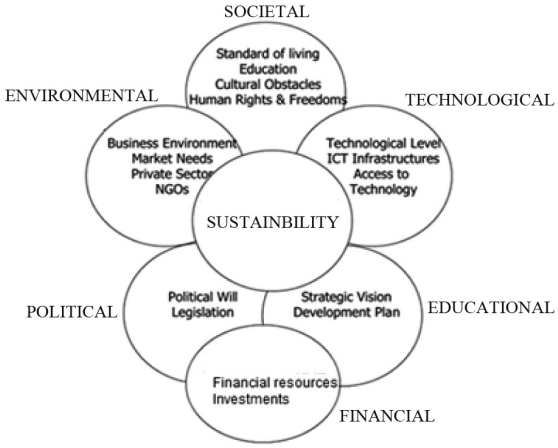

Fig. 2. The strategic objectives of country's universal sustainable development (Source. Created by the authors (Alam & Kabir, 2013))

Apparently, it has not be made absolute understanding of technology, that this is the knowledge and skills how to use mechanical tools and the results of applied science (Ertmer & Ottenbreit-Leftwich, 2010; Pacharapha & Ractham, 2012), or that the technology – is the whole of industrial processes and ways (Bekhami & Daim, 2012; Bjornson & Dingsoyr, 2008; Varghese, 2013; Veugelers, Bury & Viaene, 2010).

On the one hand, the perception of the manufacturing process is not identified with the use of mechanical tools and the second, in literature (Bestalich, 2010; Bekhami & Daim 2012; Goel, Dwived & Sherry, 2012; Vargas-

Hernandez & Garcia-Santillan, 2011) is abound observation that technology is a complex adaptive system. So integral KNIT cluster without additional arguments can be understood as a technology adaptively responsive to the cluster object properties and change targets.

3. Pragmatic integral knowledge, innovation and technology cluster structure characterization

Often for the original understanding of KNIT cluster structure invoked simplified partial model of interacting units, the military unit in the face of pre unfamiliar opponent. Then an observation unit in the role of recovering the knowledge subsystem which through all the options developed an adequate picture of the opponent while formulating vision, which should include: operating unit of military action – the investment subsystem and strategic action unit- the technology subsystem.

In other words, the knowledge subsystem – is the substance, which highlights what we should know and what you need to know, innovation –is the substance mobilizing the strategic objectives through both the knowledge and innovation. There is no doubt that the development process of becoming an integral part of the development code, which is the most important information about what happens if the subsystem is not exercise their functions and development process initiated stagnate. Visual development and the source of knowledge, innovation and technologies interacting between subsystems shown in Figure 2 (Santos Silva, Kovaleski, Gaia, Garcia & Junior, 2013; Shiu-Li & Chia-Wei, 2009; Suh, Furst, Mihalyov, & de Weck, 2010; Sullivan & Marvel, 2011; Todtling, Lehner & Kaufmann, 2009).

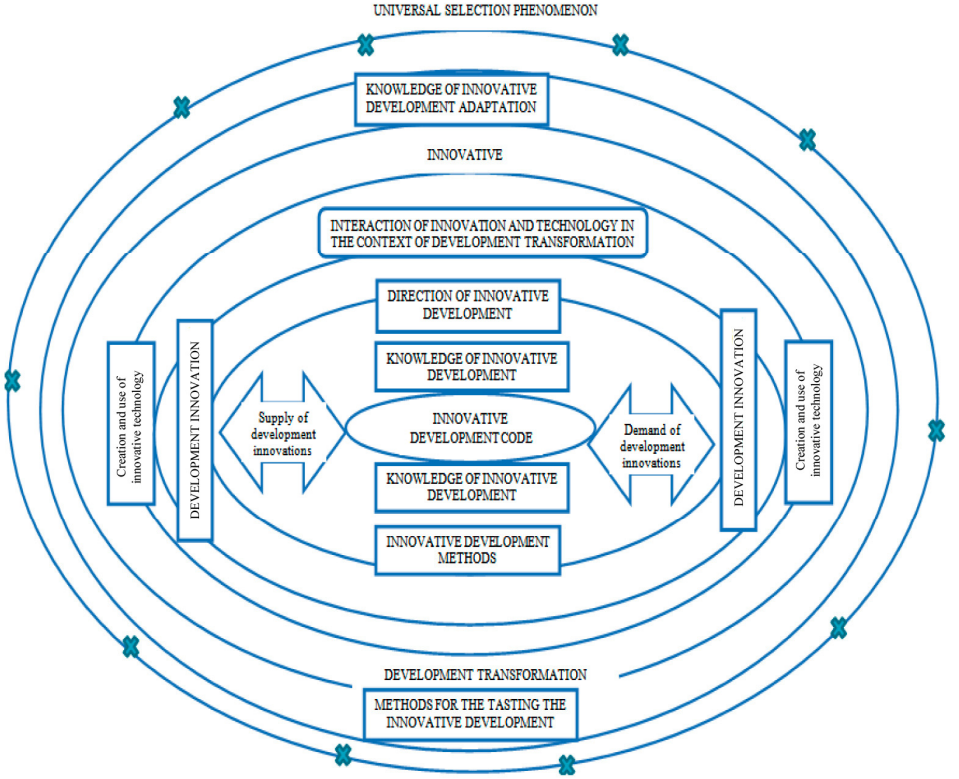

Fig. 3. The use of innovative development code information (Source. Created by the authors)

4. The illustration of experimental situation, optimizing the allocation of resources

If it is assumed that the sustainability of the country development can be examined through a model of complex system advance we have to admit that in the actual reality of the existing elements as a rule is characterized by the following features:

- a very complex structure;
- high sensitivity to even small dependencies between changes of components;
- it is characterized by interactions between the abundance of different components;
- It may reveal new features, or even state through time.

It is no doubt that all of these characteristics are common to the country's sustainable development phenomena. However, if it still required to be so open to self-regulating system, whose function required resources, that towards becoming the input elements can lead not only the changes in the internal dependencies, but also in the individual subsystem, and the whole system created effect. Then it is needed to agree that the systems, whose content is made of above mentioned features, require the cognition of adequate system and creation of management opportunities.

Figure 3 presented the study conception of interaction between the subsystems, formulation of solutions and the set of instruments for solution search: the systems of information knowledge, management solutions, uncertainty assessment and the models of stochastic quantitative solutions and expert evaluation. But at exceptional moment here we have to recognize the assessment of separate problems, when on the basis of collected and generated information is searched interoperability between different aspects of the development. And the fact that here invoked so-called stochastic informative examination methods for expert evaluation. Annexes, which added in the Figure 3, demonstrate that the system focused on opportunities formation of quantitative interviews, when it is analysed or designed development system of the country.

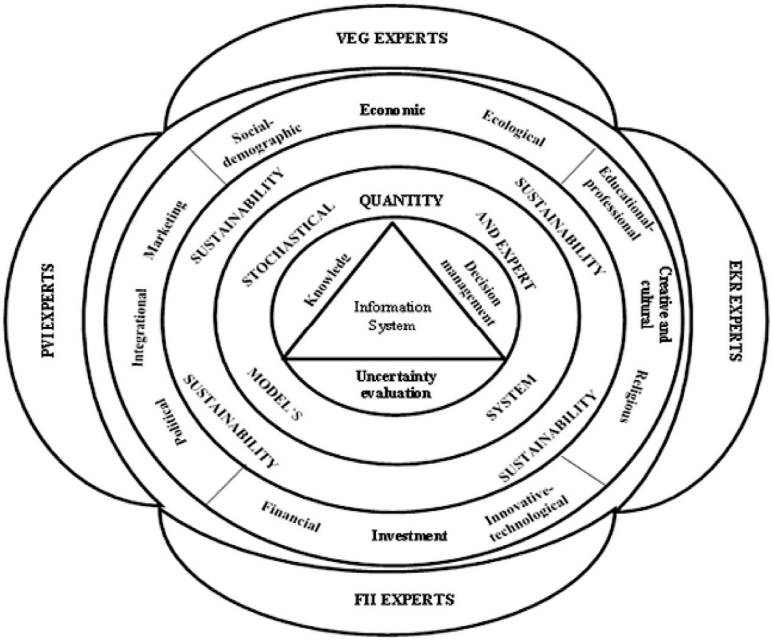

Fig. 4. The idea of round table: the formation of components for sustainability development and, and preparation of measures for knowledge and expert evaluation, fostering the development of sustainable management capabilities (*Source*: Rutkauskas, 2012).

A separate challenge is examination of sustainable development problems in the context of complex systems methodology, where raises the question for alignment of separate subsystems and overall system performance measurement dimensions. First of all, let us remember that sustainability measurement we associate with two-dimensional dimension – the efficiency and reliability. Reliability has without dimensional measurement method; however, the measurement of efficiency won't be without indicators, representing subsystems or all the contents of the existence of the system – developed product, the crop and so on.

It is true that in complex systems are the possibilities that one subsystem state may be another subsystem factor that the last indicator of all system can be difficult separate subsystems indicator's function. However, the most difficult problem arises when you need to deal with the basic economic problem – how to rationally allocate scarce resources with the purpose – to orient system moving in an optimal state or trajectory.

Further, assume that each of subsystem state, we can measure without dimensional indicator and using an informative expert valuation we can determine the marginal efficiency of the unit, if it is used in the *i*-subsystem functionality developing. Then we can form a task – how to find the optimal resource allocation among subsystems in conditions of uncertainty.

Let's suppose that the expert evaluation shows that the marginal investment unit utilization, observing certain investment proportions between isolated subsystems and subsystems formed inside, opportunities to change state of each subsystems index (which will take equal to one unit) can increase (decrease) the following stochastic multipliers:

$$D_1(a_1, S_1),\ D_2(a_2, S_2),\ D_3(a_3, S_3),\ D_4(a_4, S_4), \tag{1}$$

where:

a_i, S_i– are mean and standard deviations of respective random variables.

Let's try to determine under what proportion we can divide marginal investment between the abstracted subsystems, if the system status indicator – I formed as a product of subsystems indicators: $I = I_1 \times I_2 \times I_3 \times I_4$.

Let us consider two cases:

1. When we accepted that mention multipliers are normal random variables;
2. When the situation is complicated and mentioned multipliers takes on specific – typical forms for these subsystems.

D_1 – becomes lognormal, D_2 – becomes Gumbel distribution, D_3 – becomes Laplace distribution and D_4 – becomes normal.

In both cases the distributions are governed by the following averages and standard deviations:

$a_1 = 0{,}94$, $S_1 = 0{,}03$; $a_2 = 1{,}22$, $S_2 = 0{,}06$; $a_3 = 0{,}99$, $S_3 = 0{,}05$; $a_4 = 0{,}90$, $S_4 = 0{,}02$.

Results are presented in Figure 5 and Table 1. They are obtained by means of adequate investment portfolio logic and technique (Rutkauskas 2006).

Table 1. Notes of detailed decisions.

1 active	2 active	3 active	4 active
PIV	SEE	EKR	FII
The normal probability distribution			
0.38	0.08	0.28	0.26
Parameters			
e = 1.023116			
p = 0.57			
r = 0.01370			

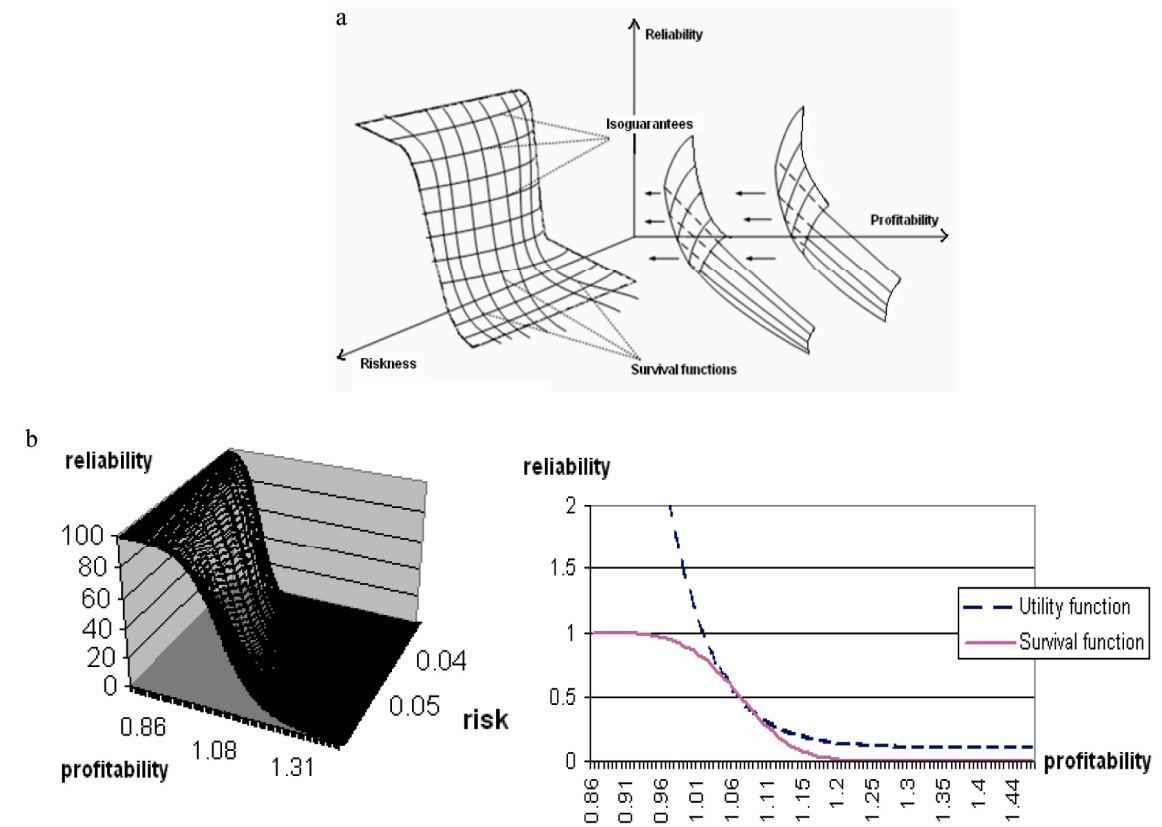

Fig. 5. Optimal allocation of resources among four subsystems of universal sustainability development. (a) The general view of three-dimensional efficient surface and respective utility functions; (b) The common search for the solution scheme, on the left – possible solutions surfaces, on the right – the particular decision finding.

5. Allocation of financial resources in order to attain effective integration of knowledge, innovation and technology

Moving from the possibility analysis of financial resource allocation, when focusing on the necessity of the country's sustainable development to actual allocation of financial resources, pursuing an effective integration of knowledge, innovation and technology, we will discuss the most important functions of main development factor components.

- Knowledge – a resource that is naturally emerging, human created, continuously updated and necessary for:
  1) developing a full understanding of what is happening in the surrounding environment;
  2) clusterizing techniques as measures of performance to ensure human survival and continuity;
  3) fostering innovation that can guarantee sustainable development.
- The process of generating knowledge, as a means of complete understanding, seems to be a process that is easiest understood and least influenced by subjective interest. However, adequate knowledge generation remains a major integrated KNIT cluster efficiency prerequisite, considering that inadequate knowledge can generate insightful technologies.
- Knowledge clusterization into activity technologies includes abundant material and financial resource integration. In turn clusters of technological knowledge combine knowledge of different nature and direction.

Besides, different interest groups participate subjectively in the use of technology. Therefore, the unwary formation of technology can create considerable loss not only to an individual entity, but also to the whole activity, country or region.

- Innovation system is defined as a network of private and public institutions whose activities and interactions initiate, import, modify and insert technologies.

As mentioned in the introduction to the article, here we describe experiments in finding the optimal allocation of resources, forming an integrated knowledge, innovation and technology cluster in order to universally sustainable development in Lithuania.

Trying to directly identify and generate the knowledge, implemented technologies and cherished innovations for longer perspective would require the analysis of quite debatable problems since most already set universal component of sustainable development is social – economic. Here, the identification of technologies and innovations and assessment of their need of cost implementation provoked a lot of discussion problems.

Therefore, as a rather simplified scheme for solution of mentioned problem, we will use the model structure of innovative functions of the system submitted by (Rutkauskas, Račinskaja & Kvietkauskienė 2013; Rutkauskas, 2006; Hekkert & Negro, 2009; Hekkert, Suurs, Negro, Kuhlmann & Smits 2007) and here reformatted for opportunities analysis of universally sustainable development through in the previous paragraph used stochastically informative expertise principles for the optimal allocation of financial resources among four integrated components of universal sustainable development. Very early results of the assessment are provided in the Table 2.

Table 2.The optimal allocation of financial resources between KNIT cluster components: knowledge, innovation and technology.

KNIT components		
Knowledge	Innovation	Technology
The marginal cost per unit of component		
0.19	0.30	0.51
Parameters		
$e = 1.1007$		
$p = 0.56$		
$r = 0.331$		

Source: created by authors

6. Conclusions

Universally sustainable development dominates as the primary way to sustainable future for economy in the UN and the EU special documents. For Lithuania universal sustainable development way is the only real possibility to save the autonomy and well-being of the country.

The advancement of science and technology for Lithuania, as well as for many small, not disposing abundant natural resources countries, remains the main factor and resource of development sustainability.

The optimality of KNIT cluster structure is very important, as well intelligent development of cluster that it will be ready to fulfil all needs of sustainable development creation in perspective.

It is essential that this factor, called inexhaustible, does not become inaccessible. Particular importance that in the study programs would be created modules guaranteeing the highest level of necessary knowledge for graduates and the ideology of business projects would ensure progressive necessity for development and adaptation of innovation and technology.

A real opportunity to continuously improve the knowledge, innovation and technology cluster is the status of a complex adaptive system technology attribution.

References

Alam, S. & Kabir, N. (2013). Economic Growth and Environmental Sustainability: Empirical Evidence from East and South-East Asia. *International Journal of Economics and Finance, 5(2)*, 86–97. http://dx.doi.org/10.5539/ijef.v5n2p86

Antonelli, C. (2009). The economics of innovation: from the classical legacies to the economics of complexity. *Economics of Innovation and New Technology, 18 (7)*, 611–646. http://dx.doi.org/10.1080/10438590802564543

Bastalich, W. (2010). Knowledge economy and research innovation. *Studies in Higher Education, 35 (7),* 845–857. http://dx.doi.org/10.1080/03075070903406533

Bekhami, N. A. & Daim, T. U. (2012). Research Forecasting for Health Information Technology (HIT), Using Technology Intelligence. *Technological forecasting and social change, 76*, 498–508. http://dx.doi.org/10.1016/j.techfore.2011.08.015

Bjornson, F. O., & Dingsoyr, T. (2008). Knowledge management in software engineering: A systematic review of studied concepts, findings and research methods used. *Information and Software Technology, 50,* 1055–1068. http://dx.doi.org/10.1016/j.infsof.2008.03.006

Boehm, G., & Fredericks, L. J. (2010). Strategic Innovation Management in Global Industry Networks: The TFT LCD Industry. *Asian Journal of Business Management, 2 (4),* 110–120.

Camic, Ch., Gross, N. & Lamont, M.(2012). *Social knowledge in the making*, University of Chicago Press.

De Noronha Vaz, T., & Nijkamp, P. (2009). Knowledge and innovation: The strings between global and local dimensions of sustainable growth. *Entrepreneurship & Regional Development: An International Journal, 21 (4),* 441–455. http://dx.doi.org/10.1080/08985620903020094

Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher Technology Change: How Knowledge, Confidence, Beliefs, and Culture Intersect. *Journal of Research on Technology in Education, 42 (3)*, 255–284.

Goel, S., Dwivedi, R. & Sherry, A. M. (2012). Critical Factors for Successful Implementation of E-governance Programs: A Case Study of HUDA. *Global Journal of Flexible Systems Management, 13(4),* 233–244. http://dx.doi.org/10.1007/s40171-013-0021-1

Hekkert, M. P. & Negro, O.S. (2009). Functions of innovation system as a framework to understand sustainable technological change: Empirical evidence for earlier claim. *Technological forecasting and social change, 76, 584*–594. http://dx.doi.org/10.1016/j.techfore.2008.04.013

Hekkert, M. P., Suurs, R. A. A., Negro, S. O., Kuhlmann, S. & Smits, R. E. H. M. (2007). Functions of innovation systems: A new approach for analysing technological changes. *Technological Forecasting & Social Change, 74*, 413–432. http://dx.doi.org/10.1016/j.techfore.2006.03.002

Luke, B., Verreynne, M. L. & Kearins K. (2010). Innovative and entrepreneurial activity in the public sector: The changing face of public sector institutions. *Innovation: management, policy & practice, 12,* 138–153. http://dx.doi.org/10.5172/impp.12.2.138

Naštase, G. I. (2013). Innovative Models of Increasing Competition and Competitiveness in Science. *Journal of Knowledge Management, Economics and Information Technology, 2*, 233–240.

Noor Al-Jedaiah, M. (2010). The Impact of Information Technology (IT) on Decision-Making Process in the Public Sector. *Interdisciplinary Journal of Contemporary Research In Business, 2 (5),* 320–329.

Pacharapha, T. & Ractham, V. V. (2012). Knowledge acquisition: the roles of perceived value of knowledge content and source. *Journal of Knowledge Management, 16 (5),* 724–739. http://dx.doi.org/10.1108/13673271211262772

Rutkauskas, A. V. (2006). Adequate Investment Portfolio Anatomy and Decisions, Applying Imitative Technologies, *Economics* 75: 52–76.

Rutkauskas, A. V. (2012). Using Sustainability Engineering to Gain Universal Sustainability Efficiency. *Sustainability, 4,* 1135–1153. http://dx.doi.org/10.3390/su4061135

Rutkauskas, A. V.; Račinskaja, I.; Kvietkauskienė, A. (2013). Integral cluster of knowledge, innovation and technology as a self-regulating complex system, *Business, Management and Education* (in print).

Santos Silva, L. C., Kovaleski, J. L., Gaia, S., Garcia, M., & Junior, A. (2013). Technology Transfer and Knowledge Management in Technological Innovation Center: A Case Study in Brazil. *Journal of Management and Strategy, 4 (2),* 78–87. http://dx.doi.org/10.5430/jms.v4n2p78

Shiu-Li, H., & Chia-Wei, Y. (2009). Designing a semantic bliki system to support different types of knowledge and adaptive learning. *Computer & Education, 53,* 701–712. http://dx.doi.org/10.1016/j.compedu.2009.04.011

Suh, E. S., Furst, M. R., Mihalyov, K. J., & de Weck, O. (2010). Technology Infusion for Complex Systems: A Framework and Case Study. *System Engineering, 13 (2)*, 186–203.

Sullivan, D. M., & Marvel, M. R. (2011). Knowledge Acquisition, Network Reliance, and Early-Stage Technology Venture Outcomes. *Journal of Management Studies, 48(6),* 1169–1193. http://dx.doi.org/10.1111/j.1467-6486.2010.00998.x

The Wild Peak. [online] <http://thewildpeak.wordpress.com/2012/08/05/thoughts-on-the-limits-of-economic-prediction/>.

Todtling, F., Lehner, P., & Kaufmann, A. (2009). Do different types of innovation rely on specific kinds of knowledge interactions?. *Technovation, 29,* 59–71. http://dx.doi.org/10.1016/j.technovation.2008.05.002

Vargas-Hernandez, J. G., & Garcia-Santillan, A. (2011). Management in the Innovation Project, *Journal of Knowledge Management, Economics and Information Technology, 7,* 148–171.

Varghese, P. G. (2013). A Communication-Focused Model for Learning and Education. *Business Education & Accreditation, 5 (2)*, 117–130.

Veugelers, M., Bury, J. & Viaene, S. (2010). Linking technology intelligence to open innovation. *Technological forecasting and social change, 77*, 5335–5343. http://dx.doi.org/10.1016/j.techfore.2009.09.003