Innovation Systems in the Twenty-First Century: Toward the Mergence of "Democratic Competitiveness.

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Abstract:
The main characteristics of the recent era is the growing importance of Information and Technology of Communication (ITC) which invades various aspect of life. Yet, according to Schwab (2015) a new industrial revolution is to be born in the near future, as a result of ITC pressure. This is true once we take in consideration that IT are changing the way supply and demand interact each other to generate new products. Their interaction creates what is known as the Quadruple Helix of innovation, in which not only supply side are called to produce, demand side are welcomed in the conception of new products. As a result competitiveness is said to be democratic.

This paper shows that through the development of the innovation systems, since the nineties, there is a tendency to create competitive advantages, which receive the approval of various actors and lead to the emergence of "*Democratic Competitiveness*".

Keywords: Innovation System, Quadruple Helix,

ملخص:

يتميز القرن الواحد والعشرون بكونه ألفية غزوتكنولوجيات الإعلام والإتصال. فبحسب شواب يتجه العالم نحو ثورة صناعية جديدة كنتيجة لتنامي دور التكنولوجيات الإعلام والإتصال. ولعل هذا صحيح نظرا لكون هذه التكنولوجيات تتجه لتغيير الطريقة التي يؤثر بها كل من العرض والطلب في خلق منتوجات جديدة. إذ أن هذا التأثير، الناتج أصلا من إلتقاء صيغة جديدة من الطلبات والعروض، يسهم في خلق ما يعرف بالمروحة الرباعية حيث تعطى أهمية بالغة للمجتمع المدني في تحديد المنتوج. ومن هنا يصبح مفهوم التنافسية مغاير لما هو شائع حاليا. فهو يأخذ نوع من الديمقراطية في تكوينه.

ولعل موضوع هذا المقال هو توضيح هذا المفهوم، **التنافسية الديمقراطية**، والذي يأخذ جذوره وتطوره مع ظهور وتطور أنظمة الإبداع منذ تسعينيات القرن الماضي، والتي كان لها الأثر البالغ في إعادة صياغة مفهوم التنافسية، لتستقر في الآونة الأخيرة إلى ما نطلق عليه تسمية "**التنافسية الديمقراطية**".

i- National Innovation Systems:

It seems that political and economic events go hand to hand. While Cold war attenuated during 1990, new economic thought based on original hypothesises grew in parallel. The collapse of Soviet Union brought a similar move in standard economic growth models and neoclassical models precisely. As the same as Soviet Union failed to generate growth to almost all socialist followers, neoclassical growth models failed to explain miraculous advancement that has been enjoyingSouth East Asian Economies during 1980s and 1990s.

For many specialists, the shortcuts reside in the simplistic and unrealistic assumptions of the model and the ignorance of the dynamic role of technology. Briefly, standard economic thought bases its analysis on the perfect behavioural power of the market. The underlying idea is that rationality that enjoys the representative agent leads to market equilibrium. However, agent rationality is constrained by resources scarcity and utility maximisation, rendering his choices an optimal position.

Unfortunately, less intuitive explanations result when introducing technological change in the model. This limitation in explaining economic growth was at the origin of new stream, which tackle the problem of technology and innovation dynamism within the model.

Under this thought, economic growth can be explained by an evolutionary process within which actors behave to draw a best fitted policy by the mean of learning and discovery. These set of ideas are well known in literature as "evolutionary economics". One way to define evolutionary economics is that itrefers to "a set of theories…[that] pay particular attention to the role of technology and institutions in the process of economic growth"(Verspagen 2001). AsDosi and Nelson(1994) highlighted the optimal behaviour of agent results from learning process that guide the whole economy which finish up by the presence of temporary and highly suboptimal adaptation. That is to say, rational choice's assumption omits the factors that lead agents to behave as such rendering the prediction of behaviours impossible task. Further active agents in the economy include not only firms, but institutions, universities, organisations (governmental and non-governmental) media and society. This variety of actors, combined with the above definition, gives rise to collaborative and network activities within which interaction, cooperation and partnership shape economic growth.

In parallel, the rise of evolutionary approach in economics brought new themes of study; most important one since 1990 is the National Innovation System (NIS henceforth). A simple search on the internet figures out a huge number of studies (3050000 entities[1], including books, articles and reports), by different sectors (Governmental and international institutions).That is to say, NIS overpasses its use as a concept to become a tool for testing economic performance in developed and developing world as well. What make NIS popularity is certainly its fluidity as model and instrument for studying difference between countries in term of productive and learning system that reflects the absorptive capacity and the learning capability of individual and organisation involved in innovation process (Teixeira 2014).

The diagnostic of the existing original definitions highlight such importance; in effect founding fathers of the term all argue about the importance of institutions and their interactions. For Freeman the NIS is "*the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies"* (Freeman 1995), while Lundvall look at NIS as "*the elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge ... and are either located within or rooted inside the borders of a nation state"*(Lundvall 1992); Nelsonon the other hand define NIS as "*a set of institutions whose interactions determine the innovative performance ... of national firms" (*Nelson 1993*).*For others, NIS isa *"set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artefacts which define new technologies*" (Metcalfe, S. 1995as cited by(Niosi 2002).According to these definitions, innovation is the matter of institutions. Their mode and their timing of interaction shape the systematic environment of the emergence, development, dissemination and transfer of new knowledge. Therefore, our initial definition of the term refers to the "***set of distinct institutions and elements, in the public and private sectors, whoseinteractions in form of network determine the innovative performance, in terms of initiation, development, usage and diffusion of new knowledge and technologies within the borders of national firms***".

Yet, some critics can be made. First: the epoch at which the concept emerged; indeed studies on NIS launched earlier in 1980s by the contribution of Freeman (Sharif 2006, Freeman 2004) then his printed work on Japan in 1987. It was followed by pioneering works of B.A. Lundvall (1992), R. Nelson(1993)and C. Edquist (1997) (Lundvall 2007). However, this era characterized by the victory of American mode of economic

[1]Result are as in 30-12-2014 at 16:22 using Google scholar engine.

thought. Liberalism jointly with the spread of multinational firms areconsidered as the engine for economic leadership; on the other hand, the diffusion of silicon valley model in the United Statesannounce the beginning of new era, that of chipset and digital technologies. Another characteristic is the emergence of new powerful economies on the scene, ***China and India grew remarkably in ITC sectors, making more pressure on governments*** to sustain their local firms by setting up policies for collaboration and partnership amongst prominent parties. The need for identifying the system that wraps the unprecedented jumpbetween industries, authorities grew consequently. Secondfor the geographical location,a recent study by Teixeira(2014) shows thatspecialized journal, articles published and the most cited authors by the NIS literature belong to developed economies (USA and Europe especially) rendering thus the previous definitions partially relative. The third critic consists of author's background. For Sharif(2006) there are controversies among practitioners about the academic or policy-making origin of the term. Prominent leaders of NIS work at university, public and supranational institutions or both. This is why we believe that the articulation and the way the NIS is defined reflect author's affiliation. In addition, no clear decision about author's first use of the term is done. Sharif(2006) concludes that NIS concept arose simultaneously in both field at the same time.

Yet, the ongoing use of the term, possibly, will create some confusion in recent time. The reasons is that these definitions consider developed economies as referring point (second criticism), while a projection attempt on developing economies may not match fully given the lack of clarity surrounding the system itself and its prominent components; this is due to the type and quality of rules in these areas.In our best knowledge, there are several studies which treat conveniences and efficiencies of the concept in developing world. Even results diverge from one study (or countries) to another, the evidence is that they use the same definition, while it is essential to updating them vis-à-vis time and location. Further, new thoughts emerged while others expandsince 1990s (first criticism); the globalization, which becomes a fact rather than aconcept, has changed the ways of looking at and thinking of things.It was immediately accompanied with new concepts. The term «Governance», which is an economic synonym of "democracy, much more political concept" appears recurrently in non-governmental world institutions like OCED, WB, and WEF to designate the conduct of micro and macro policy of institutions at local, national or regional level. As such, governance measures the quality of democracy in a given economy in the sense that it quantifies some basic requirement (the WB measures the governance by referring to 6 major criteria, while WEF

uses 12 pillars). Both institutions classify developing world at the back (neck) of the list.
It results that an updating process of the term should be done to encompass these novelties. With regards to the up cited critics NIS, we believe, consists of ***naturally, heterogeneous and*** **formal representative** ***active actors who*** **interact** ***mutually*** **to develop national innovative capacity, namely** ***in the creation, dissemination and use of know knowledge within a limited field or boundaries.*** This definition is well suited to designate both parties. In developed world where governance and democracy are highly respected, a network of altruistic interactions appear among society to get a maximum gain. On the other hand, violating democratic standards and governance requirements freezes the spread of interactions, which in turn squeezes the implementation of networks in developing world.
Beside this discussion,looking at the previous definitions opens new windows for analysis. Reporting the word “national” renders the NIS concept less intuitive. A flexible use of the term "national" gives birth to two levels of analysis: the macro level, which refers to purely political meaning of boarders; and the micro level for referring to the type of systems.
Focusing on the macro level, innovation system can refers to local, regional, national or global meaning. The Local innovation system, the smallest system, denotesthe concentration of firms and related non-market organizations that connect to generate new products in localized area. In that sense, it constitutes the backbone of industrial clusters. Regional innovation system, which refers to a meso-level of analysis, consists of a ‘*constellation of industrial clusters surrounded by innovation supporting organizations*’(Asheim and Coenen 2005)[2]. The emergence of the term was developed to respond to the success of certain regions in developed world, especially the model of Silicon Valley in USA (Lundvall 2009, 142-143). However, we believe that the term conveys for countries with federal system ruling like Germany, Canada, Malaysia and India (in some extent, we can include France). The global view of the system consists of harmonizing national innovation policies toward a global trend, generally under the framework of world institutions, OCED for instance.
The micro analysis level of innovation system gathers some intuitive concepts. The most reputed concept refer the sectoral innovation system.

[2]For further understanding, the reader is invited to consult:
- Cooke P 1992. *Regional Innovation Systems: Competitive Regulation in the New Europe***.**
- Cooke P 1998. *Regional systems of innovation: an evolutionary perspective.*

Malebra (2002) defines the concept as a set of agents carrying out market and non-market interactions for the creation, production and sale of new and established products for specific uses.To insure its vitality, heterogeneous interveners, with deferent background learning, interact through variety ways in market and non-market relations for a specific sector. A suitable example is the Agricultural innovation System. Under this concept, agricultural sector is seen as a network of multitude interactions from various actors whose main objective is to bring novel and useful technologies that affect positively the agricultural production(World 2012, Kingiri 2013,Temel, Janssen, and Karimov 2002). In a similar view, technological innovation system is regarded as a sector (a micro oriented variety of Sectoral Innovation System, if we use the proper words of Suurs(2009, p38) since it refers to a network of interactions from active agents; these cooperation is reflected by the generation, diffusion and the use of a specific technology(Carlsson and Stankiewicz 1991).A nanotechnology is a typical example. Developing a nanotechnology is not devoted to a specific sector; rather it is introduced in numerous key industries.

National Innovation System is thus, regardless boundaries and level of analysis, acombination of institutions and organizations with the aim of promoting innovation capacity. However, a primordial role in all these efforts is preserved to firms. Either in local, regional, national, sectoral or in technological conception, the system keeps its vitalityfor the simple raisonthat firm is conceived of as a *processor of knowledge*, as a *locus* of setting-up, construction, selection, usage, and development of knowledge; and all other components of the system support it. Feinson(2003)states that public and academic efforts support but never replace firms efforts in term of technology, while Peters(2006) relates thefunctioning of the overall system by the firm which determines its efficiency. Others insist on the leading role of firms in term of size, numbers and activity(Niosi et al. 1992).This view is warmly infected by the surrounding events of last 1980s and early 1990s when firms constitute the source of growth.

Later in the mid of nineties, a new stream of interest, complementary rather than rivalry, described the shift in academia and higher education philosophy. The central idea is that knowledge within academia followsnew trend that is different from conventional one in prominent characteristics. The following point address the shift in the mode of knowledge production.

ii- ‘Mode2’ of Knowledge Production:

The immediate perception is the existence of ‘mode1’. Also known as ‘*basic research*’, ‘mode1’ knowledge production refers to the disconnection of research from real life concerns.University, as an ‘*Ivory Tower*’(Bok and Bok 2009), produces knowledge in accordance to pre-defined rules which are strictly followed and revised by a cognitive community;the generated knowledge is strictly mono-discipline and responds to disciplinary interests. Hence knowledge with its generative researches never leave university (only accessed by highly trained academic staff). In addition, the application of research’s findings will be approved latter by other scientists of the same filed.

Yet, it has been recognised a transformation in the way knowledge is produced. The changing environment of research process can be summarised, according to Nowotny, Scott and Gibbons(2003), to three elements:

- *The Determining of research Goals*:

Many programs have been elaborated at systemic, national and supranational level to responding to specific social and economic needs; generally to meet political agenda and developing future research capacity (here, different sectors and ministries engage in such activities).

- *Engaged Research*:

By combining the effect of public funding cut and the benefit of exploiting intellectual property, knowledge thus is not regarded as public good and will never be acquired freely. This pushes research toward society agenda and inquiries.

- *The accountability of Knowledge*:

This element follows the previous in the way that only effective and highly qualified research is commercialised.Managing research become a priority in developed and developing world both, for the sake of assessing research programs through publishing taxonomical criteria and indices.

As a result of these elements, research (simultaneously knowledge) underwent a remarkable shift in term of studied problems, its quality and its definition (it does not regarded as public good). In an original work, Gibbons et al(1994)published a book whose core idea is to explain this transformation. The novelty is the introduction of ‘Mode 2’ term, which is based on interactiveness and distributiveness. In effect, ‘Mode 2’ differs in some attributes.

- The First attribute is theincreasing aware that science does not take problem from nature then produces its application, in the sense that science itself seeks to retreat in the Ivory Tower; rather, it intertwines with society, economic and politics. That is to say,knowledge is only generated provided the inclusion of actors' interest; this means that problems are formulated earlier while communicating and dialoguing with different actors. The research activity will not take place until the group (the actors) defines the problem specificities (context) and how it will be solved (application). In that sense, the context of application frames the total atmosphere in which problem-solving is defined; and further covers a broader range of considerations, which go beyond market's aspirations to include industrial, political and societal interest. Simply stated, knowledge in 'Mode 2' is socially distributed as its diffusion takes place during its generation, and is highly interactive as the problem-solving includes large set of considerations. So the first attribute concerns *'the context of application*'.

- The second attribute is '*transdisciplinarity*': in contrast to multi-disciplinarity, which necessitatesa pre-existing disciplines and regenerates new disciplines, transdisciplinarity refers to the recruitment of a '*range of theoretical perspectives and practical methodologies*'(Hessels and Van Lente 2008) to shape the group assent. Hence, heterogeneous skills and expertise, as well as the genius to manage theoretical and practical methodologies, condition the potential solution. As we can see, knowledge is not registered in articles, but researcher and research teams contributes vividly to its production (in form of expertise they bring). This knowledge is said to be 'Tacit' that needs no theoretical aspects, i.e. embedded in the minds of individual researchers who work on the problem. Further,Gibbons et al(1994) depicts four specificities of trans-disciplinary knowledge:
  - *It is distinct and evolving*: its governing framework is not based on previous knowledge of a specific discipline, though elements of knowledge exist; this is why it is distinct. It is evolving because it is not developed then applied after. Once a consensus on theoretical aspect is attained, it will be difficult to refer it to a specific discipline: it will be trans-disciplinary.
  - *It is a contribution to knowledge*: while no dominant discipline lead the project, knowledge under transdisciplinarity distinguishes its theory, method and mode of solving.
  - *Its diffusing is instantaneous*: diffusion of results are communicated with participants at the time of their conclusion. The context of application in which the knowledge is produced reduces, even deny, the conventional channels of communicating

results. This make transdisciplinarity a highly mobile knowledge or ‘Tacit’.

- *It is dynamic*: in the sense that the solution attained (and the knowledge produced) can became a starting point of further development, or knowledge formulation. The solution itself (which is definitively confirmed and need no further validation) became a new problem in a different context of application.

- As a consequence of what preceded, it result that there is a great diversity of entities and types of knowledge; his is labelled “Heterogeneity *and Organisational diversity*’: the third characteristic. University constitutes a fragment part of potential entities where knowledge, science and innovation is produced; non-academic organisation gain place in that market such as governmental agencies, industrial laboratories, consultancies, resulting in an interaction of different skills and competences linked by means of formal and informal channels of communication. Therefore, a dynamic hybrid network is established within which a recombination of fields and areas leads to creating new forms of knowledge. Accordingly, organisational types change and vary in accordance to attacked problem and yield to a flexible team formation. Researchers can meet to tackle a specific problem, in a specific context of application, which disappear when solving the question (or redefines it), then work on different issue with totally different context of application. Such flexibility reinforce and contribute to creating highly valued competence (this competence will be transformed to different context of application in researchers join different groups under different organisational types: (inter/multi) national organisations, (non) governmental institutions…)

    - Another attribute of ‘Mode 2’ is the increasing responsibility of scientists about what they create, on one side, and awareness of the overall society of what is produced. A sort of dialogue process, a conversation between science and society governs the creation of knowledge from the start. To be clear, there is a sensitivity for the impact of the final solution on society, in the sense that the solution has to incorporates public interests. This is due to the context of application in which the problem is defined according to actors’ backgrounds. Scientists, hand to hand with lawyers, businessmen andengineers each contribute to forming final problem and then finding suitable solutions. Society as whole is considered when creating knowledge, and no group is regarded as outside the system. The forth attribute deals with ‘*accountability and reflexivity of science*’.

- Finally, a fifth attribute has been observed: '*Quality Control*'. Quality control concerns the peer-reviewers. Because the knowledge is defined and created in the context of application and includes overall society, reviews do not restricted to academia (and has to follows strictly codified criteria, predefined by the discipline, rather in encompasses broader range of political, societal, cultural and economic criteria; and good science cannot be measured by academic excellence, but judgements include the contribution to as well as the efficiency and usefulness of the overall solution. Differently stated, quality in traditional science is controlled by the importance of individual contribution to the advancement of the discipline, generallythrough judgments made by professionals and pioneers in their domain. Under 'Mode 2' controlling quality requires the inclusion of wider range of criteria which were considered to be outside scientific and technical system.

It is clear that knowledge production under "Mode 2" is merely dynamic. While the solution is on progress, testing results are communicated instantaneously and may lead to the formation of a new problem, and so on. A fertilisedsystem of knowledge generation, in the form of a complex matrix, appears. This system differs from NIS especially in the leading roles. Whilst firms conduct the system and possess the supremacy to innovate, "Mode 2" distributes this role between participants and even with the whole society. The context in which the problem is designed innovates and controls the quality of solutions. Herein each participant takes part to the solution and its efforts are less useful outside the system.
During the last twenty years, "Mode 2" thesis has received an enormous interest. Many studies are conducted to testify and/or validate its claim; however tow studies contain the question. Findings of a bibliometric study conducted by Martin(2011)witness a growing elements of interdisciplinarity as well as a significant shift of bibliometric researchconducted in the context of application; also there are evidences of heterogeneous institutions. However, literature review, in a study by Hessels and Van Lente(2008), reports a list of critics classified into three categories, generally addressing the lack of evidence to endorse "Mode 2" attributes namely transdisciplinarity, quality control and reflexivity.
Indeed, "Mode 2" thesis is one of many studies which tried to theorise the shift in the way knowledge, science and innovation are produced. Most of them appeared simultaneously with "mode 2". Their impact on research arena vary remarkably; though, only one receives a growing importance since its conceptualisation in 1997.

A clear image of what 'Mode 2' knowledge production is actively talking about was cleverly explained by *Etzcowitz* and *Leydesdorff*when formulating the 'Triple Helix' concept. Even these authors consider it as different from "Mode 2", there is no evidences to validate their claim; however, many facts document that the rapprochement between university and industry is not casual, but it is built upon a mutual interest thus any research agenda (defining research problem) must fit with the context of application.Another point is the institutional independency of actors: each partner belongs to completely independent environment in terms of mission and objectives; accordingly, heterogeneity constitutes an element of the Triple Helix concept. Further 'Mode 2'encompasses it in the sense that a wider range of actors participates in the knowledge production, the Triple Helix bases on three strands.

iii- The Triple Helix Model:

The Triple Helix approach, as other innovation models, represents a new stage of capitalism evolution; the model exposes the transition from the industrial economy toward the knowledge-based economy, in which entrepreneurial activities in terms of innovation uncommonly grew to foster competitiveness and economic development. It can also be seen as a doctrine that argues a prominent role of government in economic activities. Though it differs in that it stresses the historical continuity of collaboration among university, industry and government. From this point, one can define the Triple Helix as dynamic development, represented as a spiral model of innovation, which is based upon the range of agreements and partnership network amongst university, industry, government and leads to more institutional flexibility and emergence of hybrid organisations.It is, according to Etzkowitz(2010)'a platform for institutional formation, the creation of new organisational formats to promote innovation'. This is why greater emphasis is placed on interactions, linkages and collaborations that appear and develop between the three strands. There, three basic elements can be highlighted:

- A prominent role of the university in innovation;
- A movement towards collaborative relationship, where innovation policy is an outcome rather than a prescription from the government or industry;
- Each strand can fulfil the role of others, in addition to its traditional function.

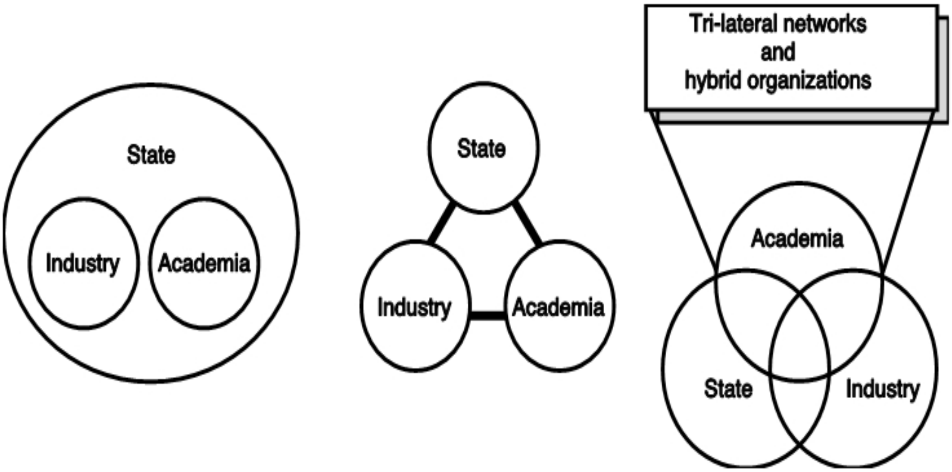
Yet before dealing with these points, it is necessary to have a look at the historical development of the Triple Helix system.

According to Etzkowitz(2003) the final format of the Triple helix model is the outcome of two previous ones, which he labelled 'statist' and 'laissez-faire'(Triple Helix I and Triple Helix II as in Etzkowitz and Leydesdorff(2000).

- ***The Statist model***: under this configuration, the government takes the leading role in developing projects and providing resources; the government encompasses the industry and the university, which are considered as being subordinate entities or state-owned organisations.The Soviet Union in the past and most of Arab countries are typical examples of government dominating all initiatives (left side of the figure 1). Industry and university only receive support and guidance from the government which provides planning and exercises controlling and management activities, aimed at encouraging innovations (Razak, and Saad.*The challenges arising in the evolution of the triple helix institutional system.*In (Saad and Zawdie 2011), pp. 191-206).the type of organisation is basically hierarchic and centralised with the industry as national champion and university as teaching institutions; the government thus, determines which industry should be adopted and sustained while university has to provides necessary trained workforce. Also, the government organises technology projects and raises the level of research at universities to support national (regional) development. This trend can be observed in countries whose objective is to develop technological industry separately from what is happeningoutside[3](Etzkowitz 2010), though research tends to be removed from industry needs and universities provide trained persons to work in the other sectors; it researches have negligible role in the creation of wealth, then it lack any incentive to commercialise its research findings.

[3]Accordingly, most of countries adopt a statist model of the triple helix when taking into account strategic industries, such as armament, aeronautic, aerospace, agricultural (wheat), mineral (oil and water in the near future) industries. The government supports the dominant companies in the domain

Figure 1: The Triple Helix Configuration
Source: (Etzkowitz 2003).



- ***The Laissez-faire model*:** under this configuration, a complete separation among institutional spheres takes place (middle sideof the figure 1).the three elements operate independently as separate institutional spheres, by acting as competitive rather than cooperative in their relation with each other; this also hold for firms that operate solely both in R&D and product development. In this model, industry is considered as driving forces and the two other as supporting structures. The role of university is limited to provide training workforce and basic research; it is also asked to supply publications and graduates. From these sources, firms select what they judge as useful knowledge. The role of government is also limited to dealing with market failure; it can buy products for its own usage or intervene as regulator. It may play a civilian role only when the market fails to provide or performs an activity. Further, laissez-faire model is characterised by individualistic mentality; individual person (and not a group) can lead to the creation of new firm and thus receives great admiration. He may be seen as a hero if his/her managerial talents lead to the success of the firm. However, indirect interaction may exists in this modelthrough an intermediary body. Its objective is to select prominent research which can be transferred to industry in form of patents. Accordingly, the laissez-faire model consider industry as a locus of production, university as a lieu of basic research and government as regulator. A strong boundaries definition determines the institutional role of each strand.

- ***The Hybrid model:*** this configuration reserves an equal importance to partners where university displaces military as leading sector (Etzkowitz 2002). A more flexible overlapping system of mutual interaction with a specific organisational structure emerges to promote innovation. Each partner tries to enhance the performance of two others (right side of the figure 1) and at the same time gains values from them; thus there is a tendency to establish a common long term strategy of well-defined goals.

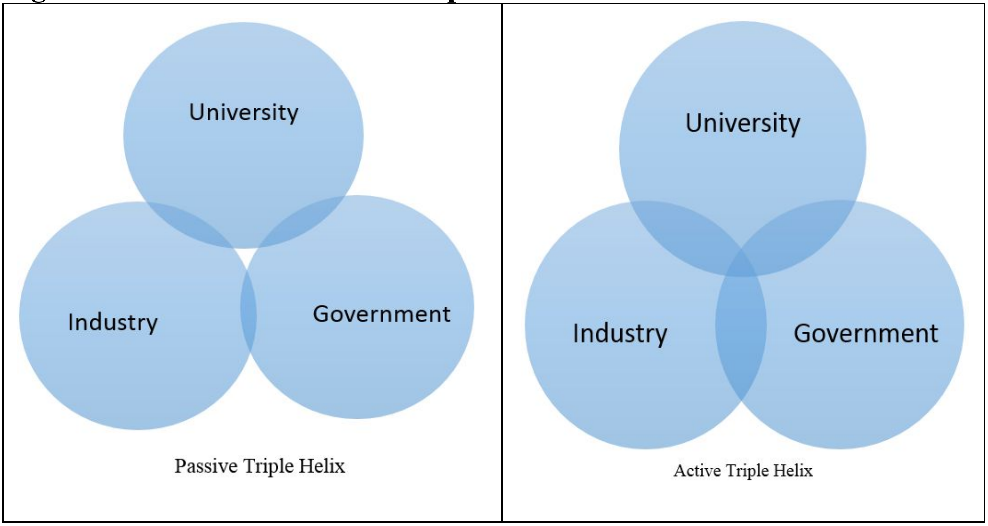
The implications of the Triple Helix in its final stage on each partner can be listed in the following points: *First*, university receives an enhanced role translated by the adoption of new rolebeyond its traditional services of teaching and research. Modern universities tend to encompass 'commercial taches' namely through the capitalisation of research findings. According to(Ragna and Etzkowitz. *Creative Reconstruction:A Triple Helix–Based InnovationStrategy in Central and EasternEurope Countries*. In (Saad and Zawdie 2011), pp 249-282) this new model which is transformed to 'an entrepreneurial activity' is the result of two revolutions: the first academic revolution led to the inclusion of research , in parallel to preserving and transmitting of knowledge. In literature this type of university is well known as 'Humboldian model' reflecting the idea of assuming teaching and research simultaneously. The second academic revolution designates the inclusion of a third mission that of economic and social development; the term of entrepreneurial university captures the idea that university commercialises the final results of its researches.

Second, each helix performs the mission of the others and takes their role. It does not mean that university become firms or act as governmental authority; rather it means that university for example develops capabilities to act as firms and firms improve their competences in providing reaching tasks. The idea is that each partner fulfil its mission and perform new tasks, generally considered as extreme to its original ones. That is, the government continues supplying rules and regulations that guarantee freedom, girths and duties of the society, while provides venture capital to help start new enterprises. Firms, the locus of production, still do offering goods and services in a competitive price and quality as their perform research activity. Yet, they conserve a great resource to offer training at higher standards and share knowledge by joint venture. The university act as industrial firm by promoting the creation of new firms and introduce the capitalisation of knowledge as an academic function.*Third*, the Triple Helix model is basically build upon the description of collaboration emerged after the breaking down boundary resistance and institutional rigidity of spheres, most involved in innovation. The principle requires the engagement of

university, industry and authorities in flourishing discussion to enhancenational (regional) economy and social well-being, throughestablishment of technology centre and development of growth agreement. In this context, the university undertakes the formation of students by providing training programs which correspond better to national (regional) needs. Firms, among them, try to find and found new supplier relationship and government (national/regional) creates stable environment. Then a network of relationship appears at the front: university-industry partnership; public-private cooperation arise. Further, bilateral interaction among university-government; university-industry and government-industry increase remarkably. These forms of collaborating are mutual and spontaneous as shall we see in chapter 2.*Fourth*, the inevitable result of university-industry-government rapprochement is the adoption of a 'hybrid structure' both as organisational and institutional. In terms of 'Mode 2' a context of applicationdetermines the framework of innovation policy by defining the problem from multiple views. The final agreement considers, implicitly, the adoption of unique structure to activate the innovation policy; this includes the organisational aspects as well institutional ones. The hybrid structure in terms of the Triple helix constitutes the ultimate goal of the model. It is located at the centre of the interaction; the hybrid organisation necessitates colossal effortsfrom the three partners. Their initial bilateral rapprochement facilitates the framing of broader arrangement to overpass boundaries and institutional bottlenecks of hybrid. Therefore, three types of hybrid structures appear; hybrid structure which relates university with industry; hybrid structure that gather university and government and hybrid structure of government-industry relation. Each partner within the structure fulfils specific considerations and responds to an agreed policy as it conserves an independent identity and boundary autonomy. In an advanced stage, the success of the hybrid organisations encourages the fusion for a unique body of triadic parties, in which innovation policy and programs even their execution, is an outcome of interaction rather than a dictation from a dominant party or an external body. The final hybrid structure or the Triple Helix organisation still conserves a core identity of parties; however less attention is devoted to boundary separation. Further, entrepreneurial activities multiple their existence and take new forms such as entrepreneurial university or entrepreneurial government.
The Triple Helix describes, thus, an evolutionary process and the implications of interaction among partners. In such environment, high process of selection constitutes a key element for the emergence and the success of the hybrid organisation. However, a crucial remark when studying the Triple Helix model should be highlighted.

The Triple Helix emerges when university, industry and government establish a reciprocal relationship with each other. Yet, this statement should be treated by caution. Indeed, establishing interaction among them does not necessary lead to the emergence of Triple helix as it is conventionally described. University, industry and government may interact closely but negatively; the figure 2 presents two types of Triple Helix.

Figure 2: Neutral and Active Triple Helix Format



Source: adapted from Hossain et al(2012)

From the lift side, a neutral form of Triple Helix is formed. The neutrality concept here designs the intensity of interaction among the three strands and which lead to the formation of bilateral connection of two separate access. The benefit from collaboration is partial andpolicy designing excludes important portions for innovation. University, for instance, elaborates mutual policy/programs with industry and government separately and generates hybrid organisations accordingly. Under this format, any effort from the partners will never lead to the emergence of trilateral connection. An active format of the Triple Helix (right side of the *figure 2*)refers to the establishment of instantaneous triadic interaction with a unique hybrid organisation at the centerof collaboration. The result is the drawing of a clear and complete image of innovation policy/programs; any further effort from any partners will change the conception of innovation policy of the two others. Further, active Triple helix will not exclude bilateral connection; a sort of take and give activities reshapes for the better the bilateral as well the triadic relationship. What can guess from these two formats is that the intensity of interaction, i.e. the willingness to cooperate, helps to pass from neutral to active Triple Helix.

Even the proposition of *Etzkowitz* and *Leydersdorff* about innovation has seeing a wider acceptance, researches on innovation systems carry to encompass new facts and enquiries both at national and global level it result new approaches and concepts, generally regarded as an extension to the Triple Helix. Introducing government to the initial relation not only helps to reorient efforts and resources toward macro goals, it brings new actors and novel concepts. This changing may regards as a result and basically related to the Globalisation phenomenon. The narrow connection of countries to each other obliges them to draw or try to align their policies to respond to global issues. Governments are in the obligation to choose and direct programs accordingly. The next pointrefers to these extensions. However, it is convenient to notice that triple helix model has received some critics and limitations[4].

First, the triplehelix model has some level of abstraction namely “actors” which are introduced without decent analysis (Cooke 2005, Tuunainen 2005). Then, the model fails to recognise the national settings that have influences on university, industry and government; this claim can be seen when analysing innovation systems among nations. Third, the model ignores people from the scene. Lastly, Tuunainen(2002) argues that the triple helix approach provides weak justifications when explaining university-industry collaboration.

What can we guess from these critics is that the process of innovation and the passage from Knowledge based economy is not limited to the collaboration of the three strand devoted by the triple helix. Yet, the model can be served as a basic for further development that can lead to emergence of the Knowledge-based society, much wider than the Knowledge economy. The extensions that the triple helix has submitted result in the adoption of a fourth helix, then the emergence of a fifth one. In what follow we addresses these two points.

[4] For a detailed understanding of these critics, readers are advised to return to the following references:

Balzat, Markus, and Horst Hanusch. 2004. "*Recent trends in the research on national innovation systems*."

Brännback, Malin, Norris Krueger Jr, Alan Carsrud, and Jenny Elfving. 2008. "*Re-visiting the “Molecular Biology” of regional innovation systems: Competing models of technology development*."

Lavén, Fredrik. 2008. *Organizing Innovation. How policies are translated into practice.*

Viale, Riccardo, and Andrea Pozzali. 2010. "*Complex adaptive systems and the evolutionary triple helix”.*

iv- Beyond the Triple Helix:

Examining the third critics reveals that the triple helix model omits people from the picture. Pillay (2005)stresses the necessity of social cohesion for both industry and societies to achieve economic and social development. That is to say that any study must include or may take into consideration civil society as a *key variable* in the conclusion of results. Further, global integration, challenges and issues that arise (firmly speaking ecological issues) exert pressures on innovation and knowledge creation.

Carayannis and Campbell (2009) stresses the necessity to add a fourth strand within the innovation system to understand the rise of the knowledge societies in the twenty first century. The new strand refers to civil society (the public) and is placed at the heart of the model. The public under the quadruple helix not only own but participate in the design of innovation process. Their quality as "innovation users" gives them the right to be involved throughout the production process. In addition, the quadruple helix model considers civil society as innovative partner and knowledge producer in line with academia, industry and government. Citizens have the power to propose solution, ideas, or new type of innovation for other strands, which are invited to support then exploit the citizen-based innovations. However, civil society opinion's is highly influenced by media and/or culture. Indeed, two passages in(Carayannis and Campbell 2009)states the following "*…media reality overlaps with political and social reality; perception of politics primarily through the media; and the laws of the media system determining political actions and strategies …*"*"…On the other hand, the public is also influenced by culture and values…"*in this regard, Ivanova(2014) stresses on the role of media and consider it as the fourth pillar. According to her the innovation activity is performed in an external space of consumers, which requires the setting of a mechanism to guarantee a stream of communication between university-industry-government and consumer, and maintain a favourable conditions for the growth of innovations among consumers. The required infrastructure is declined to design all mean of mass media. Throughout her study, Ivanova demonstrates how *huge hum* (infrastructure technologies) is now shaping public awareness and consumer consciousness to the extent that the modern economy is characterised by the standardisation of production in individual consumption. Accordingly, extending the standard Triple Helix model to a Quadruple Helix must include the media and results for new interactive areas of commercial advertising, public provision of information and usage of communication by the government. Other new area on the form of Triple Helix emerged within the Quadruple Helix model, namely media-industry-government; media-industry-university and media-university-government.

Finally, a unique hybrid organisation of four strands appears at the core of the model as shown in figure *3.b*. panel a gives an introductory presentation of the Quadruple Helix model. Therefore, four circles are putted on contact with minimum interaction and unique hybrid contact at the centre. Panel '*b*' is more inclusive; the four circles are in advanced, dynamic relations with nine primary contact: six as double helices and three as triple helix) and one sophisticated relation at the core (note that many figures are presented to show the Quadruple Helix concept. All of them agree about the positive interactions of the spheres in contrast with the Triple Helix were a neutral model can exist. This result is one powerful point of the Quadruple helix model when studying innovation system with regard to producers-users aspects).

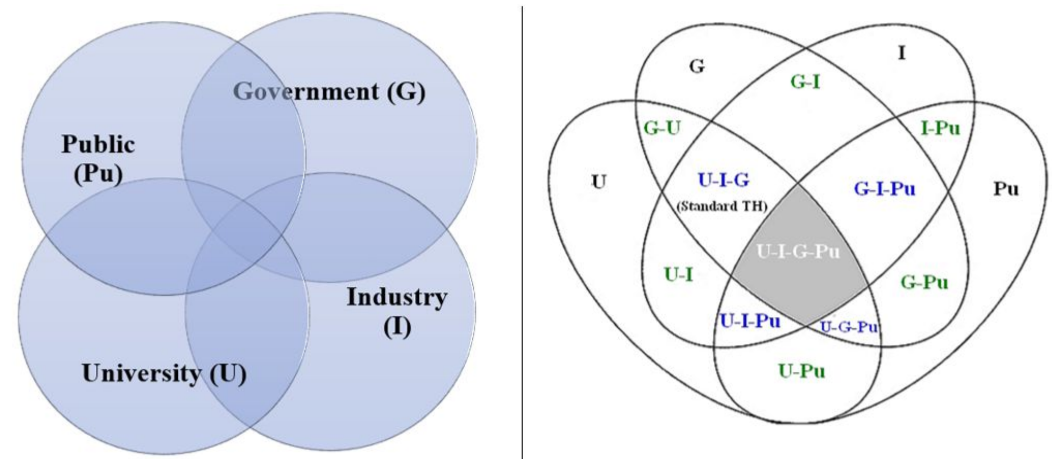
Yet, even there is a wide convention about adding a fourth helice, there is a debate about its nature. Media cannot be considered as the ultimate delegate of civil society; the voice and the influence of the public can also be channelled by thepower of Non-Governmental Organisations (NGOs)(Heng et al. 2012). These authors consider that the power of the public is well expressed when it is unified under the umbrella of NGOs whose role is to defend social objectives rather thancompleting political or economic goals. Theinfluence of NGOs came from their right to organise sanction, boycott or embargo. Further, NGOs can provide information and establish a link between other strands. Apart from these roles, NGOs, the well-established and the best reputed help firms achieving their social programs and provide information for market capitalisation.

One important point, even result, when adding civil society or the public which are formulised under "media" or "NGOs" is the introduction of the term "*Governance of Innovation*" and "*Knowledge Democracy*". Indeed, the complexity of the model that result by adding new helices makesadditional pressure about sharing and diffusing tasks or results instantaneouslyand among participants equally.Carayannis and Campbell(2009) refer to the term "Knowledge Democracy" because the innovation program or the knowledge adopted is mandated by the majority, i.e. recognising the concept of pluralism in a society and the respect of other opinion which lead to an unbiased decisions as they are ligitimated by the majority.

The complexity of the environment on which innovation is produced, renders the understanding of innovation system more ambiguous. The adoption of Global Innovation System, as a result of Globalisation stream, adds new variables to the process of innovation/knowledge creation; using *Etzkowitz and Leydesdorff*'s term, additional helices are needed to conceptualise the new interval of innovation. Indeed, one challenge that arise world consciousness is the question of climate change and ecological awareness; accordingly novel terminology emerged namely "*the Green Economy"*and*"Naturally-Friend Activities".Carayannis and Campbell* in an advanced proposal introduce environment issue as an imperative factor for innovation the same as industry, university or civil society; therefore the Quintuple Helix model contextualises the Triple Helix and embeds the Quadruple Helix by extending the architecture of innovation to the global ecology. Further, the Quintuple Helix model can be seen as a framework for trans-disciplinary analysis of sustainable development and social ecology(Carayannis, Barth, and Campbell 2012). This can bring a full analytical comprehension of how innovation is produced when social sciences, social science, humanities, politics and economics are oriented toward a unified objective of prosperity and protection. The Figure 3conceptualises the Quintuple Helix model.

Figure 3: the Quadruple Helix model of innovation

As for Quadruple helix, adding new helices generates additional



a. Standard presentation | b. Interactive presentation

Source: panel "a" adapted from (Carayannis 2013). panel "b" adapted from (Ivanova 2014)

interactions. We can see that the Triple Helix consists the platform for the Quintuple Helix. In addition to the standard Triple Helix model advanced by *Etzkowitz and Leydesdorff*, one can subtract fifth additional trilateral interactions which are: U-I-E; U-G-E; U-P-E; I-G-E and G-P-E. In each of them environmental issues constitute the core of discussions and programs. For instance any rapprochement between university and industrial sector should consider climate change as departure point for researches; this is because environment prevention became an important asset for corporations and a key variable of academic researches. Hence any scientific advancement must be in favour of environment. Further the concept of competitiveness may see a drastic deviation to designate *environmental competitiveness* where an economy is considered as competitive if its activities are harmless vis-à-vis the environment. Therefore, Government will favour those industries and researches which fit better to the environmental criterion.

On the other hand, the Quintuple Helix model facilitates the emergence of new interactions in form of Quadruple Helix; this refers, in addition to the model advanced by *Carayannis and Campbell*, to U-I-G-E; U-G-P-E; U-I-P-E and I-G-P-E. The multiplication of such four length interactions lead us to invent a new term, that of "***Democracy of Competitiveness***".

The competitiveness within economic thought has been used to designate the product side; that is to say that a firm, a sector, an industry or even a country is competitive if its production costs are relatively or absolutely less than its rivals. However, with the coming of the Quadruple helix view of the twenty-first century and the rise of environmental issue advanced by the Quintuple helix, the production process does not concern firms only; civil society can participate vividly in the setting of productcharacteristics which reflect their preferencesand thus, the product contains user side since its elaboration. This cooperation between producer-user sides at the earlier stage of production, under the framework of government and enforcement of research institutions, willorient efforts to reduce costs and create advantage in selected industries. We notice that the selection represents both participation and acceptance of all actors and includes both side of production in contrast to the traditional view; therefore, the competitiveness is rather "*democratic*".

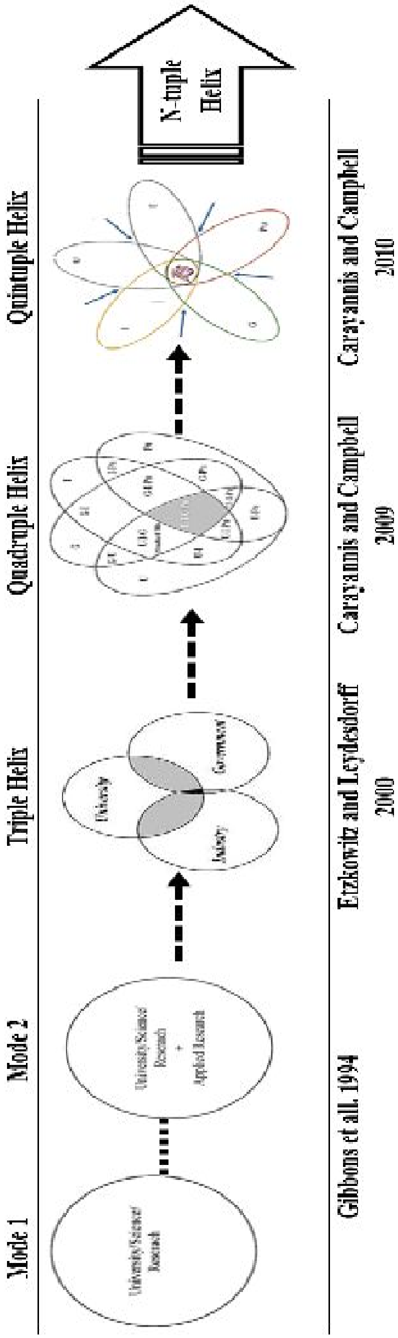
The democracy of competitiveness is well presented in the Quintuple Helix; the rise of green economy and naturally friend products reflects the influence and the weight of "*the public*"-represented as NGOs and Media-in the selection of actions, products and innovation programs that take in consideration the protection of environment. This vision is far away from the purely industrial approach of competitiveness. That is to say industries and production sectors that are designated to exports reflect the convention of different actors in an economy, including non-market performers and respond to global queries.

Referring to the figure 3, one can find numerous examples in real life where the centre presents a pumping mechanism. One example refers to cardiovascular system in human body. The circulatory system here refers to the flow and the transport of knowledge and innovation to and from organs to provide consistency, development and sustainability of the knowledge economy. Each organ (helix) provides (participates by) new ideas, creative tasks and shares new practices that are helpful and necessary for the others, the same when the hand takes a cup of water and the head open the mouth to escape dehydration then dysfunction of the entire body. Furthermore, the lieu of interaction of contributors (the heart) is so important. Its role is to accept all contributions, treat them and pumps results equally and efficiently among helices. Notice that the more helices cooperate, the greater benefit results as shown by the blue arrows.Another example can be borrowed from physics or astrology; indeed, both solar system and nucleusrelate the continuity of the whole system to the power generated by the rotational movement of its components around a centre, which guarantees the redistribution of energy to the entities.

Apart this discussion, one can question whether the environment should be presented as a separate actor, the same as the remaining four helices. This is because university, industry or civil society are either producer or user of innovation while this quality is hard to be distinguished with environment. However, climate change and otherglobal warmingare mandatory factorsto draw policies in the twenty-first century.Figure 3, bcaptures this idea. In contrast to figure 3, a, environment is not an independent strand; rather it is the result of human (societal) consciousness about his (its) continuity (sustainability) and the surrounding creatures.

The inclusion of environment provokes the integration of further helices into the model, which however, require substantial specification,operationalization and the development of relevant indicators (Leydesdorff 2013).

Figure 5 : The Innovation Systems



Source : adopted from (Carayannis 2013)

Conclusion:

The innovation system has been seeing a rapid changes. At the turning of the last century, different approaches emerged with the aim to understand and explain changes in the pattern of innovation and knowledge creation. All these changes resulted when university adopted new role with additional missions. However, five stages can be distinguished. At the beginning, and for a long period of time, the dominant model of knowledge creation consists of “Mode 1” when university transmits divine knowledge and undertakes the mission to illuminating people about religion. In an advanced stage, a Humboldian university model was born. In this station, questioning and observing phenomena constitutes the engine for knowledge advancement.Yet, the interwoven events at global level during the twentieth century contributed to the adoption of collaborative thought. The Triple Helix model on innovation, belonging to this stream consists of establishing partnership between three main blocs ofknowledge production which are university, industry and government. This view has gained acceptance of wider range of academic, practitioners and policy-makers. In addition a fourth approach of innovation system resulted to include user-side. The Triple Helix according to this view represents a half part model of innovation. This is because innovation ideas are primarilyinspired or influenced by consumer and users; accordingly adding “civil society” to the model brings further understanding to the process of knowledge creation. Finally, the rise of global warming and the green activity practices calls for the inclusion of environment as a fifth partner, thus the emergence of the Quintupleapproach of innovation system. We notice that the last two models include the concept of “Democracy”. While the Quadruple helix enforces the democracy of knowledge, the Quintuple Helix model facilitates the rise of “*the democracy of competitiveness*”. In addition, there is believe within research community about prospective extensions of the innovation model to include additional helices.

Yet, a common observation that re-appears since the conception of “Mode 2” is that knowledge production results from an established partnership between naturally different actors, both in term of goals and missions. This remarks is further complicated with Quadruple and Quintuple models. Therefore the question to be addressed is what bring these heterogeneous entities to cooperation? Furthermore, which factors facilitates their successto improve the innovation environment? These questions will be addressed in future researches.

References List

Asheim, Bjørn T, and Lars Coenen. 2005. "Knowledge bases and regional innovation systems: Comparing Nordic clusters." *Research policy* no. 34 (8):1173-1190.

Bok, Derek Curtis, and Derek Curtis Bok. 2009. *Beyond the ivory tower: Social responsibilities of the modern university*: Harvard University Press.

Carayannis, Elias G. 2013. *Encyclopedia of creativity, invention, innovation and entrepreneurship*: Springer Dordrecht.

Carayannis, Elias G, Thorsten D Barth, and David FJ Campbell. 2012. "The Quintuple Helix innovation model: global warming as a challenge and driver for innovation." *Journal of Innovation and Entrepreneurship* no. 1 (1):1-12.

Carayannis, Elias G, and David FJ Campbell. 2009. "'Mode 3'and'Quadruple Helix': toward a 21st century fractal innovation ecosystem." *International Journal of Technology Management* no. 46 (3-4):201-234.

Carlsson, Bo, and Rikard Stankiewicz. 1991. "On the nature, function and composition of technological systems." *Journal of evolutionary economics* no. 1 (2):93-118.

Cooke, Phil. 2005. "Regionally asymmetric knowledge capabilities and open innovation: Exploring 'Globalisation 2'—A new model of industry organisation." *Research policy* no. 34 (8):1128-1149.

Dosi, Giovanni, and RichardR Nelson. 1994. "An introduction to evolutionary theories in economics." *Journal of Evolutionary Economics* no. 4 (3):153-172. doi: 10.1007/BF01236366.

Etzkowitz, H., and L. Leydesdorff. 2000. "The dynamics of innovation: from National Systems and "Mode 2" to a Triple Helix of university-industry-government relations." *Research Policy* no. 29 (2):109-123. doi: Doi 10.1016/S0048-7333(99)00055-4.

Etzkowitz, Henry. 2002. *The triple helix of university-industry-government: implications for policy and evaluation*: Swedish Institute for Studies in Education and Research.

Etzkowitz, Henry. 2003. "Innovation in innovation: The triple helix of university-industry-government relations." *Social science information* no. 42 (3):293-337.

Etzkowitz, Henry. 2010. *The triple helix: university-industry-government innovation in action*: Routledge.

Feinson, Stephen. 2003. "National innovation systems overview and country cases." *Knowledge Flows and Knowledge Collectives:*

Understanding The Role of Science and Technology Policies in Development no. 1:13.

Freeman, Chris. 1995. "The 'National System of Innovation'in historical perspective." *Cambridge Journal of economics* no. 19 (1):5-24.

Freeman, Christopher. 2004. "Technological infrastructure and international competitiveness." *Industrial and Corporate Change* no. 13 (3):541-569.

Gibbons, Michael, Camille Limoges, Helga Nowotny, Simon Schwartzman, Peter Scott, and Martin Trow. 1994. *The new production of knowledge: The dynamics of science and research in contemporary societies*: Sage.

Heng, Low Hock, Nuratika Fatima Mohd Othman, Amran Md Rasli, and Muhammad Jawad Iqbal. 2012. "Fourth Pillar in the Transformation of Production Economy to Knowledge Economy." *Procedia - Social and Behavioral Sciences* no. 40 (0):530-536. doi: http://dx.doi.org/10.1016/j.sbspro.2012.03.226.

Hessels, Laurens K, and Harro Van Lente. 2008. "Re-thinking new knowledge production: A literature review and a research agenda." *Research policy* no. 37 (4):740-760.

Hossain, M. D., J. Moon, H. G. Kang, S. C. Lee, and Y. C. Choe. 2012. "Mapping the dynamics of knowledge base of innovations of R&D in Bangladesh: triple helix perspective." *Scientometrics* no. 90 (1):57-83. doi: DOI 10.1007/s11192-011-0507-6.

Ivanova, Inga. 2014. "Quadruple Helix Systems and Symmetry: a Step Towards Helix Innovation System Classification." *Journal of the Knowledge Economy* no. 5 (2):357-369.

Kingiri, Ann N. 2013. "A Review of Innovation Systems Framework as a Tool for Gendering Agricultural Innovations: Exploring Gender Learning and System Empowerment." *The Journal of Agricultural Education and Extension* no. 19 (5):521-541.

Leydesdorff, Loet. 2013. "N-Tuple of Helices." In *Encyclopedia of Creativity, Invention, Innovation and Entrepreneurship*, edited by EliasG Carayannis, 1400-1402. Springer New York.

Lundvall, Bengt-Åke. 1992. *National systems of innovation : towards a theory of innovation and interactive learning*. London: Pinter.

Lundvall, Bengt-Åke. 2009. *Handbook of innovation systems and developing countries : building domestic capabilities in a global setting*, *Elgar original reference*. Cheltenham, Glos, UK ; Northamption, MA, USA: Edward Elgar.

Lundvall, Bengt-Åke. 2007. "National innovation systems—analytical concept and development tool." *Industry and innovation* no. 14 (1):95-119.

Malerba, Franco. 2002. "Sectoral systems of innovation and production." *Research policy* no. 31 (2):247-264.

Martin, Ben R. 2011. "What can bibliometrics tell us about changes in the mode of knowledge production?" *Prometheus* no. 29 (4):455-479.

Nelson, Richard R. 1993. "National innovation systems: a comparative analysis." *University of Illinois at Urbana-Champaign's Academy for Entrepreneurial Leadership Historical Research Reference in Entrepreneurship*.

Niosi, Jorge. 2002. "National systems of innovations are “x-efficient”(and x-effective): Why some are slow learners." *Research policy* no. 31 (2):291-302.

Niosi, Jorge, Bertrand Bellon, Paolo Saviotti, and Michaël Crow. 1992. "Les systèmes nationaux d'innovation: à la recherche d'un concept utilisable." *Revue française d'économie* no. 7 (1):215-250.

Nowotny, Helga, Peter Scott, and Michael Gibbons. 2003. "Introduction:Mode 2'revisited: The new production of knowledge." *Minerva* no. 41 (3):179-194.

Peters, Stuart. 2006. *National systems of innovation : creating high-technology industries*. Basingstoke: Palgrave Macmillan.

Pillay, Hitendra. 2005. "6 Knowledge and social capital." *TEAM LinG*:80.

Saad, Mohammed, and Girma Zawdie. 2011. *Theory and practice of the triple helix system in developing countries : issues and challenges*. New York: Routledge.

Schwab, Klaus. 2015. *Are you ready for the technological revolution?* (World Economic Forum) [web article] 2015 [cited 19-02 2015]. Available from http://www.weforum.org/agenda/2015/02/are-you-ready-for-the-technological-revolution.

Sharif, N. 2006. "Emergence and development of the National Innovation Systems concept." *Research Policy* no. 35 (5):745-766. doi: DOI 10.1016/j.respol.2006.04.001.

Suurs, Roald AA. 2009. "Motors of sustainable innovation: Towards a theory on the dynamics of technological innovation systems."

Teixeira, A. A. C. 2014. "Evolution, roots and influence of the literature on National Systems of Innovation: a bibliometric account." *Cambridge Journal of Economics* no. 38 (1):181-214. doi: Doi 10.1093/Cje/Bet022.

Temel, Tugrul, W. G. Janssen, and Fuad Karimov. 2002. *The agricultural innovation system of Azerbaijan : an assessment of institutional* *linkages*, *ISNAR country report*. The Hague: ISNAR, International Service for National Agricultural Research.

Tuunainen, Juha. 2002. "A Critical Comment Based on a Case Study." *Science Studies* no. 15 (2):36-58.

Tuunainen, Juha. 2005. "Hybrid practices? Contributions to the debate on the mutation of science and university." *Higher Education* no. 50 (2):275-298.

Verspagen, B. 2001. "Economic Growth and Technological Change An Evolutionary Interpretation."

World, Bank. 2012. "Agricultural Innovation Systems: an investment sourcebook.".