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An Equilateral Triangular Model Approach for the Sustainable Development of a Region: the Role of Science Parks

Plenary Session 1:
Entrepreneurship as a key value in knowledge economies – role of STPs

Author:
Prof. Petros Groumpos (groumpos@psp.org.gr)

Patras Science Park
Stadiou Str. Platani Patras, 26504, Greece

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Executive Summary:

Science and Technology are vital not only for the progress and the exploitation of knowledge, but also for the achievement of viable and balanced growth, stability and prosperity. The contribution of technology to economic growth and prosperity is of no doubt, mainly because of the recognition of the importance of the innovation within an economy. Science and Technology Parks (STEPAs) are essential means for the transferring of scientific and technological knowledge from the research institutes and universities to enterprises. A STEPA is a mediator that contributes considerably to the regional growth, facilitating the creation of high technology spin-off firms and disseminating innovative technological achievements to regional SMEs. This paper attempts to highlight this increasingly important role of STEPAs within sustainable regional development by utilising existing knowledge within economic development and linking it with the concepts of innovation, knowledge and entrepreneurship on a triangular approach. By undertaking mathematical calculations and geometrical axioms, this study shows different approaches in regional development based on various settings between these three fundamental concepts. Particular contribution to the knowledge is attempted through the introduction of Excellence within the proposed Equilateral Triangular Model Approach (ETMA). Particular emphasis is also given to the concept of knowledge based society and its main advances as well as differences compared with industrial society. The interesting question as to what constitutes Technology Transfer is addressed extensively. Finally, the dynamic role of STEPAs is addressed and discussed concerning the sustainable development of a region.

Keywords: Sustainable Development, Economic Growth, Geometric Approach, Science Parks, Economic Models, Technology Transfer.

"Science give us the knowledge, but only philosophy can give us the wisdom"

Will Durant, 1926

1. Introduction

It is an accepted fact that a country's economic growth is largely been driven by the pursuit of scientific understanding and continuous technological innovation. As technological and new industries are becoming more sophisticated, universities, research centers and scientific - technological parks are playing an ever more important role in the processes of research, invention, innovation and commercialization. A major part of a strategy for all countries, regardless of geographic borders must be the development of regions, through initiatives which will eliminate inequalities in the periphery and will provide citizens and communities with a satisfactory level of welfare. To mention a few strategic perspectives:

1. Collaboration between companies and public research and academic institutions, through the formation of regional and intra-regional clusters of excellence
2. Support and enhancement of research and innovation within SMEs and access to research and technology outcomes of public institutions
3. Regional, trans-national or inter-regional forms of co-operation that aim to introduce partnerships within research fields of high priority
4. Support of research capabilities, such as research infrastructure, human capital, IT and Telecommunications and others within scientific areas that boost development

This paper will begin its elaboration by examining the field of economic development and presenting its most important models. By addressing some key concepts and considerations regarding economic growth and development, it will also identify the trends within regional policy and its main directions. Further or, sustainable development will be investigated, in terms of social, economic and environmental sustainability. A geometric approach to sustainable growth will be proposed and the reader will be introduced to the concept of the Equilateral Triangular Method Approach (ETMA) for the sustainable development of a region. Particular emphasis will be given onto the driving forces of research-innovation, knowledge-education and entrepreneurship and their inter-relationships within a developmental perspective. The ETMA approach will be then linked with the concept of Aristia (Excellence, *in Greek*), where specific examples will be analysed and presented through mathematical calculations and geometrical axioms. The knowledge based society will be investigated on a further section and helpful insights will be provided with reference to the differences between the industrial versus the knowledge society. Finally, the role of Science and TEchnology PArks (STEPAs) will be presented and particularly within the critical area of sustainable development. The paper will at a last stage present its final conclusions and point out areas for further investigation.

2. Economic development and models

In recent publications (Van den Bergh 1996, Giaoutzi and Nijkamp 1993) the issue of regional sustainable development has been examined under the three broad headings of economic, social and ecological concerns in specific geographical areas. The economic aspects are related to income, production, investments, market developments, price formation etc. The social concerns refer to distributional and equity considerations, such as income distribution, access to markets, wealth and power positions of certain groups or regions etc. In terms of the environmental dimensions, these are concerned with quality of life, natural resources, pollution matters and other variables of similar character. It is clear that the above mentioned three classes of variables are strongly interlinked, but they are also conflicting in many cases. Putting more emphasis on a higher availability of the one category tends to reduce the availability or usability of either of the other ones. This may in a stylized way be depicted by means of the following Mӧbius triangle (see Figure 1). Two observations are in order in relation to Figure 1. The three force fields are essentially latent variables which have to be measured (or approximated) by means of manifest, observable indicators. And secondly, the actual state of (un)sustainable development is never static in nature, but always in a state of flux (see Kay 1991, Norgaard 1994). Consequently, there is a need for monitoring actual development over time and for identifying changing conflicts of interest between actors.

In general, it would be desirable to construct a comprehensive impact model which would encapsulate the complex interacting patterns of regional development and related land use in relation to social and environmental variables. Such a modelling activity could take the form of either an econometric model (validated by empirical data on solid statistical grounds) or a simulation model (calibrated at best by plausible information). In light of the near-impossibility to construct for each individual regional development plan or project a dedicated model, in practice one often resorts to an ad hoc impact assessment, based on simple cause-effect relationships. Such a more limited approach has obviously several shortcomings, but has the advantage that it is manageable, practical and based on local expertise. In such a case, foreseeable consequences of various types of human or government intervention can be assessed by a combination of ad hoc surveys, comparative studies and other research works or methods

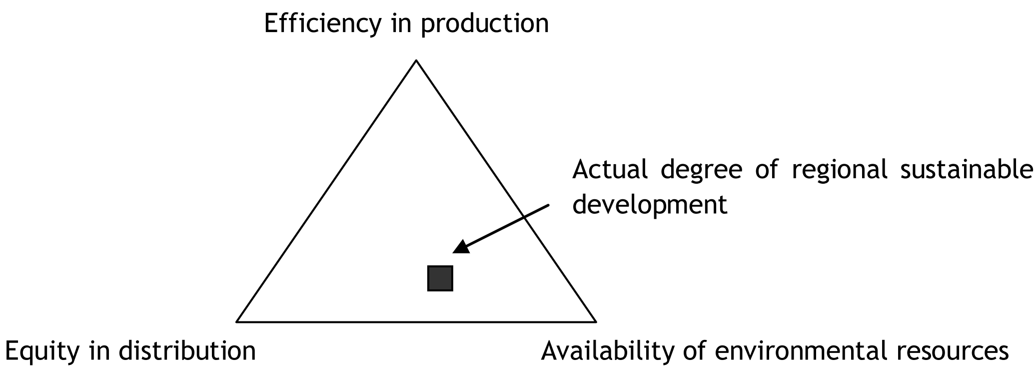

Figure 1: Mobius triangle illustrating mutual dependence of policy goals[1]

[1] Source: Nijkamp, P. and Ouwersloot, H. (1997) A decision support system for regional sustainable development: the Flag Model, p.2

2.1 Economic growth and development: some issues and considerations

Economic growth is defined as the increase in value of goods and services produced by an economy. It is measured as the percent rate of increase in real gross domestic product (GDP). It is accepted that growth is calculated in real terms in order to net out the effect of inflation on the prices of goods and services produced. In the science of economics, economic growth concerns the potential output (i.e. production at *full employment*) that is caused by growth in demand or output (Wikipedia, the free encyclopedia, 2008).[2]

Economic development, on the other hand, is the development of economic wealth of countries or regions focused on the achievement of well-being for their inhabitants. In other words, economic development refers to the efforts towards the improvement of the economic well-being and quality of life for a community through creating of employment, generating of jobs and supporting the growth of incomes.[3]

At this point, it should be noted that significant differences do exist between economic development and growth. The term "economic growth" refers to the increase (or growth) of a specific measure such as real national income, gross domestic product, or per capita income. National income or product is commonly expressed in terms of a measure of the aggregate value-added output of the domestic economy called gross domestic product (GDP). When the GDP of a nation rises economists refer to it as economic growth.

The term "economic development," is a generic term and typically refers to improvements in a variety of indicators such as literacy rates, life expectancy, and poverty rates. GDP (Gross Domestic Product) is a specific measure of economic welfare that does not take into account important aspects such as leisure time, environmental quality, freedom, or social justice. Economic growth of any specific measure is not a sufficient definition of economic development. Economic development is often used in a regional sense as well, where it focuses on the recruitment of business operations to a region, assisting in the expansion or retention of business operations within a region or assisting in the start-up of new businesses.

In its broadest sense, economic development encompasses three major areas:

1. Policies that governments undertake to meet broad economic objectives;
2. Policies and programs to provide infrastructure and services;
3. Policies and programs that are exclusively focus on job creation and retention.

2.2 Models of economic development

The 3 building blocks of most growth models are: (1) the production function, (2) the saving function, and (3) the labor supply function (related to population growth). Together with a saving function, growth rate equals s/ß (s is the saving rate, and ß is the capital-output ratio). Assuming that the capital-output ratio is fixed by technology and does not change in the short run, growth rate is solely determined by the saving rate on the basis of whatever is saved will be invested.

[2] http://en.wikipedia.org/wiki/Economic_growth
[3] http://en.wikipedia.org/wiki/economic_development

The Harrod - Domar Model

The Harrod - Domar model delineates a functional economic relationship in which the growth rate of gross domestic product (g) depends directly on the national saving ratio (s) and inversely on the national capital/output ratio (k) so that it is written as $g = s / k$.

The exogenous growth model

The exogenous growth model (or neoclassical growth model) of Robert Solow and others places emphasis on the role of technological change. Unlike the Harrod-Domar model, the saving rate will only determine the level of income but not the rate of growth. The sources-of-growth measurement obtained from this model highlights the relative importance of capital accumulation (as in the Harrod-Domar model) and technological change (as in the Neo-classical model) in economic growth. Even so, in our postindustrial economy, economic development, including in emerging countries is now more and more based on innovation and knowledge. Creating business clusters is one of the strategies used. One well known example is Bangalore in India, where the software industry has been encouraged by government support including Software Technology Parks.

The surplus labor model

The Lewis-Ranis-Fei (LRF) model of surplus labor is an economic development model and not an economic growth model. The LRF model takes the peculiar economic situation in developing countries into account: unemployment and underemployment of resources (especially labor) and the dualistic economic structure (modern vs. traditional sectors). This model is a classical model because it uses the classical assumption of subsistence wage.

Here it is understood that the development process is triggered by the transfer of surplus labor in the traditional sector to the modern sector in which some significant economic activities have already begun. The modern sector entrepreneurs can continue to pay the transferred workers a subsistence wage because of the unlimited supply of labor from the traditional sector. The profits and hence investment in the modern sector will continue to rise and fuel further economic growth in the modern sector. This process will continue until the surplus labor in the traditional sector is used up, a situation in which the workers in the traditional sector would also be paid in accordance with their marginal product rather than subsistence wage. In the LRF model, saving and investment are driving forces of economic development. This is in line with the Harrod-Domar model but in the context of less-developed countries. The importance of technological change would be reduced to enhancing productivity in the modern sector for even greater profitability and promoting productivity in the traditional sector so that more labor would be available for transfer.

3. Sustainable development[4]

[4] Note: for reasons of completeness, the author has extensively utilised particular sections from Wikipedia, the free encyclopedia, available through the Internet – http://en.wikipedia.org/wiki/Sustainable_Development

In the academic literature, sustainable development is characterised as development in which total “welfare” is not decreasing over time. Just as economic development is sustainable provided economic (man-made) capital is non-decreasing, sustainable development requires total capital – that is, economic capital, human and social capital and environmental capital – to be non-decreasing. In this context, capital is referring to both the stock and to the quality of the resources (e.g. the skills, health and knowledge of the population or the quality of air and other natural resources).

Sustainable development does not focus solely on environmental issues. Moreover, sustainable development policies include three major areas: economic, environmental and social sustainability. In support of this, several United Nations texts, most recently the 2005 World Summit Outcome Document, refer to the "interdependent and mutually reinforcing pillars" of sustainable development as economic development, social development, and environmental protection.

One should also not forget the cultural dimension of sustainability as well. The Universal Declaration on Cultural Diversity (UNESCO, 2001) elaborates the concept by stating that "...cultural diversity is as necessary for humankind as biodiversity is for nature”. It becomes “one of the roots of development understood not simply in terms of economic growth, but also as a means to achieve a more satisfactory intellectual, emotional, moral and spiritual existence". In the light of the previous statement, cultural diversity is the fourth policy area of sustainable development.

Economic Sustainability: Agenda 21 clearly identified information, integration, and participation as key building blocks to help countries achieve development that recognises these interdependent pillars. It emphasises that in sustainable development everyone is a user and provider of information. It stresses the need to change from old sector-centred ways of doing business to new approaches that involve cross-sectoral co-ordination and the integration of environmental and social concerns into all development processes. Furthermore, Agenda 21 emphasises that broad public participation in decision making is a fundamental prerequisite for achieving sustainable development (Allen, 2007).

Green development is generally differentiated from sustainable development in that Green development prioritizes what its proponents consider to be environmental sustainability over economic and cultural considerations. Sustainable development argue that it provides a context in which to improve overall sustainability where cutting edge Green development is unattainable. To present an example, a cutting edge treatment plant with extremely high maintenance costs may not be sustainable in regions of the world with less financial resources. An environmentally ideal plant that is shut down due to bankruptcy is obviously less sustainable than one that is maintainable by the indigenous community, even if it is somewhat less effective from an environmental standpoint.

Some research activities start from this definition to argue that the environment is a combination of nature and culture. The Network of Excellence "Sustainable Development in a Diverse World", sponsored by the European Union, integrates multidisciplinary capacities and interprets cultural diversity as a key element of a new strategy for sustainable development. Still other researchers regard environmental and social challenges as potential opportunities for development action. This is particularly valid in the concept of sustainable enterprise that frames these global needs as opportunities for private enterprise to provide innovative and entrepreneurial solutions.

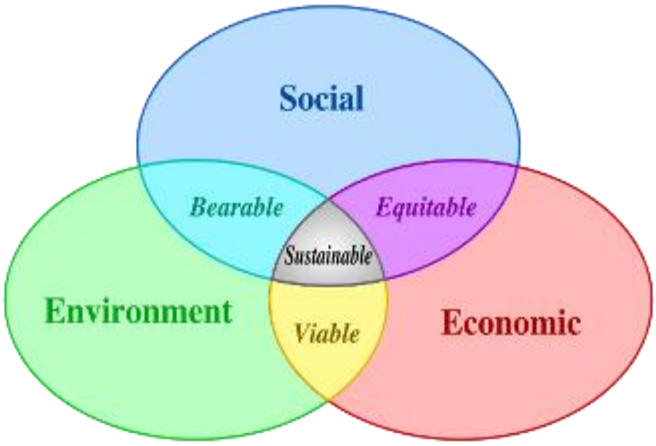

Figure 2: Scheme of sustainable development: at the confluence of three preoccupations. *Source: Wikipedia, the free encyclopedia*[5]

4. A geometric approach to sustainable growth

Geometry is one of the oldest sciences, part of the major of Mathematics. Plato has said "Αγεωμέτρητος μηδείς Εισίτω"- which means "Let no one ignorant of geometry enter". Tradition has it that this phrase was engraved at the door of Plato's Academy; the school was founded in Ancient Athens.

After reviewing a number of economic models, somehow the concept of interdependence between the three factors becomes apparent. Furthermore, in most studies this interdependence is connected to the geometric figure of the triangle. In this section, the concept of an *Equilateral Triangular Model Approach* (ETMA) for sustainable growth is presented mathematically. A first approach to Equilateral Triangular Model Approach (ETMA) for control theories was presented at an international scientific – technical workshop in Russia, in 1999 (Groumpos, 1999).

Development on all levels, but more importantly, development on a regional basis that will accelerate national growth appears as the key to success. It is therefore becoming apparent that the application of a developmental model, which will sustain economic self reliance, is a true necessity. The latest is ensured with the "treatment" of the feeble business parts, the exploitation of collaborations, the increase of competitiveness, and the cleansing of all the things that, in the past, created and raised ineffectual systems. To the previous list another element should be added and that is the guarantee of an educational system which would lead to a multilateral knowledge; that is education.

Prejudices, lack of executives, insufficient competitiveness and risk capital, incrimination of profit, limited research activity, arrogance created by the 'academic mentality' within industrial situations, fear of the new, etc., shape a kind of a pathogeny that should be overcome by a modern economy. This kind of systems (anti productive conceptions) could be eliminated by effective as well as flexible models. These models are based on the dynamic relationship between *knowledge - education*, *research – innovation* and *entrepreneurship*,

[5] http://en.wikipedia.org/wiki/Sustainable-development

having *excellence* as their core basis. This approach is presented in a triangle that contains the key – points (pivots) of Development (see figures 1, 2 & 3).

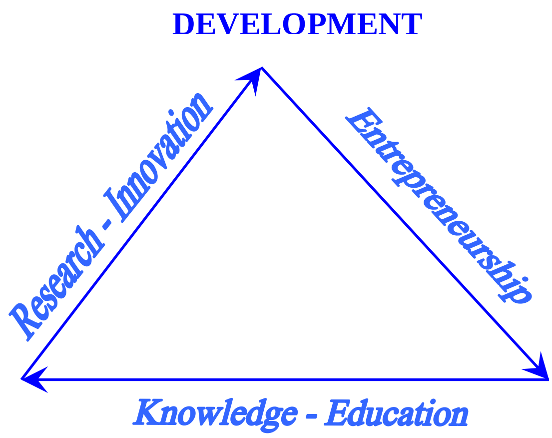

Figure 2: An Equilateral Triangular Model Approach for Sustainable Development (ETMA)

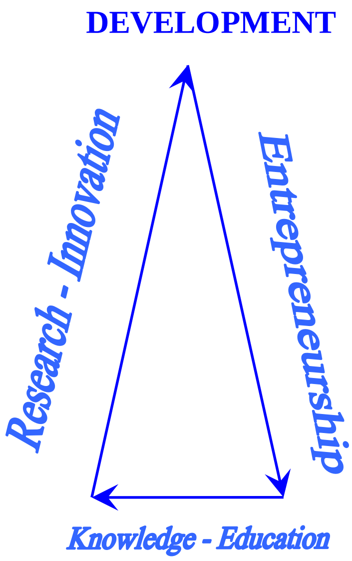

Figure 3: A triangular approach for sustainable development, emphasizing on research-innovation and entrepreneurship.

The above figure shows the base of the triangle – knowledge & education – as the weak factor. It is shown that the entire triangle could easily become unstable. A neglected knowledge and education could not feed the factors of research-innovation and entrepreneurship with a vital level of human resources. It is also apparent that minor-levered education could not be a robust base for entrepreneurship in any level. It is clear that the situation described above, cannot be sustained in the long run.

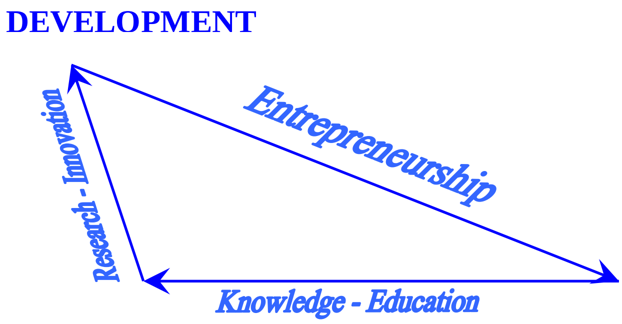

Figure 4: A triangular approach for sustainable development, emphasizing on entrepreneurship

In this situation, entrepreneurship is the dominant factor, where research-innovation is in a weak position. The weakness of research-innovation cannot sustain entrepreneurship in the long-run, while of problematic character is the relationship with education.

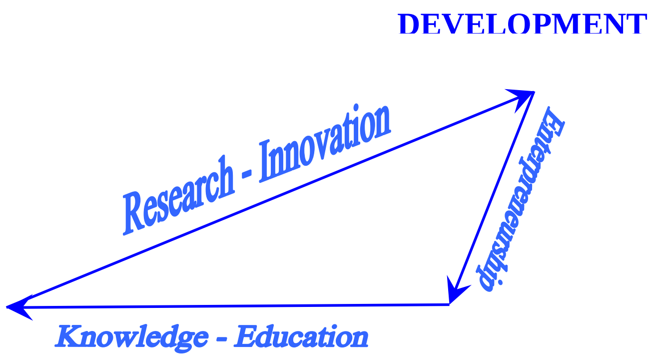

Figure 5: A triangular approach for sustainable development, emphasizing on research - innovation

In this situation, the weakness is observed in the area of entrepreneurship. This weakness may also imply the inefficiency of the remaining factors. In this case, research and innovation has a particularly importance weight, although lack the power to boost development within entrepreneurship. It is a case where assumptions about non-effective allocation of resources towards research and innovation, could be valid. At the same time, it is observed that entrepreneurship within the role of a dynamic messenger carrying valuable messages from the global economic scene, the entire system suffers in attracting the necessary information. The latter may lead to pressures resulting in new trends and therefore, improvements.

A number of significances (in other words the key points, for the achievement of growth) arise from the previous figures and are discussed further on.

1st: Knowledge - Education

Knowledge does not constitute luxury or property of the few. What kind of knowledge should transfer the education? The Knowledge of the 21stcentury is the combination of the rapid development of science and technology, which will form the basic component of the future society. Biotechnology, Genetics, Information technology, Nanotechnology, Energy, etc., are the obvious sources of the scientific knowledge which are produced and will continue to be produced in laboratories. These sources result in the conversion of this knowledge into "product" and services disposal for transaction. Education is a complex term that transfers the Science and the empirical Knowledge that involves the questioning and the percolation of cognitive data, the study of philosophy and the ideologies and achievements of the art. In other words, Education encompasses the culture which "gives birth" to visions as well as targets for achievement.

Education constitutes a major necessity for the 21st century's society, concerning the development and the predominance of a human-centred developmental model. An educational system, which secures the transfer of knowledge and at the same time, shows to students the necessity of research. It also introduces people into the world of ideas, visions, and values (freedom, justice, self-respect, respect for the others, altruism, charity) that leads them to the Platonic virtue and provides the Education.

2nd: Research - Innovation

Innovation, as a source of competitive advantage for national economies, is setting the path for enhanced productivity, but is fundamentally connected with research which appears as an integral part of entrepreneurship. The term *science research* refers to the organised and systematic search for new science knowledge. Research is traditionally distinguished into *basic research*, which aims at increasing the knowledge of science, *applied research* that is executed by specific applications and finally, *industrial research* that deals with the conversion of applied research into industrial products.

Innovation is a necessary condition for the application of new technologies in the labor environment of enterprise, in the import of new products and in the adoption of pioneer methods concerning the administration and the promotion of the enterprise. The scientific research and the technological development lead to innovation, which is resulting in the increase of competitiveness as a matter of concern for business and employment.

3rd: Entrepreneurship

In economic theory, entrepreneurship is the fourth element of production, accompanied by land, labour and capital. The term derives from the verb “attempt” that means “I make efforts for something new”. Therefore the term already contains the significance of innovation. Thus, the conversion of an idea into a commercial, new or improved product, service, and method of production or distribution, constitute the innovation in the grounds of the entrepreneurship.

Innovation is not independent, but is determined by specific factors, like the consumer demand for new products, the availability of scientists and executives and their ability to produce and to develop the innovation, the availability of resources in the suitable conditions and the appropriateness of material and technical supplies to support the needs of creation and of promotion of innovative products. The competitive advantage of an economy lies within its ability to innovate and, as a result, to get upgraded.

Innovation as a competitive advantage of a national economy is closely related with productivity. Productivity on the other hand deals with the value that is being produced by the elaboration of one labour or capital unit. A potential source of competitive advantage can be also resulted by a weaknesses of a given production element. More specifically, when there is a certain weakness within.

5. The Equilateral Triangular Model Approach (ETMA) based on excellence

In our case here we should need to be aware of the following geometric axioms regarding triangles.

Axiom 1

Given the perimeter of a triangle p=a+b+c then the maximum area of it, is when the triangle is equilateral or when a=b=c.

Axiom 2

Given the three sides of a triangle then each side is less that the sum of the other two and is greater than the difference of the other two.

Axiom 3 (Theorem of Heron)

The area (E) of a triangle, given its three sides a, b and c is given by the equation

$$E = \sqrt{\tau(\tau-a)(\tau-b)(\tau-c)} \qquad (1)$$

Where τ is the semi-perimeter or $\tau = \frac{1}{2}(\alpha + b + c)$ (2)

Axiom 4 (Theorem of Archimedes)

Given the three sides of a triangle, a, b and c there always exists a in-circle of radius r and is equal to r = $\frac{E}{\tau}$

Where E is the area of the triangle and τ the semi-perimeter (equation 2 is given in Axiom 3).

Given the above geometric axioms we do run a number of simulations based on a triangular, where π=150 (a=50, b=50, c=50), which are given on tables 1 and 2 with some very interesting results.

Table 1: Results of the Performance of ETMA

Case	a (base)	b (side 1)	c (side 2)	Area (m^2)	Performance (%)
1 *optimal*	50	50	50	1082.532	100 *optimal*
2	50	60	40	992.157	91.60
3	50	70	30	649.519	60.00

4	50	74	26	303.109	28.00
5	50	65	35	866.025	80.00
6	60	45	45	1006.231	92.99
7	60	40	50	992.157	91.65
8	70	40	40	677.772	62.00
9	70	30	50	649.519	60.00
10	70	20	60	556.215	51.38
11	74	38	38	320.429	29.60

From the above table it is evident that the optimal maximum area in case that the triangular is equilateral it is very interesting in the case number 4, where the base remains the same as the optimal. It is observed that in this case (number 4), where a=50, b=74 and c=26, the performance of the model is dropping to 28% (in other words, a loss of competitiveness of 72%).

5.1 Performance indicators of complex dynamic innovation systems, based on ETMA

A formal study of complex dynamic innovation systems has evolved over the past few decades from common observations made by researchers from many fields. Complex innovation systems are dynamic and many of their properties emerge from the interactions among the entities in them. They also have a propensity to exhibit power law or scaling correlations between primary measures used to characterize them. A complex dynamic innovation system is composed of individuals and organisations that directly and indirectly invest time and energy in the creation of new scientific and technical knowledge. This "knowledge" flows and recombines in complex ways.

Observers of complex dynamic innovation systems, for example, national systems of innovation, frequently make comparisons. Invariably they aggregate individuals into groups or collective entities such as countries, institutions, departments, and companies. They use quantitative and qualitative measures of the inputs, outputs and processes of these "entities" to construct performance indicators that are used to inform governments and/or decision makers.

For example, performance indicators such as national wealth (GDP per capita), R&D intensity (GERD/GDP) and scientific impact (citations/paper) are used to compare innovation systems. These indicators are derived from the ratio of primary measures such as population, GDP, GERD and pares. Frequently they are used to rank members of an innovation system and to inform decision makers.

Considering as a performance indicator the area of a triangle, we showed above both from a theoretical perspective as well as through a simulation run, that the maximum benefit is obtained when the triplex (Education + Research – Innovation + Entrepreneurship) is formulated in an equilateral triangle balance. Now, one more notion is added, that of Aristia (Excellence, *in Greek*) as an in-circle within the triangle presented on figure 6. Furthermore, we provide the following geometric axioms.

Axiom 5
Given a triangle there always exist an in-circle which is tangent to all the three sides, has a center at the intercept point of the angle bisectors.

Axiom 6
Given the three sides a, b and c of a triangle ABC, the area of the in-circle ($A=\pi r^2$) is maximum when the triangle equilateral, when a=b=c.

Axiom 7
Given the three sides a, b and c or a triangle the ratio of the area (A) of the in-circle to the area E of the triangle is the largest only when the triangle is equilateral, when a=b=c.
Axiom 7 in equation form

$$P = \frac{Area\ of\ incircle\ (A)}{Area\ of\ triangle\ (E)}$$

where P is referred as the Excellence Performance Indicator.

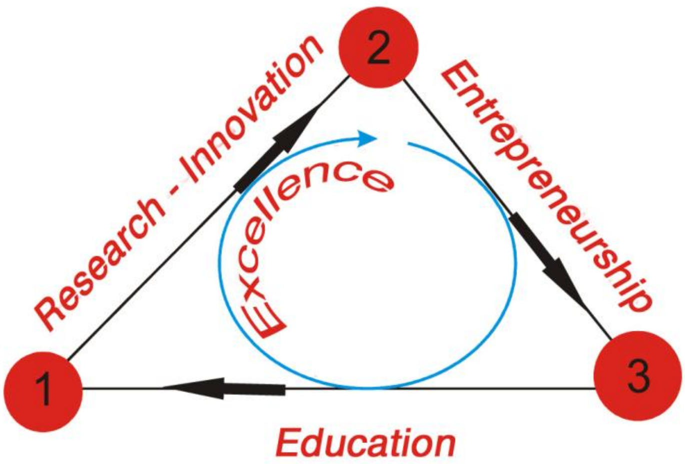

Figure 6: The Equilateral Triangular Model Approach (ETMA) based on Excellence

Table 2: Excellence Performance Indicator (P) based on the concept of the In-circle of a triangle

Case	Area of Triangle E (m^2)	In-circle Radius (r)	Area of in-circle $A=\pi r^2$ (m^2)	Excellence Performance Indicator P=A/E
1 *optimal*	1082.532	14.434	654.5205	1 *optimal*
2	992.157	13.229	549.7989	0.84
3	649.519	8.66	235.6056	0.36
4	303.109	4.041	51.3012	0.0784
5	866.025	11.547	418.8786	0.64
6	1006.4	13.416	565.4523	0.8639

7	992.157	13.229	549.79889	0.84
8	677.772	9.037	256.5656	0.392
9	649.519	8.66	235.6056	0.36
10	556.215	7.416	172.7783	0.264
11	320.429	4.272	57.334	0.0876

***Remarks**: please note that the cases 1-11, correspond to the entries presented on table 1*

Based on axioms 5, 6 and 7 and the simulation results of table 2, a number of interesting observations can be made:

1. The Excellence Performance indicator P=A/E is maximum=1 when the triangle is equilateral (case 1: a = b = c = 50 units)
2. The Excellence Performance Indicator [P] is always less than 1 for all other cases.
3. The Excellence Performance Indicator [P] is decreasing drastically when the triangle is based in only **1** (one) of the side components (case 4, P=0.0784, when a=50, **b=74** and c=26 and case 11, when P=0.0876, when **a=74**, b=38 and c=38)

6. The knowledge-based society

The 21st century marks the beginning of a new era in which the traditional pillars of economic power – land, capital, materials and labour – are no longer the main determinants of business success. Instead, achievements will be essentially determined by our ability to use knowledge, a precious global resource, wisely.

This is due to the constant and overwhelming change in the business environment, from one in which the market assumptions were stable, the business rules were rigid, the command-and-control management model was adequate, competitors and customers were known and the future was almost predictable, to an environment in which the only thing that can be predicted is unpredictability itself. In this knowledge economy most organisations depend for their value and competitiveness on the development, use and distribution of knowledge-based competences. As knowledge increasingly becomes the key strategic resource of the future, the need of organisations to develop a comprehensive understanding of knowledge strategies, processes and tools for the creation, transfer and deployment of this unique asset is becoming critical. The challenge is to seek fundamental insights, to help organisations to nurture, harvest and manage the immense potential of their knowledge; to help them to create new and measures and reinvent themselves in order to innovate and excel in the context of the knowledge economy.

But what would “knowledge” be in an organizational setting? Debates and discussions about the definition of knowledge abound. In everyday language, it has long been the practice to distinguish between information, i.e. data arranged in meaningful patterns, and knowledge, i.e. something that is believed, that is true (for pragmatic knowledge, that works) and that is reliable. The interchangeable use of information and knowledge can be confusing if it is not made clear that knowledge is being used in a news unusual sense, and can seem unscrupulous insofar as the intent is to attach the prestige of knowledge to mere information. It also tends to obscure the fact that while it can be extremely easy and quick to transfer information from one place to another, it is often very difficult and slow to transfer knowledge from one person to another.
In the West, intuitive knowledge has often been devalued in favour of rational scientific knowledge, and the rise of science haw even led to claims that intuitive knowledge is not

really knowledge at all. However, recognition of the difficulties inherent in transferring knowledge from one person to another haw tended to highlight the importance of tacit knowledge, notably in the writings of Polanyi (The Tacit Dimension, 1966) and Nonaka and Takeuchi (1995). In the East, the tradition has been to celebrate the importance of the intuitive, in comparison with the rational. The Upanishads, for instance, speak about and a lower knowledge, and associate lower knowledge with the various sciences. Chinese philosophy has emphasized the complementary nature of the intuitive and the rational and has represented them by the archetypal pair yin and yang.

Similar debates about the meaning of knowledge have continued for thousands of years, and seem likely to continue for some time to come. A definition that is suitable for our purposes is the one given by Davenport and Prusak (1998), who define knowledge as: a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowledge. In organisations, it often becomes embedded not only in documents or repositories but also in organizational routines, processes, practices, and norms". This definition highlights two important types of knowledge: explicit knowledge and tacit knowledge (see also Nonaka and Takeuchi, 1995). Tacit knowledge refers to that knowledge. Tacit knowledge includes insights, hunches, intuition and skills that are highly personal and hard to formalize, making them difficult to communicate or share with other. Tacit knowledge is also deeply rooted in an individual's commitments to a specific context as a craft or profession, a particular technology or product market, or the activities of a work group the team. In other words tacit knowledge is deeply ingrained into the context, i.e. the owner's view and imagination of the world, and into his or her experience, which is previously acquired knowledge.

Explicit knowledge is knowledge that has been articulated in formal language and can be easily transmitted among individuals. It can be expressed in scientific formulae, codified procedures or a variety of other forms. It consists of three components: a language, information and a carrier. The language is used to express and code knowledge. Information is coded externalized knowledge. It is potential knowledge, which is realized when information is combined with context and the experience of humans to form new tacit knowledge. The carrier is capable of incorporating coded knowledge and storing, preserving and transporting knowledge through space and time independent of its human creators. Both explicit knowledge and tacit knowledge are important for the organization. Both must be recognized as providing value to the organization. It is through the conversion of tacit to explicit knowledge and explicit to tacit knowledge in the organization that creativity and innovation are released and the potential for value creation arises. The goal, then, is to leverage both explicit knowledge and tacit knowledge and to reduce the size of the organizational knowledge gaps.

It is interesting to view a comparison of characteristics between the Industrial Society and the Knowledge Society as it is presented in table 3.

Table 3: Industrial Society vs Knowledge Society: a comparison of some characteristics.

CHARACTERISTICS	INDUSTRIAL SOCIETY	KNOWLEDGE SOCIETY
LAND	Specific dominant economic resource.	Less critical economic resource.
LABOR	Traditional factor of production.	Transformed demands of the labor market in economies throughout the world. In industrial countries, where knowledge-based industries are expanding rapidly, labor market demands are changing accordingly. Tacit knowledge replaced labor (knowledge work),
CAPITAL	Required in processing natural resources.	Codified knowledge replaced capital (equipment).
MATERIALS	Critical assets.	Strong revival of growth in demand for raw materials.
INNOVATION	Scarce.	Key element for economic growth.
CREATIVITY	Not applied.	Driving force of economic growth. Creating new products and services based on research results.
SEED MONEY	Non-existent. Based on own funds.	Seed Money Funds to finance innovative small companies.
VENTURE CAPITAL FUNDS	Non-existent.	Highlight of the knowledge economy. Closely associated with technologically innovative ventures
MARKET	Domestic markets, expanded Through wars.	Global market, expected to be regulated through international agreements.
PRODUCTS	Medium quality. Medium intellectual content.	Very high quality. Very high intellectual content.
COMPETITIVENESS	Cheap labor, natural Resources, capital etc.	High educated people, use “new knowledge” and innovations.
ROLE OF THE GOVERNMENT	Strong intervention.	More regulatory and less executive. Partner of private concerns in public domain projects.
ENVIRONMENT	Irresponsible use of the resources of the planet.	Ecological awareness. International regulations.
APPROACHES	“Mass production” culture. Isolation of specializations.	Respect toward individual rights and minorities. Pluridisciplinarity, synergy.
INFORMATION INFRASTRUCTURE	A few local TV channels, a few local newspapers etc. Limited access to telecommunications services.	Optoelectronic interactive worldwide net-works, virtually with unlimited number of channels. Easy access to global telecommunications services. Easy access to interactive global data banks services.

By undertaking a more detailed analysis in table 3, the following question arises: Can a Science and TEchnology PArk (STEPA) play any significant role in the 21st century for the sustainable development of a region, while preserving the Environment and Social and Economic infrastructures? The following two sections are trying to give a partial answer to this challenging question.

7. The Technology Transfer Problem

Today, we all accept that technology changes are the most powerful long-term influence affecting business and nations. Technological progress is a forcing concept but undoubtedly it operates on a time scale long enough to confound casual observation.

Technology progress, which originates in Universities, research centers and high tech companies of the scientific community, reaches the marketplace serving the needs of people and nations' interests via companies. As a result, there is a gap between the leading edge of technology and its applications (otherwise known as "application gap"). This gap will continue to exist as long as technology advances rapidly and as long as we have the research as the "source" of progress on one hand and industry as the "user" of technology progress on the other hand.

It is well known that, there are very significant differences in the practices and attitudes of university and industry and in order to bridge the gap between the two, considerable effort is required. Let us face it; most university professors are very much interested in scientific publications. After all, this effort is to promote them from one academic rank to the next one. Even when one is a full professor he or she is usually not interested in non-scientific publications and organizational matters.

Furthermore, university links with industry are either non-existent or very weak. On the other hand, industry, which always works to tight schedules, is ever aware of budget and quality control and usually operates within low risk parameters. Obviously there is a gap between many excellent technological results and market place, between research (the "source") and industry (the "user").They lack a joint platform. Experience has shown that most market-oriented managers lack proper understanding of new and advanced technology.

Similarly most university professors and industry researchers seem to show little understanding of market needs. Technology Transfer (TT) in the strict sense is defined as a suitable joint platform. And I said in the strict sense, because TT today means different things to different people, as we will see later on. Indeed there is a need for "incubators" of Science and Technology Parks (STPs) in which TT would effectively take place.

Today TT takes on different forms and meaning. I can think and list the following cases:

1. TT between university and / or research centers of large industries
2. TT between university and/or research centers and SMEs
3. TT between large industries and SMEs
4. TT between industrial research labs of centers of a company and the production division of the same company
5. TT through interdisciplinary University-Industry-Government Centers
6. TT between developed nations and developing or underdeveloped nations.

Over the last two decades, one of the most noteworthy trends in regional-industrial policy has been the development of programs to facilitate access to new process technologies by manufacturing firms. Such initiatives, associated with the term “manufacturing modernisation” in the United States have also been developed in the manufacturing regions of Europe.

In addition the new kind of information knowledge based society that is taking place adds new dimensions on the technology transfer process. The information-knowledge society is not just a society in which information is universally accessible, but in which information can be universally intercepted, manipulated and even used erroneously. An information-knowledge based economy signifies not simply the employment of people with the highest levels of qualifications, but also the spread of secondary and higher education; it involves the intellectualization of not only the economy but the whole society. In such a society, permanent superiority over rivals is seldom the result of access to a particularly vital factor of production. Rather, it results from the ability and opportunity to perceive the possibilities and to bring together all the resources needed to achieve them more rapidly than others. In this process, the significance of knowledge derived from research and development is essentially no different from that of capital or labor power. The various technology transfer initiatives regardless if they are undertaken in Europe, USA or Japan have been prompted by a number of considerations.

First, the advent of computerised, programmable automation beginning in the late 1970s and early 1980s was recognised as representing a paradigmatic shift in the core technology of manufacturing processes-away forma an older electromechanical regime to a new order of “mechatronics”. Early optimism about the power of such technologies to revolutionise the world of manufacturing was soon replaced by the realisation that adopting and implementing these programmable, “flexible” production methods was anything but straightforward.

Indeed, as the litany of failure and frustration began to accumulate, it became clear that the process of technology transfer developing in the private economy was not meeting the needs of many manufactures - especially, though not exclusively, small and medium-sized enterprises (SMEs). It stood to reason that such firms would benefit from some form of assistance as they attempted to master the use of such processes.

Second, when one reviewed the experiences of new technology users (and would-be users) across a range of different regions and countries, it was evident that the greatest difficulties seemed to be encountered by manufacturers in older, more nature industrial regions still dominated by earlier technological paradigms, or by manufacturers in small centers and rural locations.

Hence, a growing number of state/provincial and national jurisdictions in the United States, Europe, Canada, and other countries have recently launched modernization programs to help manufacturers upgrade their operations. Such programs have most commonly focused on assisting firms with the implementation of advanced machinery and production systems. However, in many cases these programs have been enlarged to include two other distinct but interrelated dimensions of change: (I) the adoption of a variety of forms of “workplace reorganization” and (II) the promotion of network relations (i.e. co-operation, information-sharing, longer-term relationships) between client firms and their customers, suppliers and perhaps even competitors.

Such programs are typically delivered by using one of two principal methods. In the first case, technology transfer centers, sometimes been referred to as Business Information Centers or in other cases been part of a Technology Park, are set up for the purpose of allowing potential user firms to learn about the latest process technologies, and to receive assistance in learning how to use such technologies properly. Training is frequently provided for a client firm's machinery operators. Furthermore, such demonstration centers are usually located within close proximity to a group of target client firms in a particular region.

A second common approach, modeled on the decades-old concept of "agricultural extension", uses mobile consultants who travel to the user firm's plant. These "manufacturing extension" agents are usually trained in engineering or other relevant technical and scientific disciplines, and give specific advice and assistance to help solve technology implementation problems. This approach is extensively used on medical applications where mobile doctor consultants are used for remote areas especially in less developed countries.

Another problem of Technology Transfer is that in relation to brain drain or technology imitation, not to mention "reserved engineering". To this we can add that in today's virtual world, the "brain drain" may take an almost literal form. Regardless of their location, researchers are able to participate, in real time, in research conducted anywhere in the world. The distinction between something produced domestically or abroad, between costs incurred domestically or abroad is being eroded. The same is true of the distinction between the domestic and foreign impact of conducting research in general. In this situation, what should be the objectives of national research and development systems, and on what principles should they be based in a country like Russia? And how should we create such a system? This is a very complicated and difficult problem, which does not have east answers.

8. The role of a Science and TEchnology PArk (STEPA) within Sustainable Development

Science and Technology are vital not only for the progress and the exploitation of knowledge, but also for the achievement of viable and balanced growth, stability and prosperity. The contribution of technology to economic growth and competitiveness is of no doubt, mainly because of the recognition of the importance of the innovation in an economy. Science and Technology Parks (STEPAs) are essential means for the transferring of scientific and technological knowledge from the research institutes and universities to enterprises. A STEPA is a mediator that contributes considerably to the regional growth, facilitating the creation of high technology spin-off companies and disseminating innovative technological achievements to regional SMEs. For these reasons, STEPAs all over the world are founded near Universities and Research Centres and are closely connected with them.

A Science Park is an organisation focusing at the concentration of high tech, science, or research related businesses. Science Park establishments host research-oriented SMEs and/or R&D sections of bigger enterprises. Science Parks attract such firms by providing various facilities. This appealing comes from the neighbouring research and academic organizations and the offering infrastructures. Science and/or Technology Parks accommodate enterprises that produce commercial applications of high technology, have great research and use novel approaches in the sale and technical support of products and services. Science and Technology term is based on the combination of research and the relative production and commerce.

Science Parks geographic proximity with research institutes could be viewed as "the generation of new and valuable knowledge through human intervention" to the extent that an "innovative milieu", which generates constant innovation, is created and sustained [3].It is proven that a Science Park Incubator is recognised as an effective support mechanism for new entrepreneurial firms and this recognition is based on the framework of shared facilities such as offices, administrative staff and access to university research and external grant support from Government and other sources, such as venture capital.

A STEPA is actually a complex economic and technological unit that aims at encouraging the growth and the application of high technology and innovation production. STEPAs provide services such as high tech research installations, pilot laboratories, centre of innovation, centre of technology transfer, "incubators" for new firms, innovative techniques unit, etc. Most STEPAs today focus their activity on the information technology (electronics and computers), telecommunications, biotechnology and new materials.

The general characteristics of a STEPA are:

- Promotes and facilitates the transfer of results research from Universities and Research Centres to the industry and more generally to the productive sector, increasing the economic growth.
- Facilitates the creation and the viable growth of new innovative enterprises (incubator of enterprises).
- Constitutes a body of research and growth of enterprises and new markets.
- Provides the suitable environment where the knowledge- based enterprises can develop stable collaborations with concrete centres of research and technology for reciprocal benefit.
- Functions as regional lever of development.

In the economically developed countries, a STEPA establishment creates the environment and the conditions so that the whole region grows to new different directions. In the developing economies, the expectations and the role of STEPAs are "catalyst for growth". STEPAs facilitate the establishment of new high technology companies and encourage the production of innovative products and services. Beyond the economic status of a country growth, STEPAs contribute effectively to the concretisation of functional objectives that conform with the strategies of regional policy.

The total number of Incubators for Enterprises and Science Parks in Europe are roughly 900, which create roughly 40.000 new work places per year. The period of incubation (average period hosting an innovating company) is usually 2-3 years. Greece today allocates an Incubator of enterprises per 106.000 SMEs. The corresponding number in Austria is an Incubator per 3.000 companies. The minimum initial capital for starting a company in Greece is among the lowest in the European Union (0,017% of the GNP compared to the 0, 036% of the Community average).

The Universities and the Research Institutions continuously propose and develop new technologies adopting innovative approaches. Even though a huge experience is accumulated and acquired, technological and innovative value remains property, usually unexploited, by the researchers that worked in the particular programs. Moreover, there is not exist particular providence how the knowledge and all the innovative results will be disseminated to the enterprises. The problem of the diffusion of research and technological results is more difficult than their usage for production.

In this direction, the role of STEPAs is essential. Their mission is mainly to bridge the gap between academic society (Universities, Research Centres etc) and the Industry. In other words, the main role of STEPAs is their activation as "lighthouses of knowledge" for the diffusion of innovation and technology, so as the industry can use directly part of the enormous available scientific of knowledge. Thus, they contribute effectively to the fast transformation of innovative results of research and technological development in successful enterprising undertakings.

The idea that scientists might join together in an "organization" to study the nature of matter and extract its secrets for the benefit of the society has its origins on the early 17th century. With the second scientific revolution, towards the end of the 19th century, the figure of the lone scientist, capable of achieving important advances in research development by means of intuitions and discoveries, which were the results of individual investigations, was gradually replaced by structures in which a great number of researchers collaborated and towards which vast financial resources flowed. Today, it is universally acknowledged that the scientific and the closely related social and economic progress depend less and less upon the individual genius and increasingly upon the technological and organizational conditions of complex systems.

It is in this perspective that "Science Parks" of a multi-disciplinary character and multi-functional organization, where high intensities of cultural exchanges and the aiming of research towards applied ends are achieved, are assuming an ever greater importance. Historically, the phenomenon of "Science Parks" appeared for first after the Second World War, in the early 1950's, especially those related to universities and research institutes. The need to foster entrepreneurial development by creating a special environment for innovation to occur and to optimize the value of land assets, while taking advantage of research results was, little by little, gaining momentum. A clear role for a Science Park is to act as a gateway for such information ensuring that the information is channeled from a wide variety of national and international sources to the individual companies and Science Park. This reinforces the importance of a Science Park as a network medium.

"why do people go there? Because there is a lot happening there"

The role of Science and Technology Parks (STEPAs) as 'seedbeds' of innovation has been examined by Daniel Felsenstein (1994). The evidence related to the limited interaction effects between science park firms on the one hand and their neighboring park firms, local universities and off-park firms on the other suggests that science parks might be functioning as 'enclaves' of innovation rather than seedbeds. However, the STEPAs and university industry interaction is based on the geographical proximity between the agents as driving forces (Vedovello, 1997). The analysis of the links between industry and university and the expectation that science parks will strengthen their linkages is presented through a case study of a single British Science Park. A wide range of potential links in three broad categories concerned with (i) informal links, (ii) human resources links and (iii) formal links'.

The assisted technology transfer to SMEs (Penco, 2001) is examined by a project of Assisted Technology Transfer (ATT) sponsored by the Science Park of Liguria and addressed to 30 small firms in the sectors of plant engineering and industrial automation. After reviewing the rationale for ATT actions and highlighting some crucial questions related to its implementation, an extensive picture of the approach emerges. Examination of Science Parks in a peripheral European country, Greece, is performed by Bakouros *et al.* (2002). The findings indicate that the picture of the three science parks of Greece is not the same in terms of the links between university and industry. Informal links have been developed between the firms and the local university, however, only the firms located at one STEPA have developed formal links, while the formal links of the companies of the other two parks are at the infant level at this time. The determinants for Science Parks as entrepreneurial milieus and policy in growing firms are examined by Lofsten et Lindelof (2003). The analysis is focused on new technology-based firms on and off Science Parks (273 firms) in Sweden during 1996–1998 in an effort to identify any element of added value which the park provides for the new technology-based firms (NTBFs).

The promotion of innovation activity in Russia through the creation of STEPAs is depicted in the case of St. Petersburg for the years 1992- 1998 (Kihlgren, 2003). STEPAs in St. Petersburg have been rather successful in securing financing for their tenants, but deficient in providing management assistance. In addition, the transfer of technology to industry has been weak due to the limited demand for high-tech products. Science and Technology Parks as a tool to foster and transfer technology have been examined with the case of Tecnoalcala (Perez and de La Chica, 2007). Different definitions of STEPAs, the two models of STEPAs (American and European) and the value the companies attribute to the STEPAs have been examined. In addition, the role of universities in the innovation process, in the technology transfer and in the way Universities must interact with STEPAs have been analyzed. Finally, the case of Tecnoalcala and its Innovation Promotion Plan, which is planned to act as a bridge between industries and academy worlds, is presented.

The way STEPAs should be shaped so as to become key agents in their innovation systems has been examined by Llach et al (2007). The results of the analysis of four STEPAs are presented: the Technological Park of Heidelberg (Germany), the AREA Science Park (Trieste, Italy), The Manchester Science Park (England) and the Science Park of Barcelona (Spain). The objective of the paper is to study the characteristics and find the differences of the parks. The future planning of STEPAs concerns with the less and less importance to physical space and more emphasis on the synergies and the diversity of centers in the Park. Finally, the way to build a positive environment for creativity in a specialized science park has been presented by Conicella et al, (2007). The Bio-industry Park del Canavese, which has coupled two innovative initiatives (Discovery and Kite) is examined. Discovery is a program of identification, selection and support for start-up companies supported by Eporgen Venture, an innovative private seed capital working in strict cooperation with a science park. KITE initiative, instead has the role to promote a cultural and multidisciplinary debate inside the park through creative performance, meetings and concertos so as to stimulate creativity and in order to transform the working place in a favorable place to live, produce and exchange ideas. Therefore, the role of STEPAs is not only to support economic growth, but to create and support the growth of a socio-economic-cultural environment that can enable the growth of new economic and cultural ideas.

9. Conclusions

This paper presented a new concept in modeling economic developments for complex dynamic innovation systems. These systems are based on the triplex of the “Knowledge Triangle” that includes Education + Research – Innovation + Entrepreneurship. A new geometric approach was developed using as a base the education on an equilateral triangle to maximise its area. Introducing a new Excellence Performance Indicator and based on known geometric axioms, a number of simulation runs were performed and a number of interesting results were obtained and discussed. These results clearly show that in order to have maximum performance of a complex dynamic innovation system, the balance of the three factors of the “Knowledge Triangle” (Education, Research – Innovation and Entrepreneurship) must be formulated on an equilateral triangular fashion.

This approach is referred as the Equilateral Triangular Model Approach (ETMA) for sustainable development of a region when using complex dynamic systems. In order to find ways for better utilisation of the ETMA philosophy the characteristics of the Industrial Society were compared with the knowledge Society as has been steadily emerged on the 21st century.

In order to further analyse and explore the usefulness of the ETMA concept, more simulation studies must be performed especially by employing sets of real data. In addition, the ETMA economic model needs further theoretical development and comparison with other models, such as the *Triple Helix*, which has been proposed by VINNOVA of Sweden, the *Mobius Triangle* approach and perhaps other economic models been used by governments. It is hoped that this new mathematical approach been proposed here will initiate a fruitful dialogue as to how the dependence of many economic factors can be analysed with the help of geometry.

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