Global innovation and production networks: new rationales and policy challenges

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Introduction

Can European policy keep up with global innovation and production dynamics? Europe is committed to maintain its welfare model in the long run but challenging this commitment are two important dimensions. The first concerns the building of Europe itself and its internal contractions that are continually evolving and limiting its capacity to swiftly act globally with a single voice (see Simms, 2014; Lehndorff, 2012). The second regards significant shifts in the international competitive landscape where the Europe appears to be losing ground in traditional and advanced technology markets (see Tate *et al.*, 2014; and Kinkel, 2014 in this book). The focus of this chapter concerns the second dimension. This note argues that despite its internal contractions Europe is striving for the co-creation of a new global market structure according to a new and ambitious vision reflected in several policy documents. It aims to create new global value networks and provide new rationales for globalization (see, European Commission, 2012; van de Velde *et al.*, 2013). It will be shown in this note that a number of weak signals together indicate that Europe is underway to prepare the terrain to remain a relevant global actor on innovation and production networks - with or without full concerted action of its member states.

The vision consists of creating the conditions for a grand structural transformation, mediated by new knowledge and innovation. Where such transformation is aiming not only to fulfil the goals of the European 2020 Strategy but also contributing to tackle the grand challenges (by providing new approaches and technical solutions embedded in new technological applications, products, services, standards, regulations and institutions). In this new strategy global innovation networks are to be an important factor that serve as leverage for global restructuration. The new global innovation networks are likely to be organised around contributing to the solution of the grand human challenges underpinned by logic of systems integration. Several key trends justify such a new rationale.

This note aims to provide some of the elements that justify the appropriateness of a new approach and rationale for global innovation networks and their competitive environment as an issue for policy intervention. The note is organised in an inductive fashion progressing from the presentation of how the international competitive context has evolved from export oriented to innovation driven to likely arrive in the next decade in a challenge and demand driven paradigm, where intrinsic human and natural issues are used to generate institutions that legitimise the creation of new markets. Section two describes synthetically the evolution of the international competitive context.

Section three defines what is known as the grand challenges and outlines their relevance for future global competitiveness. Section four presents what could be an evolving model that serves as blueprint for other grand challenges underpinning future markets and new geopolitical asymmetries but also great opportunities for global innovation networks to underpin new international collaboration models. Section five looks into some actions in Europe and the platform provided by the Europe 2020 Strategy and one of its strongest arms, the Horizon 2020 Research and Innovation Program. The last section offers some reflections and discusses challenges for the operation of global innovation networks themselves under a new rationale and some policy implications.

Evolution of the international competitive context

The evolution of the international competitive context from mid last century to date could be described along three stages that overlap for some years until a dominant paradigm emerges and then remain stable for about two decades. The first stage is characterised by a strong focus on the creation of national competences in R&D and industrial organisation oriented to the substitution of imports focusing on national demand up to the late seventies. The organisation of production is done in vertical and horizontal fashion following Fordist and Taylorist approaches (Piore and Sabel, 1984). Innovation activity and management occurred primarily within the confines of vertical integration.

Second stage of evolution

A second stage that opens a great restructuration of industrial organisation is characterised by an export oriented model. The first experiments of off-shoring manufacturing and the creation of export platforms date back to the mid-sixties (Hong-Kong and Mexico). This stage is known and characterised by the international outsourcing and globalisation of production. Such a model was enabled by the advent of the flexibilisation of technologies (multipurpose), labour (lower unionisation) and capital (deregulation of capital flows across countries). The competitiveness of firms and of regions to attract foreign investment in the form of production facilities was condition for the following relative factors compared to conditions faced by competing firms or offered by other potential host regions: cost of labour; availability of educated and skilled labour; labour unionization; availability and cost of critical raw materials (e.g., energy, water, minerals, etc.); fiscal regime (tax exemptions); available infrastructures (roads, ports, railways, etc.); regulatory regime stringency (labour, health, safety and environment); easiness to open and close businesses; social and government stability (see Bernard *et al.*, 2006; Faust, et al., 2004; Pennings and Sleuwagen, 2000; Boyer and Saillard, 2002; Koido, 2000; Driscoll and Berhman, 1984).

This period up to the turn of the century created a new international competitive environment where firms enjoying the best conditions listed above were likely to have better performance. In mid to high technology sectors (electronics, automotive, aviation, pharma, etc.) R&D and innovation started to play a more important role in defining global competitiveness and the internationalisation of R&D became more common and widespread. As the off-shoring model became more common and was mastered by many, the competitive edge of the firms operating in such a model eroded.

Third stage of evolution

The entry to the third stage of evolution of the competitive context at the turn of the century is characterised by such erosion on profits margins and this demanded changes in the firms' competitive strategy in a globalised organisation of production landscape. Labour cost was a key factor in the second stage but in the this stage becomes less relevant given the effects of factors like relative increases and levelling over time of wages of competing hosting regions, productivity increases in off-shoring countries firms, and new major concerns regarding the efficiency of off-shoring operations. Such issues include quality of intermediate components and final products, lead time for delivery (trans-ocean shipping from Asia to the U.S. for example takes at least two weeks), higher complexity of global operations, greater environmental and regulatory awareness in host countries, endogenous demand and social stability in host country, etc. The factors that provided competitive edge in the second stage of evolution became a necessary but not sufficient condition for good firm performance.

Global innovation networks (GIN) appear when firms off-shore aspects of the production, application and exploitation of knowledge including for example: software development, engineering, product design, research and development (Lewin and Peeters, 2006). Thus, higher importance is given to R&D and innovation, and global innovation networks are recognised to be vital in the long run as this provide access to critical new knowledge from the best available global sources (Ernst, 2006). Firms seek to

acquire knowledge which is expensive to develop in-house by using specialized suppliers, to complement their capacity for product development and capital requirements (Lewin, A.Y. & Couto, 2007). A strong interdependence exists between GIN and global production networks when the aim of off-shoring innovation activities is motivated by the aim of gaining access to local foreign markets. It is well known that major European brands have located R&D and innovation facilities in China to gain access to highly qualified researchers but also to adapt products and services to the local market (Tate et al, 2014, Kinkel, 2014). At the same time the local R&D and innovation capacity of host regions questions the current innovation models. The issue of re-shoring is currently prominent as firms must decide to gauge risk on intellectual property management when outsourcing entire manufacturing systems with their latest technology to host far away countries (Tate et al., 2014).

This stage is also characterised by the advent of new strong innovation based competitors (China, Korea, Singapore, Japan, Taiwan, etc.) that maintain high rates of R&D investments and patenting. In this stage key issues for firms and countries industrial policy are the upgrade of their role in global value chains and the creation of brands and control of OEMs (Ems and Low, 2013). Two important characteristics in this third stage concern the nature of R&D and innovation activities in themselves that are also evolving. The R&D capability that in previous stages was privilege of large and vertical (often) large companies is currently more fragmented and often outsourced and often off-shored in a way that R&D capability often has the characteristic of a commodity. Furthermore, often the benefits of large R&D investment are gained in the upper echelons of the value chain, thus having a characteristic of a risky commodity to produce. These concerns about R&D activity are now accompanied by the fact that innovation cycles are evermore shorter and often occurring in open innovation networks or common platforms sharing standards.

Inevitable emergence of a fourth stage

At first sight the fact that Europe by itself accounts for about 30% of the total world share in key science and technology indicators that are critical for innovation provides an reasonable competitive margin in world innovation affairs[1] (European Commission 2014). This is questioned by the implicit dynamics of learning and knowledge accumulation by all the actors in the global market place. It is clear that as the different competitive stages evolve in time different players learn the rules of the game and accumulate knowledge and skills until a significant number of players level the competition field. Although all the elements, operational and contextual, that affected competitive performance remain relevant now it seems clear that innovation became a must to gain competitive edge in current markets but also to create new ones and this requires orchestration skills that to some extent have been already learned by many global players. As in previous stages all the players learned the tricks and there is a likely progressive race to the bottom where R&D&I become short lived commodities and price competition rules. If the model prevalent in stage three is due to suffer erosion like previous competitive models leading to decreasing returns to R&D and innovation investments for those engaged in those activities the question here arises: What is the next and future long term strategy?

There seems to be a new rationale with several key components that might define the next competitive context whereby international collaboration might play a major role. Future competitiveness is no longer defined as the struggle to remain competitive in current markets, but primarily as the creation of new markets, underpinned by change and innovation (Montalvo et al., 2011). The question here is how you create and legitimise these new, hopefully global markets? How is the new mode of production and innovation to be driven? Some of the new elements seem to be related to the digitation and manufacturing process enabled by new technologies in robotics, 3D printing, and automation connected to the internet (the internet of things - IoT). In some instances this emerging paradigm is known as industry 4.0 (German version) or Smart Industry (Dutch version).

[1] These indicators include: Science and technology graduates, Number of researchers (FTE), gross domestic expenditure on R&D, high impact publications and patent applications.

In summary, new ICTs and manufacturing technologies enabling the reorganisation of two core aspects of industrial organisation. First, the remote monitoring and control of key aspects of manufacturing activities (materials, inventories and flows, quality monitoring and maintenance of machinery). Second, the digitation and creation of design platforms for customer intimacy directly linked to the production of goods and services now promises the conduction of relative low cost beyond modular to individualized design and production leading to full individualised mass customisation. Design, production and delivery systems are fast moving towards fulfilling the wishes of the individual customer with greater intimacy. New digitation technologies enables that the wishes of a single customer organise a unique and entire value chain and production network (see Dietel, 2013; EFFRA 2013; Sauer, 2013).

The grand human challenges

During the last 8 years there has been an upsurge of interest in the role of innovation to face the grand challenges and the subsequent effects on economic performance (Montalvo et al., 2006; Aghion et al., 2009; EC, 2010; Montalvo et al., 2011). According to the Joint Institute for Innovation Policy the grand challenges political discourse have been important for innovation, growth and facing social and environmental problems (Leijten et al, 2012). Addressing the grand human challenges will require several decades as these tend to be highly complex problems, requiring the participation and cooperation of multiple agencies and stakeholders within and across nations, characterized as long term problems requiring long term investments. The European policy agenda has selected a number of grand challenges that were considered critical for the wellbeing of European citizens:

- *Health* – including diseases of the young and elderly; neurodegenerative, musculoskeletal and chronic diseases; millennium development goals; ageing and well-being; personalized medicine;
- *Food* – including bio-economy; forestry; and marine and maritime research;
- *Energy* – including a new focus on gas; energy security; smart grids; energy storage; back-up and balancing technologies; carbon capture and utilization;
- *Transport* – including mobility and logistics;
- *Climate* – including water management; biodiversity; raw material; eco-innovation;
- *Societies* – including demography; social sciences humanities; innovation; and cultural heritage and European identity;
- *Security* – fighting crime; illegal trafficking and terrorism; protection of critical infrastructures; border management; resilience to crisis and disaster; privacy on the Internet; an EU external security policy; conflict prevention and peace building.

All the above challenges often have relevance from local to global scale, thus requiring broad policy actions due to their unparalleled scale. In the policy discourse, there is consensus that finding solutions to these challenges requires doing things and business differently and that, to a large extent, the preferred mechanisms are the generation and usage of new knowledge and innovation (e.g., European Commission, 2009; European Commission, 2010; OECD, 2011; European Commission 2012). This implies the need to orient innovation systems and research infrastructures towards the grand challenges (Cagnin et al., 2012). In the case of grand challenges the notion of innovation in particular is connected to new business models often positioned to bring a win-win situation (Porter and Kramer, 2011). Consequently, interest in the provision of solutions to the grand challenges is rapidly increasing. This is in part a consequence of the number of issues being so large and pervasive across the world that the idea of transforming challenges into business opportunities and new markets has sparked fundamental interest in the business community. The latter couples the need for a new global rationale to boost employment and growth with the need to reinvent a large proportion of our technological stock supporting the current production and consumption portfolios.

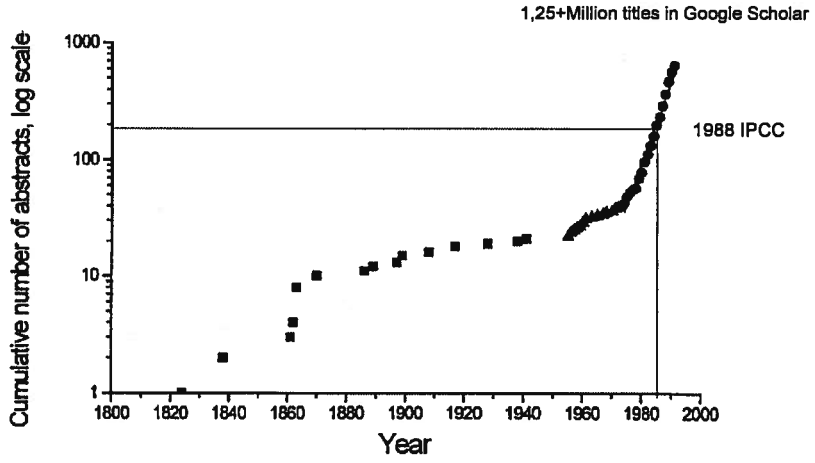
Policies, regulations and investments to face the challenges mentioned above need to be designed, enacted and implemented through actions under the rationale of *global systems integration*. Although the effects of the challenges are felt at the local and regional level, many of these challenges are moderated by globalisation and will cut across several economic sectors and national boundaries by mere definition. Changes in rationales beyond mere employment and growth generation, issues to tackle, and priorities to implement, will lead to changes in actors with influence and leverage in different nodes of the global value networks. What is clearly required is a massive impulse on behavioural change and innovation at different levels. Such impulse will need not only push for innovation concerning the way production and consumption styles are organized but also institutional innovation that enable changes in rules and regulations concerning designs, services, production processes and industrial relations. As leading and emerging economies are aiming to complement competitive strategies driven by cost optimisation with R&D and innovation driven by demand, there will be the need to bring forward new policy concepts that incorporate global value chains, IPR governance, financial flows and regulation, maintenance of R&D infrastructures at home, optimisation of value chain integration, etc. Global innovation networks present reinforcing characteristics that create synergies of increasing importance. In particular the Grand Challenges require international collaboration to find and implement not only inter-firm and cross-sector actions and solutions but also across national borders. In that sense global innovation network are likely to support not only the access to the markets but also to diffuse new regulations, standards and practices that support innovation and change.

Grand challenge model setting the path

Where to look for a model to follow? Recent history provides us a model to analyse the likely pattern of development of a particular grand challenge and the relation with innovation networks and global production: The issue of climate change in relation to energy. In general we can describe in a stylized form how the structuration process develops from the identification and legitimization of a grand challenge to the creation and expansion of a new market mediated by technical change and innovation. The following sequence of events is not necessarily linear and there are some recursive loops included: definition of the grand challenge (the issue); development and accumulation of a critical mass across different type of actors that recognize the issue as important and willing to generate visions and contribute to the solution; appearance of lobbying groups (pro and against) and increased public debate; emergence of institutions advocating, hosting and proposing approaches to address the issue; development of technical and managerial approaches to address the issue; adoption of the issue in the policy agenda by government and multilateral organizations; investment flows to develop and test solutions while patenting and IPRs are settled; early adoption sprout niche markets supported by policy instruments (e.g., taxes and subsidies), regulation and standards start to consolidate markets; investments for production up-scaling often backed by sectoral policy and regulation and wider diffusion takes place; mass markets growth, competition and distribution of production location become issues for industrial policy.

Climate change and innovation could well be one of the first visible and working models of grand challenges and innovation striving to restructure global production and consumption in energy markets. Some of the elements and events of such a model are outlined below. Figures 1, 2 and 3 present a summary of the process outlined above in few indicators. Figure 1 shows the number of publications on climate chance and Figure 2 depicts the parallel development of technical solutions as well as the period in which institutions advocating the taking of actions. In a large number of publications most of the attention so far has been given to energy sources and usage but also linking these to other sectors as diverse as transport, lighting, construction, cement, agriculture, etc.

Figure 1: Number of publications on the topic of climate change

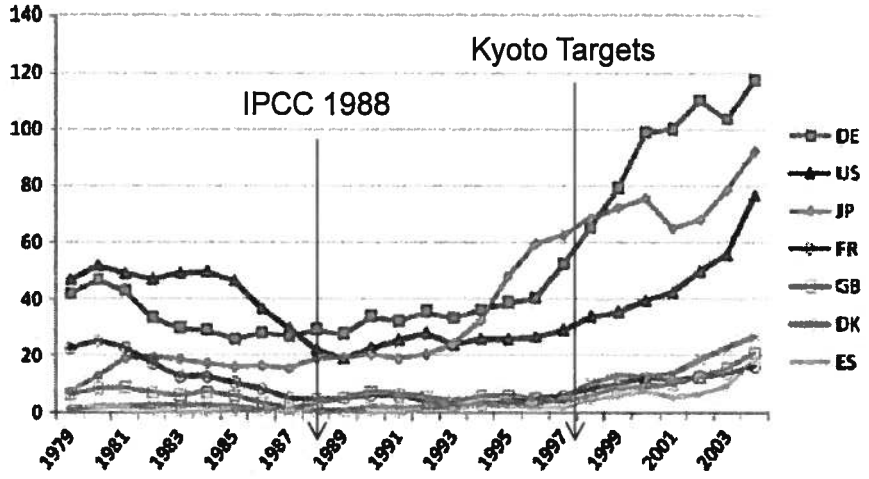


Based on Stanhill (2001), Google Scholar ("Climate change" keyword in title hits in February 2014)

In Figure 1 the confluence of two important developments can be noticed. A very rapid increase in the number of publications and the building of consensus that climate change exists and the main cause was the combination of a number of gases in the atmosphere, especially CO_2. Since 1977 the number of published papers doubles every 11 years, the trend continues to date (Stanhill 2001) confirmed by recent searchers in Google Scholar. Matching a logarithmic increase over a decade of three orders of magnitude in the number of publications, in 1988 the United Nations Inter-governmental Panel in Climate Change was created. The creation of such an institution required massive debate in multilateral organisations.

Transiting the road to the first agreement on limiting global emissions took about nine years and in 1997 the first agreement on the Kyoto Protocol was signed by some nations. The signature of the protocol and later the targets negotiations legitimated at a global scale the need for actions to mitigate the potential effects of climate change. Although a significant debate continued on the effects of climate change, technology solutions development reflected in patenting activity across key players in renewable energy technology increased significantly after the agreements of the Kyoto targets to limit CO2 present in the atmosphere. Figure 2 shows the evolution of patenting activity between 1979-2003 and the period of the two major events creating new institutions in charge of promoting an agenda that would have massive global impact in the enactment of national policies supporting the development and diffusion of alternative sources of energy.

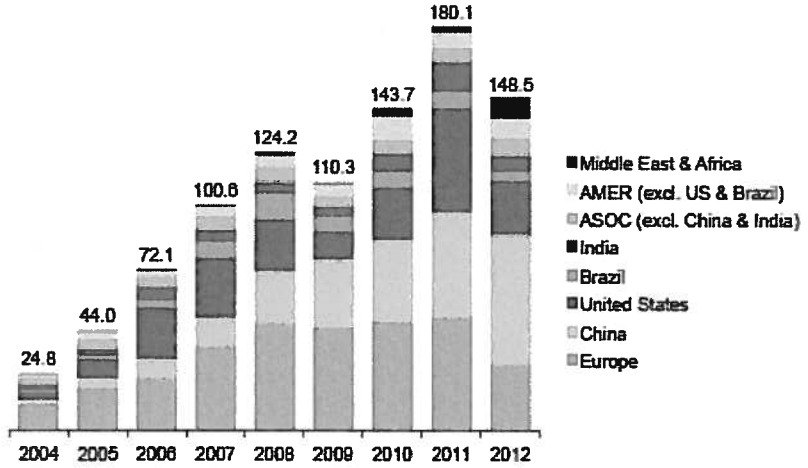
Figure 2: Patenting activity and climate change debate evolution



Based on Johnstone (2010)

Although there are still sceptics concerning the climate change projections (Whitmarsh, 2011; Poortinga et al., 2011) the need for action to reduce CO_2 emissions has entered in the discourse and policy agendas and thus gained legitimacy for the "urgent" need for action. Similarly markets have reacted to the challenge and economic opportunities this brings for global business. With a time lag of just a few years following the increase of patenting rate shown in Figure 2, the level of reported investment in the production and installation of renewable energy technologies has also significantly increased during the last decade across the key global players. Figure 3 below shows sharp increases in the levels of investment in renewable energy technologies from 24.8 billion in 2004 to 148.5 billion in 2012. Major country investors are Europe, China and the U.S.

Figure 3: Global investment trends all renewables (US$ Bn)



Source: McCrone, 2014

The interest is becoming clear from the large increase of capital flowing into energy related innovations. For example, Ethical Markets Media reported already in 2011 a $2.4 trillion cumulative worldwide investment in eco-innovation during the period 2007-2011, while the expected cumulative investment by the year 2020 was estimated at $10 trillion (Montalvo et al., 2011). Coincidentally, innovations contributing to face the grand challenges (e.g., in energy, mobility, water, etc.) are creating new global markets, allowing smart specialization of some regions and giving governments politically more comfortable long-term horizons for policy action.

Climate change as a grand challenge is one of a kind that presents truly global natural connectivity with strong local and regional implications. Other challenges like water, energy, security, immigration, also have global connotations but regional agendas tend to dominate. Here the value of global innovation networks is that science and technology serve as an arena that can help to mediate potential conflict. The strong and long standing collaborative dynamics of global innovation networks especially in the area of R&D might have some lessons to offer to other areas of policy.

2020 Europe in transition

After a decade of increasing productivity accompanied with decreasing employment rates, sluggish demand and economic growth Europe is in the mid of a transition stage. The transition period might range from the end of the strategic period guided by the Lisbon Strategy in 2010 to the end of the Europe 2020 Strategy. The Lisbon Strategy had several flagship targets (notably growth, employment, productivity, innovation and research, education and training and social and environmental policies) that to were not met during its implementation period. For this failure to meet the targets the European Commission was strongly criticized (European Parliament, 2011). The midterm and final review of the Lisbon strategy period demanded a different rationale with a more ambitious and inclusive strategy that

would allow pursuing previous targets but also allowing a different emphasis. Such new emphasis would provide some political slack and higher legitimacy for new policies. Exploratory and evaluation studies on the rationale of the grand human challenges for innovation policy making date back to 2006 (e.g., Montalvo *et al.* 2006, Leijten et al, 2012; McGrath et al., 2014). After 2010 with the advent of the new European 2020 strategy the notion that Europe should focus its efforts to tackle the grand human challenges became mainstream in policy documents (Cagni et al., 2012). What is new in the approach taken in Europe is the commitment (or need) to create a shared vision or goals aiming to guide a broad international community as a mean to bring Europe to the front of R&D and innovation (Leijten et al, 2012). Giving the nature of the Grand Challenges this would require the consolidation of political legitimacy of such rationale, new technological and innovation options, new standards and regulations.

The period 2010-2020 can be considered a transitional phase where the foundations for the period 2020-2050 are to be settled. Such foundations are to face the grand human challenges and the new global geopolitical competitive landscape. As described above, in the new landscape rules of the game for industrial competitiveness are not favourable for many of the traditional and middle technological sophistication sectors. Emerging economies are advancing not only in knowledge infrastructures, patenting and the organization of production and exploitation of new knowledge. Such new competitive landscape requires a significant restructuration of the global patterns of production and exploitation of knowledge. The notion of the grand human challenges offers the opportunity to articulate such a new structure. Innovation is to play an important role as a means for restructuration and legitimation of new global markets under strong interdependence dynamics.

The transition starts with the implementation of Horizon 2020 up to 2020. The greatest portion of the budget of the Research and Innovation program *Horizon 2020*, almost 40%, i.e., 31 billion Euro, is dedicated to explore and create approaches and technologies to tackle the so-called 'Grand Challenges' (Judkiewicz, 2014) . From a political economy perspective the 2020 European Strategy underpinned by the notion of the grand challenges aims to: 1) Develop and mature new competences, skills and technologies according to the definition of specific challenges contributing to the solution of a grand challenge; 2) Setting up new institutions, standards and regulations supporting European industrial and markets leadership, and 3) Create global consensus and shared visions that underpin the creation of new markets. Point one of such agenda and vision is reflected in the many specific research and innovation programs that form Horizon 2020, for example Factories of the future, Future and emerging technologies, Leadership in enabling and industrial technologies. Such programs are both oriented to tackle the grand challenges, underpin international global networks and to set the grounds for global industrial leadership.

Discussion

From the above and what is gathered from the literature and policy documents, there is clear interest on the instrumental role of innovation and in particular of global innovation networks to face the grand challenges and the subsequent effects on economic performance. As described above, there are several forces of historical relevance that contribute to this interest. First, the world is facing a significant number of long term challenges including climate change, population ageing, desertification, water scarcity, pollution, and critical raw materials scarcities. Second, the international economic context has moved to a new, multi-polar era in which the rules of the competitive game are being reset. The policies that have traditionally ruled international competitiveness are rapidly changing. Leading economies and newcomers into global markets (e.g. Brazil, Russia, India, China, South Korea, Taiwan, Singapore, etc.) have mastered not only the know-how for cost driven competition (Contractor et al., 2010) but they have also became innovative in traditional and in selected high-tech sectors (Montobbio et al., 2010). Firms and regions seek to differentiate themselves to become leaders in international trade via innovation and smart specialization (Foray, 2009). Third, in several advanced economies, governments

can no longer rely on the electorate's confidence and legitimacy in policy agendas to ensure the societal welfare, employment and boosting demand and growth in the context of national austerity plans are currently the norm in Europe after the 2008 financial meltdown.

Europe has banked on innovation as a saviour for its competitiveness but as seen above, global innovation dynamics face a number of internal contradiction which are not easy to tackle. The implementation of a shared vision to solve the grand challenges requires the capacity to create convergence and the capacity to interoperate in multiple actors, thinking and acting at the local and global levels where needed. This would require operating under the logic of systems integration that is often at odds with decentralised decision making and management akin to sectoral approaches (the mere definition of the challenges based on sector definitions).
The latter requires addressing the potential for better coordinated EU industrial policy. An overarching EU industrial policy that boasts an international smart, sustainable and inclusive specialization is more likely to be feasible if such policy has a strategy underpinned by the rationale of addressing grand societal challenges. A process of global innovation networks structuration mediated and targeting grand societal challenges is not only feasible but necessary. It is *feasible* due to the fact that "demand driven innovation" creates its own consensus and likely to create new markets with lesser political and economic resistance in industry and major trading partners. It is *necessary* because facing the societal challenges requires the interoperability of several technology streams, many stakeholders in a given value network that can well cut across sectors and countries. Systems integration aiming to tackle any of the grand human challenges via markets creation has a number of implicit tensions. These tensions include: i) the need for interoperability between many different firms and the need to invest resources to create value and sharing (or capture) revenues; 2) what goals are to be optimised and followed and which is at the top of the hierarchy? Systems integration dictates the need of a common target to optimise, while the kind of integration required is one with highly democratic characteristics, is taking account of power asymmetries in decision making and implementation in different sectors, and geographical jurisdictions (see example of eco-innovation in Montalvo et al., 201).

The restructuring of global innovation networks will benefit those promoting it most. The process will require the creation of new institutions that apply regulations and standards across industry and nations. Those (firms or countries) managing to succeed in setting the new standards and adapt or create their institutions according the new business models required by the new rationale of bringing solutions to the grand societal challenges are likely to be best positioned in the restructured regional or global value networks. At the core of the governance of global value chains are the business models exerted and interoperated by the participants in it. In this sense the creation of new business models and systems integration at the core of future global innovation networks structuration.

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