QUADRUPLE INNOVATION HELIX AND SMART SPECIALIZATION KNOWLEDGE PRODUCTION AND NATIONAL COMPETITIVENESS

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Abstract

Investing more in research, innovation, and entrepreneurship is at the heart of Europe 2020 and the only way to achieve growth that will be smart, sustainable, and inclusive. Smart specialization emerges as a key element for place-based innovation policies. Through this article we present the six major steps that every nation/region should follow to establish a smart specialization strategy based on the basic principles as described in the European Union Research and Innovation Strategies for Smart Specialization (RIS3), accompanied by some examples of excellence from the Nordic countries. We explain the linkage between innovation and knowledge and between innovation productivity and competitiveness. Finally, we discuss the need to apply the Quadruple Helix approach in the context of RIS3.

Introduction

"Smart Specialization Strategy means the national or regional innovation strategies which set priorities in order to build competitive advantage by developing and matching research and innovation own strengths to business needs in order to address emerging opportunities and market developments in a coherent manner, while avoiding duplication and fragmentation of effort. A smart specialization strategy may take the form of, or be included in a national or regional research and innovation strategic policy framework"

(Regulation 1301/2013 – European Commission, 2014)

The European Union (EU) has set out its vision for Europe's social market economy in the Europe 2020 strategy that aims at confronting structural weaknesses through progress in three mutually reinforcing priorities (European Commission, 2012):

- Smart growth, based on knowledge and innovation;
- Sustainable growth, promoting a more resource efficient, greener, and competitive economy; and
- Inclusive growth, fostering a high employment economy delivering economic, social, and territorial cohesion.

Investing more in research, innovation, and entrepreneurship is at the heart of Europe 2020 and a crucial part of Europe's response to the economic crisis.

Europe contains many different countries and regions, each with its own system for development and innovation, and with a distinct economic background. Smart specialization strategy needs to differ in different regions and cannot be formulated on a national level alone. There might be significant differences between regions dedicated for international export or agriculture, for instance. Different regions have different challenges and also unique abilities (Midtkandal and Sörvik, 2012). Thus, being smart is not copying other regions' great ideas, particularly if the regions differ significantly from the home region. Essentially the idea is to develop a strategy for one's own region based on its strengths. Smart specialization strategies can be based on existing strategies, as long as those are made for the region in question and can be empirically proved to be accurate (Foray *et al*., 2012).

The main aim of this article is to explore the linkages between innovation, productivity, and competitiveness (IPC). Carayannis and Sagi (2001) emphasize that innovation and competitiveness are intrinsically unified; although one does not cause the other, both are necessary for competitiveness and for each other. We also explain the connection between knowledge creation, diffusion, and innovation flow. According to Carayannis (2001), "Mode 3" knowledge system and Quadruple Innovation Helix models could serve as the foundation for diverse smart specialization strategies as they place a stronger focus on cooperation in innovation, and in particular, the dynamically intertwined processes of co-opetition, co-evolution, and co-specialization. Smart specialization approach is helping regions to upgrade their research and innovation strategies based on a number of key principles including the implementation of multi-level governance. By applying a Quadruple Helix approach, regional policymakers are

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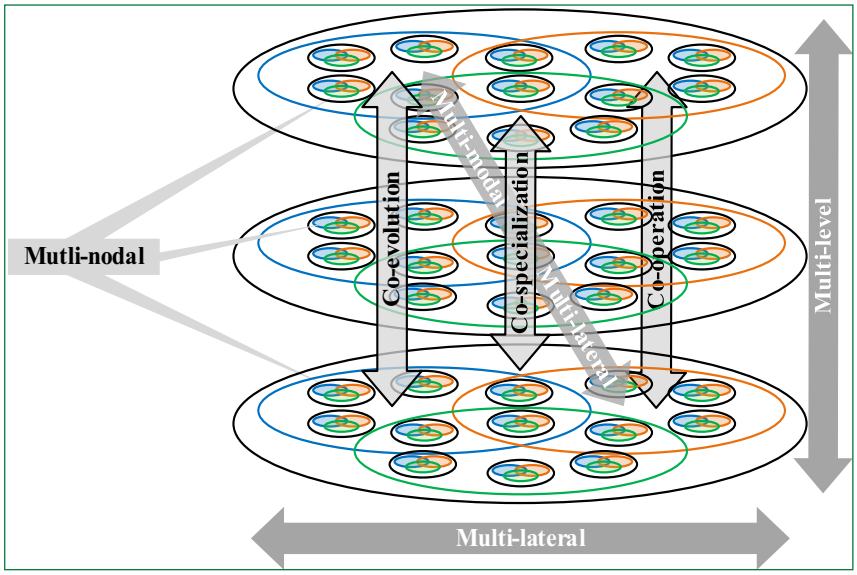


Source: Carayiannis et al. (2008)

Figure 1: Strategic knowledge, serendipity, and arbitrage: multi-modal, multi-nodal, multi-lateral, multi-level 3C's processes

more likely to enable a place-based entrepreneurial process of discovery, which would then generate intensive experimentation and discoveries enhancing at the same time innovativeness.

Mode 3 knowledge production system

The emerging *gloCalising* (globalizing-localizing) frontier of converging systems, networks, and sectors of innovation that is driven by increasingly complex, non-linear, and dynamic processes of knowledge creation, diffusion, and use, confronts us with the need to re-conceptualize, if not to re-invent, the ways and means that knowledge production, utilization, and renewal takes place in the context of the knowledge economy and society.

Perspectives from and about different parts of the world and diverse human, socio-economic, technological and cultural contexts are interwoven to produce an emerging new worldview on how specialized knowledge, which is embedded in a particular socio-technical context, can serve as the unit of reference for stocks and flows of a hybrid, public/private, tacit/codified, tangible/virtual good, which represents the building block of knowledge economy, society, and policy.

Carayannis (2001) argues that "Mode 3" model is the knowledge production system architecture that engages actively higher order learning (learning, learning to learn, learning to learn how to learn), in a multi-lateral, multi-nodal, multi-modal, and multi-layered manner involving thus entities from government, academia, industry, and civil society, as well as driving co-opetition (competition-cooperation), co-specialization, and co-evolution resource generation, allocation, and appropriation processes (*3C's*) that result in the formation of modalities such as innovation networks and knowledge clusters (Figure 1).

Organizations are open systems operating under conditions of substantial turbulence, risk, and uncertainty and seeking to balance stability and coherence with flexibility and change in pursuit of higher levels of efficacy and organizational sustainability (Carayannis *et al.*, 2014)

Firms use the "new knowledge derived through the healthy balance between competition and cooperation involving employees and business partners" in the definition of their real options. These real options serve as the basis for their decision making so as to reap the full benefits of the flexibility embedded in their investments. By the exercise of their options, firms have changed the parameters of their previously temporarily stable ecosystem, resulting in a now unstable environment. Having completed the co-opetition process, firms create "new knowledge through a series of interactions and changes at various levels of the organization, spurred by the co-generation and complementary nature of that knowledge", what Carayannis and Campbell (2009) called strategic knowledge co-evolution. Through innovation, they also undergo strategic knowledge co-specialization, "learning and knowledge which encourages individuals or groups to expand their roles into new areas and new domains, in a complementary and mutually-reinforcing fashion."

Innovation emerges from three critical firm level factors, i.e., posture, propensity and performance, where (Figure 2):

- Input indicators mainly measure resources that are put into the innovation process. These inputs include intellectual, human, and technological capital.
- Process indicators reflect the organizational and innovation management systems. They also embody the design of a firm's innovation system and its innovative.
- Performance indicators (output, outcome, impact), identify the results of organizational innovation. Output indicators represent the realized short-term success of innovative activity. Indicators of this group count patent numbers, rate, number of new products percentage of sales with innovations and other. Outcome indicators represent the realized longer term success of innovative activity such as market share, firm profit margins, and firm growth rate. The impact measure indicates the sustained advantage a firm enjoys as a result of innovation.

Strategic Knowledge Arbitrage and Serendipity (SKARSE) are real option drivers triggered from the 3C's. Strategic knowledge serendipity refers to the unintended benefits of enabling knowledge to "spill over" between employees, groups, and functional domains ("happy accidents" in learning). More specifically,

it describes the capacity to identify, recognize, access, and integrate knowledge assets more effectively and efficiently to derive, develop, and capture non-appropriable, defensible, sustainable, and scalable pecuniary benefits, whereas strategic knowledge arbitrage refers to the ability to distribute and use specific knowledge for applications other than the intended topic area. It refers to the capacity to create, identify, reallocate, and recombine knowledge assets more effectively and efficiently to derive, develop, and capture non-appropriable, defensible, sustainable, and scalable pecuniary benefits.

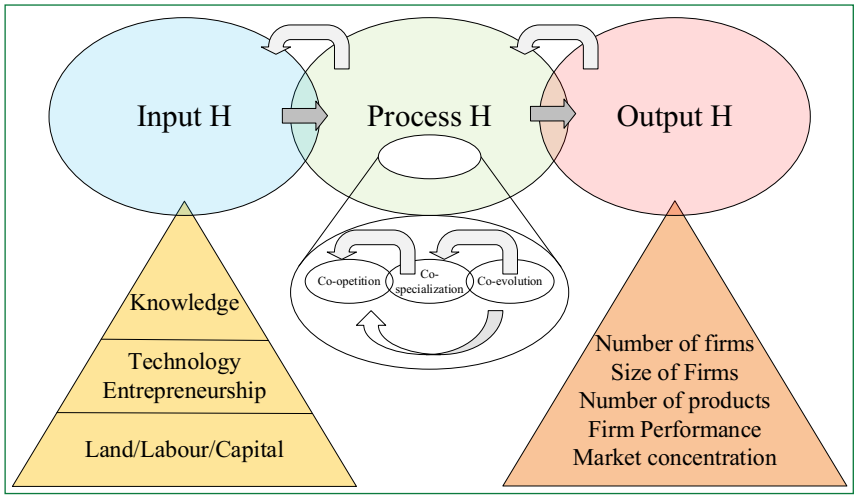
According to Carayannis and Sipp (2010), innovation and SKARSE may lead to increased competitiveness. Carefully implemented innovation policies can trigger increased innovation at the firm level and trigger a chain reaction toward more macro levels and culminate in improved competitiveness.

At a firm level competitiveness focuses on market share, whereas national competitiveness may be considered as the capability of national economies to achieve sustained economic growth, by efficiently allocating available resources (human and natural resources, capital) and having the appropriate structures, institutions, and policies. In this context, competitiveness of nations is defined as "how nations create and maintain an environment which sustains the competitiveness of its enterprises" (IMD, 2003), whereas numerous other alternative definitions may be found in the literature.

Innovation, productivity and competitiveness

Innovation-driven competitiveness is critical for a long run economic performance in today's knowledge-based global economy. When studying IPC, significant overlaps may be observed, mainly because these concepts are inherently linked (Carayannis and Grigoroudis, 2012) and thus, researchers focus on studying their drivers and outcomes, for example, in a cause and effect way (Jansen, 2006).

Methods for measuring innovation include approaches based on both single (e.g., R&D expenditures, number of patents) and composite indicators. Because a single indicator can provide only a limited view of such a broad concept, the role of composite indicators has been significantly increased in recent decades (Paas and Poltimäe, 2010). In this context, the relevant literature reveals two major approaches:



Source: Carayannis and Provance (2008)

Figure 2: Heterogeneity dynamics—input, process, output

- Evaluation of national performance and ranking of countries; and
- Analysis of National Innovation Systems.

The first approach mainly focuses on a comparative analysis of different aggregated innovation measures, whereas the second approach characterizes only a particular counter and puts emphasis on the factors that may impact innovation performance. The most widely used composite innovation index is provided by the European Innovation Scoreboard (EIS). The EIS 2015 consists of three main blocks, eight innovation dimensions, capturing in total of 25 different indicators.

Productivity measurement was initially based on a production function context and linked with economic growth, whereas in other research (see, for example, Carayannis and Grigoroudis, 2012), it integrates the theory of the firm, the index number theory, and available national accounts (OECD, 2001). Alternative productivity measures may be found in the relevant literature and these different productivity measures are classified according to the following criteria:

- Number of factors: This categorization includes single factor productivity, and multi-factor productivity, where a bundle of inputs is considered.
- Type of output measure: The alternative categories refer to either gross output or value added.

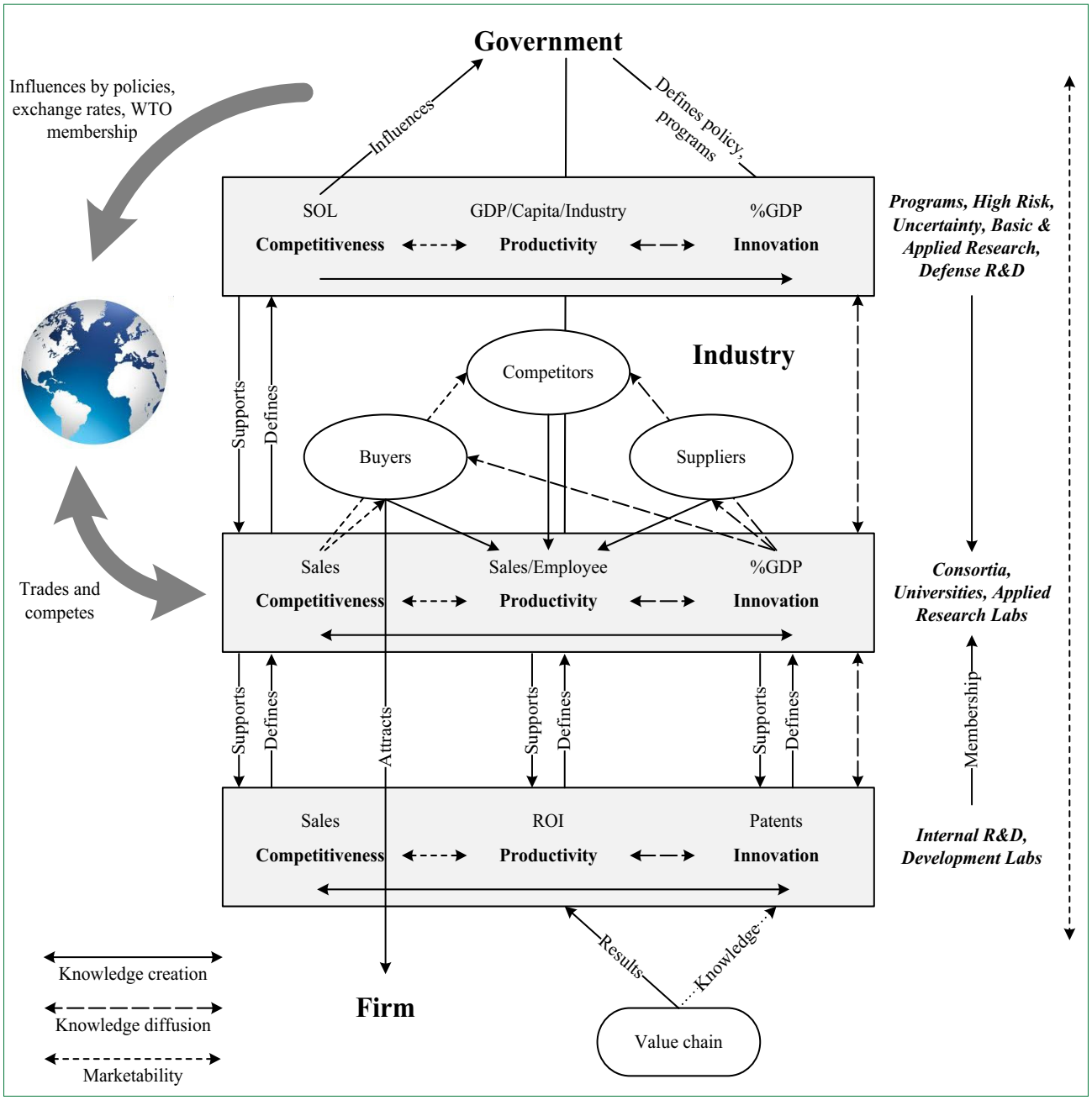
Many scholars argue that labor productivity is the most useful productivity measure because it is related with the most important factor of production, it can be easily measured, and it is a key determinant of living standards (OECD, 2001). However, it captures only partially the different aspects of this concept, and thus multi-factor productivity is usually considered.

The concepts of productivity and competitiveness seem inherently related, given that competitiveness is considered as the capability of national economies to achieve sustained economic growth, by efficiently allocating available resources. In addition, World Economic Forum (WEF, 2012) defines competitiveness as "the set of institutions, policies, and factors that determine the level of productivity of a country." Thus, in several cases, productivity is considered as the only meaningful concept of national competitiveness, and as a result the gross national product

(GNP) per capita may be used as a reliable performance index, only when a single measure should be considered. The most important efforts for developing a competiveness measurement framework refer to the global competitiveness index (GCI) developed by the WEF and the World Competitiveness Yearbook (WCY) provided by the International Institute for Management Development (IMD).

The measurement techniques adopted by the major IPC barometers are mainly based on simple estimation techniques, because a weighted average formula is usually adopted. Composite indicators are still the best tool available for analyzing such complex concepts (Paas and Poltimäe, 2010). In addition, the interrelations among these concepts are rather strong. All these justify the necessity of developing new measurement frameworks that are able to study IPC composite indices.

Moreover, the concepts of national IPC appear to have overlaps and/or significant interrelations. The relevant literature shows that, usually, these concepts are jointly studied in a firm, industry, or country level. In addition, several studies include other related aspects, like creativity and entrepreneurship (Carayannis and



Source: Carayannis and Sagi (2001)

Figure 3: The CPI model

Gonzalez, 2003) that increase the difficulty of analyzing the linkages among IPC.

The linkage between innovation and productivity/competitiveness is relatively strong, as emphasized by numerous studies (Carayannis and Sagi, 2001). Technology appears as a key factor which, through innovation, may influence the economies of scale, the timing of processes, and the introduction of new methods, and thus affect the competitive advantage of firms. Discussing these interrelations, Carayannis and Sagi (2001) emphasize that innovation and competitiveness are intrinsically unified; although one does not cause the other, both are necessary for competitiveness and for each other.

A similar linkage regarding competitiveness and productivity is also discussed in the literature. In fact several researchers emphasize that national productivity is the only meaningful concept of competitiveness. On the other hand, innovation without productivity is insufficient to produce wealth and increase national competitiveness. Thus, productivity appears inherently related with innovation and competitiveness in a country level, because it is the root cause of national capital income. Consequently, although the strength of linkages among IPC may vary depending on the level of analysis, these interrelations are adopted by numerous studies.

In the Operation Research/Management Science (OR/MS) literature these concepts are usually studied in a cause-and-effect way, adopting a Data Envelopment Analysis (DEA) approach. A characteristic holistic approach is given by Carayannis and Sagi (2001, 2002) who argue that these linkages may be observed both horizontally and vertically, sharing factors and resources such as funding, knowledge, and signals. Figure 3 presents the CPI model proposed by the authors, where national productivity results not only from national innovation programs, but also from industrial productivity, university structures, government policies, and so forth.

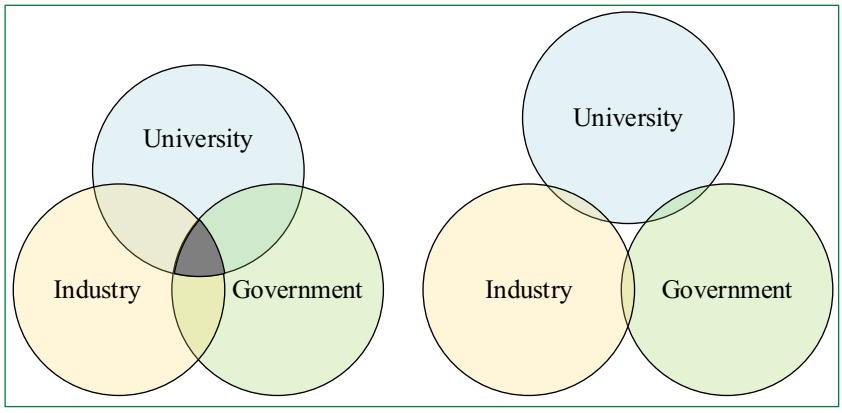
Carayannis and Grigoroudis (2012) published a work, estimating aggregated national innovation, productivity, and competitiveness indexes, based on a set of relevant indicators that describe the various aspects of these concepts. Their approach assumes that innovation may improve national productivity, which in turn gives the ability to compete on the global marketplace. Carayannis and Grigoroudis (2015) extended their work and adopted a regression-based multi-objective non-linear program (MONLP). The main characteristic of the model is that because of its multiple objective nature, it both minimizes the estimation errors and maximizes the correlation between the aggregated IPC indexes. Moreover, the MONLP model is a non-parametric approach, and thus no assumptions for the statistical properties of the examined variables are posed. In addition, the weights of the aggregation formula do not follow an arbitrary equal weighting scheme, but they are estimated based on the previous multiple objectives. Other important advantages include the flexibility of the model to consider additional desired properties for the examined variables and its ability to perform a dynamic analysis based on complete time series data.

From triple helix to quadruple innovation model

European Commission promotes the role of the multi-annual Research and Innovation Strategies for Smart Specialization (RIS3). Researchers and practitioners generally agree about the importance of building research and innovation strategies based on the involvement of local and regional bodies, businesses, social partners, and other organizations. The so-called Triple Helix model is a formalized concept behind such interactive systems (Carayannis and Campbell, 2010).

The Triple Helix concept has also been used as an operational strategy for regional development and to further the knowledge-based economy (Leydesdorff, 2012). The established Triple Helix model is a strong environment of parallel relationships between (national or regional) authorities, the wider business community (industry), and academia (including other research focused institutions). This approach places more emphasis on the role of each one of these categories of actors in the innovation process. As noted by Leydesdorff (2012), Triple Helix is a dynamic model and alternates between a number of bilateral or trilateral coordination spheres (Figure 4).

The Quadruple Innovation Helix bridges social ecology with knowledge production (Mode 3) and innovation. The most important constituent element of the quadruple helix – apart from the active "human agents"—is the resource of knowledge, which through a circulation known as circulation of knowledge, between social subsystems, changes to innovation and know-how in a society and for the economy. The Quadruple helix, thereby, visualizes the collective interaction and exchange of knowledge



Source: Carayannis and Rakhmatullin (2014)

Figure 4: A triple helix configuration with negative and positive overlap among the three subsystems

in a state by means of the following four subsystems:

- Education System in reference to academia, universities, higher education systems and schools (human capital);
- Economic System consists of industry/industries, firms, services, and banks (economic capital);
- Political System formulates the direction of where the state/country is heading in the present and future, laws, etc. (political and legal capital); and
- Civil Society (media-based–culture-based) integrates and combines two forms of capital: culture-based public-tradition values etc. (social capital) and media-based public-television Internet newspapers (capital of information).

Quadruple Helix Innovation models place a stronger focus on cooperation in innovation, and in particular, the dynamically intertwined processes of co-opetition, co-evolution, and co-specialization, within and across regional and sectoral innovation ecosystems that could serve as the foundation for diverse smart specialization strategies. The European Commission RIS3 guide outlines a set of general principles as to how S3 strategies should be developed at the regional level and recognizes the significance and need for the Quadruple Innovation Helix approach by proposing to add a fourth group to a classical Triple Helix model.

This Quadruple Helix model puts innovation users at its heart and encourages the development of innovations that are pertinent for users (civil society). Users or citizens here own and drive the innovation processes. Arnkil *et al.* (2010) maintain that the degree of user involvement could be defined as inclusive of the "design by users". In line with this perspective, new innovative products, services, and solutions are developed with the involvement of users in their role as lead users, co-developers, and co-creators (Afonso *et al.*, 2010; Carayannis, 2001). The citizens not only would be involved in the actual development work, but also would have the power to propose new types of innovations, which then connect users with their stakeholders across industry, academia, or government (Arnkil *et al.*, 2010). In turn, the role of actors in the other three helices would be supporting citizens in such innovation activities (e.g., to provide tools, information, development forums, and skills needed by users in their innovation activities). Furthermore, industrial players and public sector stakeholders would then be able to exploit the innovations developed by citizens.

The RIS3 approach also maintains that through application of horizontal forms of multi-governance, the smart specialization approach is helping regions to upgrade their research and innovation strategies based on a number of key principles including the implementation of multi-level governance and the Quadruple Helix approach. By applying the Quadruple Helix approach in the context of RIS3, regional policy makers are more likely to enable a place-based entrepreneurial process of discovery, which would generate intensive experimentation and discoveries. Such direct addition of users in the innovation process is a necessary organizational counterpart of an open and user-centered innovation policy as it allows for a greater focus on understanding underlying consumer needs (European Commission, 2012).

Quadruple helix as an architectural innovation blueprint to support RIS3

As mentioned earlier, the Quadruple Helix concept brings together four sectoral perspectives with a focus on the institutional, regional, and operational functionalities and complementarities of these sectors in the context of the knowledge economy. The overall RIS3 context provides an appropriate operationalization framework for embedding the concept in both policy and practice.

The Quadruple Helix concept thus can serve as an architectural innovation blueprint that engages simultaneously (in a dynamically balanced top-down and bottom-up approach) four sectoral perspectives (from the top-down angle government, university, industry, and the bottom-up angle civil society). The inter-sectoral and intra-sectoral as well as the inter-regional and intra-regional knowledge and learning interfaces that are embedded in the Quadruple Helix architectural blueprint determine its efficacy and sustainability. A combination of these four perspectives aims for the conceptualization, contextualization, design, implementation, and evolution of (smart, sustainable, and inclusive) growth-driving entrepreneurship and innovation ecosystems (as well as clusters, networks, and other agglomerations) at the regional level.

Civil society as the fourth pillar of the Quadruple Helix blueprint represents bottom-up actions and views of the civil society. However, to benefit from these, policymakers should ensure mechanisms such as crowd-sourcing and crowd-funding capabilities in instruments and initiatives included in their regional RIS3 strategies. Embedding these elements may allow for faster, broader, cheaper, and more resilient learning, learning-to learn, and learning-to-learn-how-to-learn dynamics (Carayannis, 2001). In addition, the social networking capabilities enacted via the fourth pillar would enhance the likelihood and impact of knowledge serendipity and knowledge arbitrage events (happy accidents). These happy accidents would then act as triggers, catalysts, and accelerators of exploration and exploitation dynamics that could substantially empower any Quadruple Helix RIS3 strategy (Carayannis *et al.*, 2008).

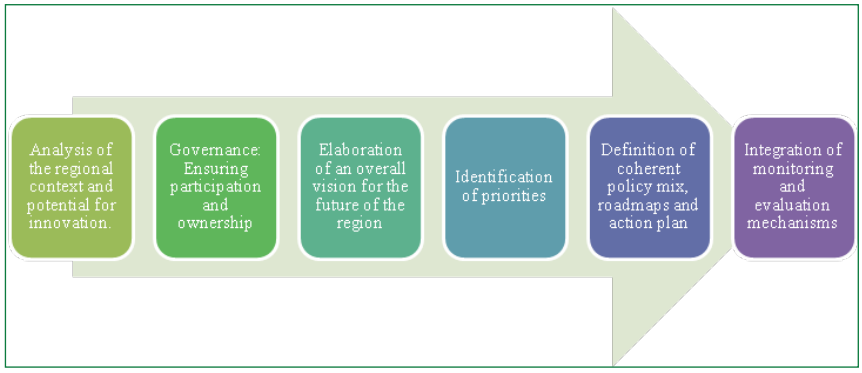
Principles of smart specialization

In the context of Europe 2020, smart specialization emerges therefore as a key element for place-based innovation policies and can be defined through the following five principles (Foray and Goenaga, 2013):

1. ***Granularity***: Smart specialization policy should concentrate on activities instead of sectors or firms. An example is the case of companies exploring the potentials of nanotech, to improve the operational efficiency of the pulp and paper industry. In such a case, the priority is not the pulp and paper sector as a whole, but rather the activity involving the development of nanotech applications for the pulp and paper industry. Targeting the development of new activities allow the government to

achieve two things through the same policy: it improves the general performance of the sector, while at the same time building capabilities and expanding the knowledge base toward new fields (Foray and Goenaga, 2013).

2. ***Entrepreneurship discovery***: The second novel insight is the process of entrepreneurial discovery. According to the business theory advanced by Kirzner entrepreneurs are continually searching for, identifying and evaluating new business opportunities and this process is called entrepreneurial discovery, which at the regional level is what regional policy makers should do, focusing on the activities instead of sectors. The policy makers should search for the entrepreneurial knowledge and discoveries to realize a regional or national vision. They should be able to differentiate between simple innovation and discoveries that have the potential to generate new areas of specialization and that might constitute the cornerstone of smart specialization.
3. ***Specialized diversification***: The third principle is that the priorities emerging today will not be supported forever. After 4 or 5 years "new activities" are no longer new. Whether they have failed or whether they have successfully reached maturity, they should no longer be priority for the smart specialization strategy.
4. ***Experimentalism***: The fourth new notion is experimentalism. There is no guarantee of success in any particular action; indeed, some actions will lead to failure. Smart specialization relies on the theories of experimental learning and it develops the idea of self-discovery elaborated by Hausmann and Rodrik (2003). According to the argument, innovation policy needs to allow for experiments to discover what works and what does not work in a particular context. Failures must also be noted to identify success. The idea of discovery and experimentation points to the role of indicators and evaluations.
5. ***Inclusive strategy:*** Smart specialization needs to be inclusive. This does not mean that the strategy will support a project in every sector but inclusive smart specialization means giving every sector a chance to be present in the strategy through a good project.



Source: European Commission (2012)

Figure 5. Six steps to a successful smart specialization strategy

One way to understand the smart specialization strategy is to look for information on how to create a successful strategy. Figure 5 presents a stepwise approach for RIS3 design.

Conclusion – examples of excellence from the nordic countries

No more Nokias

The student revolution was part of a wider reconsideration of the proper relationship between government and business. This had started in 2008 when the Finnish government shook up the universities (and created Aalto) in an attempt to spur innovation. However, it was speeded up by Nokia's problems. Finland had become dangerously dependent on this company: in 2000 Nokia accounted for 4 % of the country's GDP. The government wanted to make the mobile-phone giant's decline as painless as possible and ensure that Finland would never again become so dependent on a single company.

The Finns created an innovation and technology agency, Tekes. They also established a venture-capital fund, Finnvera, to find early-stage companies and help them get established. The center piece of their innovation system is a collection of business accelerators, partly funded by the government and partly by private enterprise, which operate in every significant area of business and provide potential high-growth companies with advice and support from experienced business people and angel investors.

As a result, Finland has become much more market-entrepreneur friendly. It has produced an impressive number of start-ups, including 300 founded by former Nokia employees. The country has also acquired the paraphernalia of a tech cluster, such as a celebratory blog (Arctic Startup) and a valley-related name (Arctic Valley).

Nokia's decline is "the best thing that ever happened to this country". The new Finland is particularly proud of its booming video-games industry, including successful companies such as Rovio Entertainment, the maker of Angry Birds and a leading supporter of the Start-Up Sauna, and Supercell, the maker of Clash of Clans.

Nordic governments recognize that they need to encourage more entrepreneurs if they are to provide their people with high-quality jobs, and that they can no longer rely on large companies to generate business ecosystems on their own. They are creating government agencies to promote start-ups. They are encouraging universities to commercialize their ideas and generate start-ups. They are telling their schools to sing the praises of entrepreneurship. Many of the region's most interesting entrepreneurs operate at the low end of the tech spectrum, often to help parents deal with the practical problems of combining full-time work and family.

Despite all this entrepreneurial energy, the Nordic region still finds it hard to

turn start-ups into enduring companies. There are too many examples of successful entrepreneurs who have upped sticks and gone elsewhere. These include not just members of the post-war generation such as the founder of giant IKEA or the founder of Tetra Pak, but also members of the up-and-coming generation. Too many successful start-ups still choose to sell themselves to foreign multi-nationals rather than becoming local champions.

Still, there is reason to hope that the entrepreneurial boom will also produce a new generation of global champions. An example is Rovio Entertainment, with the game Angry Birds. Having produced one big hit, most games companies would have started looking for the next one, but instead Rovio set about turning Angry Birds into a brand and extending its reach. It struck licensing agreements with a range of companies to make Angry Birds-branded products, from toys to chocolate to theme parks. It raised capital from outside investors such as Microsoft, which chipped in $42 million. Rovio now has 500 employees in Finland and had a turnover of $100 million in 2011 (Carayannis and Rakhmatullin, 2014)

The Ostrobothnia case

A number of attempts have been made by researchers and policymakers to evaluate different aspects of the Triple Helix model in the context of regional innovation systems, and this can indeed be extended to cover the Quadruple Helix concept.

One example is a recent exercise carried out by the Regional Council of Ostrobothnia that initiated a project where they developed a method for measuring Quadruple Helix connectedness and gaps (Virkkala *et al.*, 2014). The results of this study would then be used as factual evidence for improving RIS multi-level governance. The S3 Guide focuses on connectedness within the Quadruple Helix and taking this conceptual perspective as a guideline for good regional governance, requiring a coherent approach. In this regard, smart specialization or S3 presents itself, not just as a continuation of what we have done already under the umbrella of RIS but rather as a way of questioning existing RIS practices and removing dysfunctional policy arrangements, which prevents growth and development.

Therefore, one of the objectives of this document is to develop a self-assessment and evaluation tool, which could be used by regional policymakers to measure their region's progress in adopting, adapting and deploying the Quadruple Helix approach in their RIS3. The Fifth Report on Economic, Social and Territorial Cohesion prepared by the European Commission (2010) also suggested improving monitoring and evaluation systems across the EU to track performance and to help fine-tune efforts as needed to guarantee that pre-defined objectives are attained in the most effective manner. This requires a clear strategic vision of what the program aims to achieve and how success will be recognized and measured. Furthermore, it also requires a greater recourse to rigorous evaluation methods – both longitudinal and latitudinal (i.e., cross-sectoral, multi-level and across time and space) – for the evaluation and continuous improvement of the formulation and implementation of QH modalities and systems in the RIS3 context. (Carayannis and Rakhmatullin, 2014)

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