

Industrialization, Geography and Policy: towards a research agenda

A Background Note

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A working paper, in progress, developed as background to discuss a research agenda oriented towards industrialization and focused on role of science and human capital to promote socioeconomic resilience. Prepared for SPIDER WEB and School of Advanced Studies, UFRJ, Rio de Janeiro, February-March 2013

Abstract

This paper presents the rationale for a new research agenda on industrialization patterns of regions and countries, looking specifically at competences and capabilities of people and institutions. This is because industrialization has been the main driver behind rapid productivity growth achievement and social well-being improvements in different countries in the last 200 years. Despite this, there is a clear difference in industrialization levels of different countries, and the world's geographical patterns of production have been changing over the last decades. As a consequence, the weight of manufacturing in the economy has been decreasing substantially in many countries and regions. Production has been concentrating in certain regions, while others have been increasingly losing their productive ability, leading to changes in employment, and raising new concerns.

We propose a new research agenda addressing desindustrialization as a risk, and considering development patterns through the lenses of employment changes and competences. The proposed agenda may lead to new policy analysis with a global focus, in association with increasingly transnational businesses, technology and science, requiring to evolve from nationalistic approaches to new collaborative policy frameworks.

1. Introduction: Innovation and socio-economic resilience

It is clear that technoglobalism and the globalization of trade and supply chains led to the emergence of increasingly competitive global markets and to facilitated access to new suppliers, independently of their geographic location (Berger, 2005). This has allowed countries and regions with strong technological and industrial bases to profit on the lowering of trade barriers to access new markets, while the majority of firms located in other regions remained confined to local markets.

In addition, the analysis of the overall trend on moving towards knowledge intensive services and its relation with job creation and economic growth requires some pragmatism. This is because, in parallel to technoglobalism came post-industrialism, promoting services as the new developed countries' economic growth overtook manufacturing industries. Captivated by the prospects of accelerated and cost-effective economic growth, many countries, started shifting their focus from manufacturing industries to knowledge-intensive services (Hepburn, 2011; Ghani and Kharas, 2010).

The result is emerging with many regions worldwide lagging behind. In fact, evidence shows that, when compared to knowledge-intensive services, hard industries have higher labor productivities, a more balanced income distribution, higher income growth rates and the ability to generate exports, which are negligible in the case of services (Nairn, 2002; Fingleton, 1999).

Looking at the US, together with other most developed economies (including Germany), we can identify some common factors, but also opportunities that need to be understood in international comparative terms: strong industrial bases, diversified economy, and supply chain and knowledge networks' complexity (Amsden, 2001 ; Hidalgo and Hausmann, 2009).

Approaching this question requires the setting-up of a large task force for the "observation" of industrialization, to cover various aspects, including:

- The geography and dynamics of economic development and specialization – how scientific, technological and industrial bases evolve and impact socioeconomic development.
- The structure, geography and dynamics of supply chains and knowledge networks in different sectors and markets.
- The structure and availability of human resources and competences, as the basis for industrial activity.
- Policy tools to foster local industrialization processes (e.g., public procurement, local production agreements, public expenditure in R&D and training).
- Deindustrialization processes, characterizing them and identifying, analyzing and governing related risks.

It should be clear that a new generation of industries will drive the economic recovery over the next decade, fuelled by long-term changes in technology, society and geopolitics. The recession has not been only a point of change, and many argue that it has acted as a catalyst

for growth. As the business landscape alters, we will see the emergence of new ways of doing business in an increasingly interconnected world.

It is our understanding that under this framework, research should look at how industry is distributed, and how production is done across countries and regions, and how capabilities are being used in different countries and regions. In fact, this framework is leading to several research programs in centers and universities around the world, including the “Production in the Innovation Economy” project at the MIT (Berger, 2005), and leading to a significant body of research in Brazil on industrialization, namely through regulation and local content policies (Apolinário e Silva, 2011; Cassiolato *et al.*, 2008; Salles-Filho *et al.*, 2010).

To propose such a research agenda, this paper starts by looking at industrialization and employment in section two, where we show the evolution of industrial activity in the world, and its relation with employment. Section three following presents the background on the role of knowledge capabilities and R&D in the development of industries. In section four we propose a strategy to develop the research agenda through the development of new indicators, while considering different scales of analysis, the analysis of skills and competences and industrial case studies, looking also at the role of new technology based firms. The last section presents a summary.

2. Industrialization and employment

Industrialization has been the main driver behind rapid productivity growth achievement and social well-being improvements in different countries in the last 200 years (Murphy *et al.*, 1989). Over the last century, the world’s industrial landscape has been changing showing a shift towards emerging Asian and Latin American economies in the last decades. Industries have emerged, evolved and migrated to new countries. This transformation reflects the emergence of China, South Korea, India, Brazil, Mexico and other developing countries as major economic powers (Hepburn, 2011). The Asian shift is not new, as more than 50% of the world’s industrial trade was produced in China and India since 1750. This growth of emerging countries is affecting the world’s geography of industry and pattern of industry employment.

As a consequence, there is an increasing concern that deindustrialization is hampering growth and undermining the competitiveness of developed economies leading to loss of jobs (Wessner and Wolff, 2012). In many developed regions recent deindustrialization trends resulted not only from the mentioned emergence of new and fast-expanding markets, the surge of new pools of cost-efficient workforces, but also from the emerging countries’ aggressive development policies.

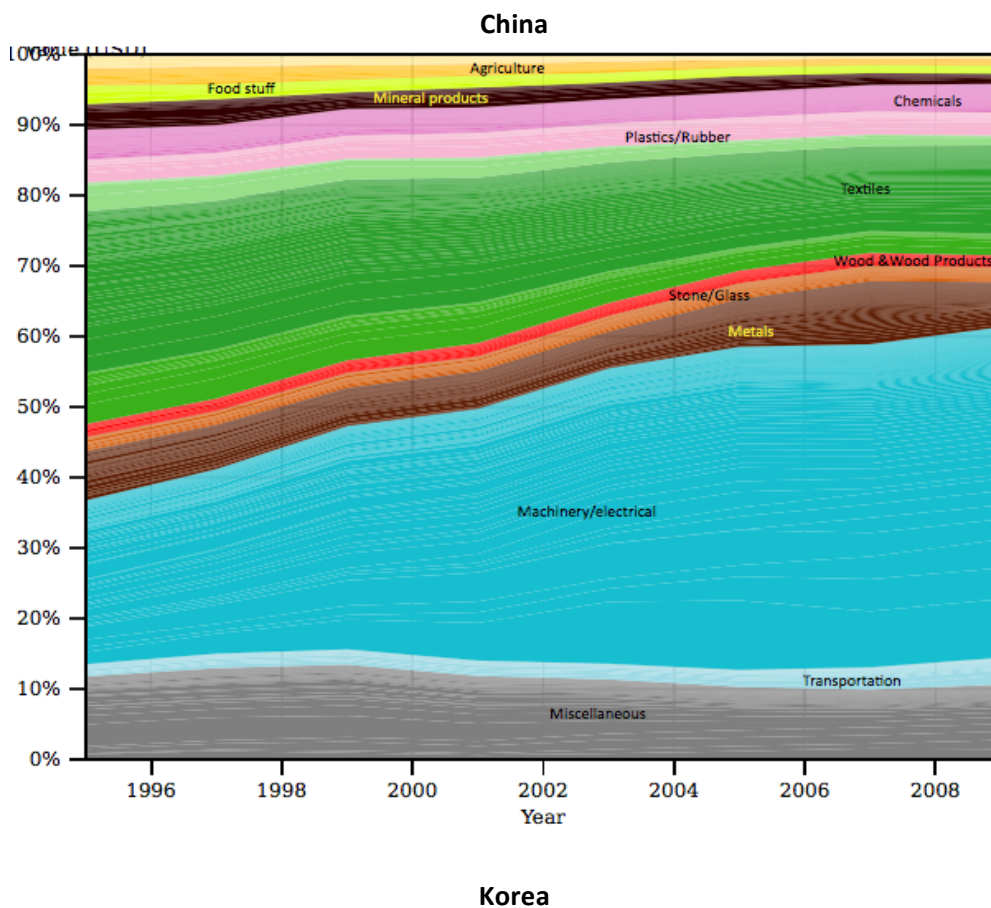
In many economies the weight of manufacturing in the economy has been decreasing substantially over the last decades, followed by an increase in services, and production has been concentrating in certain regions, while others have been increasingly losing their productive ability. In agreement, policies in the last 20 years have been favoring the development of knowledge intensive services oriented towards short-term growth and the

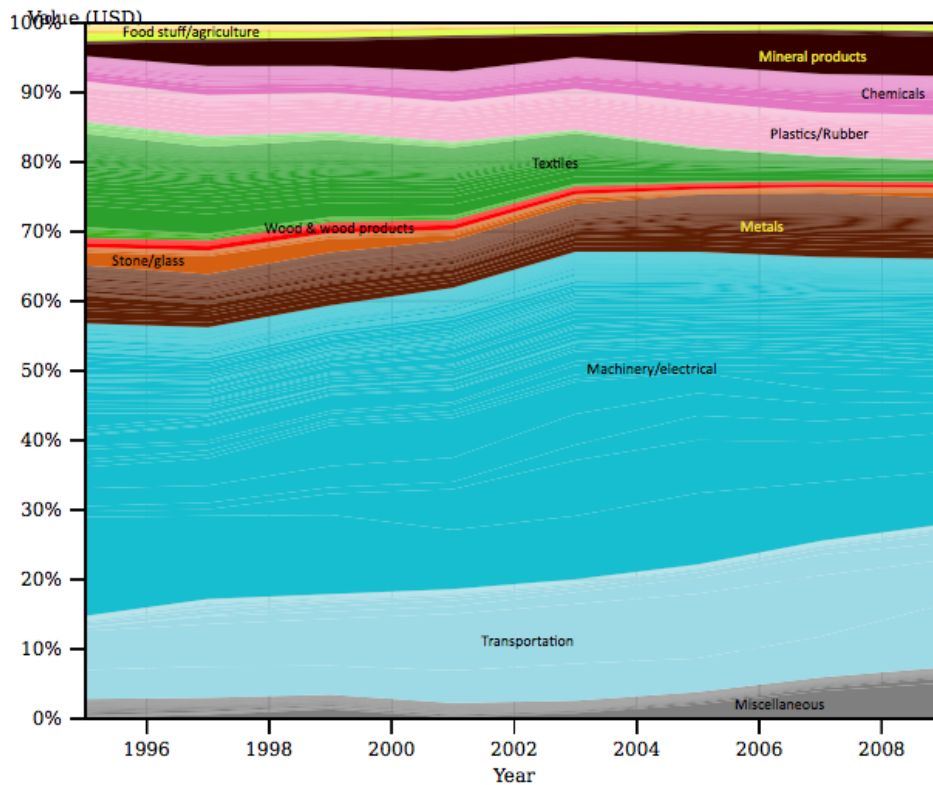
financial markets (Johnson, 2002). Parallel to this process of “technoglobalism”, post-industrialism advocates have promoted in the last decades services as a new panacea for rapid economic growth in developed - and developing - countries, overtaking the role of manufacturing industries as drivers of growth (Bell, 1973; Kelly, 1998; Naisbitt, 1982).

In an increasing manner, growing emerging economies are shifting to higher added value components of international supply chains, while their physical, human and institutional capital strengthens, and begin to compete directly with the more developed ones (Spence and Hlatshwayo, 2011). This trend is visible when looking at China’s exports manufacturing structure, which has been shifting in a similar way to Japan and Korea did, going from labor-intensive products, to more capital intensive products, eventually to move to human-capital intensive activities.

Figure 1 shows the evolution of exports for China and Korea for the period 1995-2009. China is in a catching-up phase, and it is making a clear move out of apparel, textiles, footwear, and toys and a move into electrical machinery, telecom, office machines, and to a lesser extent metals, leading to a very different product export distribution from the early 1990s (Amiti and Freund, 2007). Korea’s pattern is already different, as it had been catching up before, by developing their industrial capacity first, and later their science and technology (Hollanders and Soete, 2010).

Figure 1 - Evolution of exports in China and Korea per type of product - 1995-2009



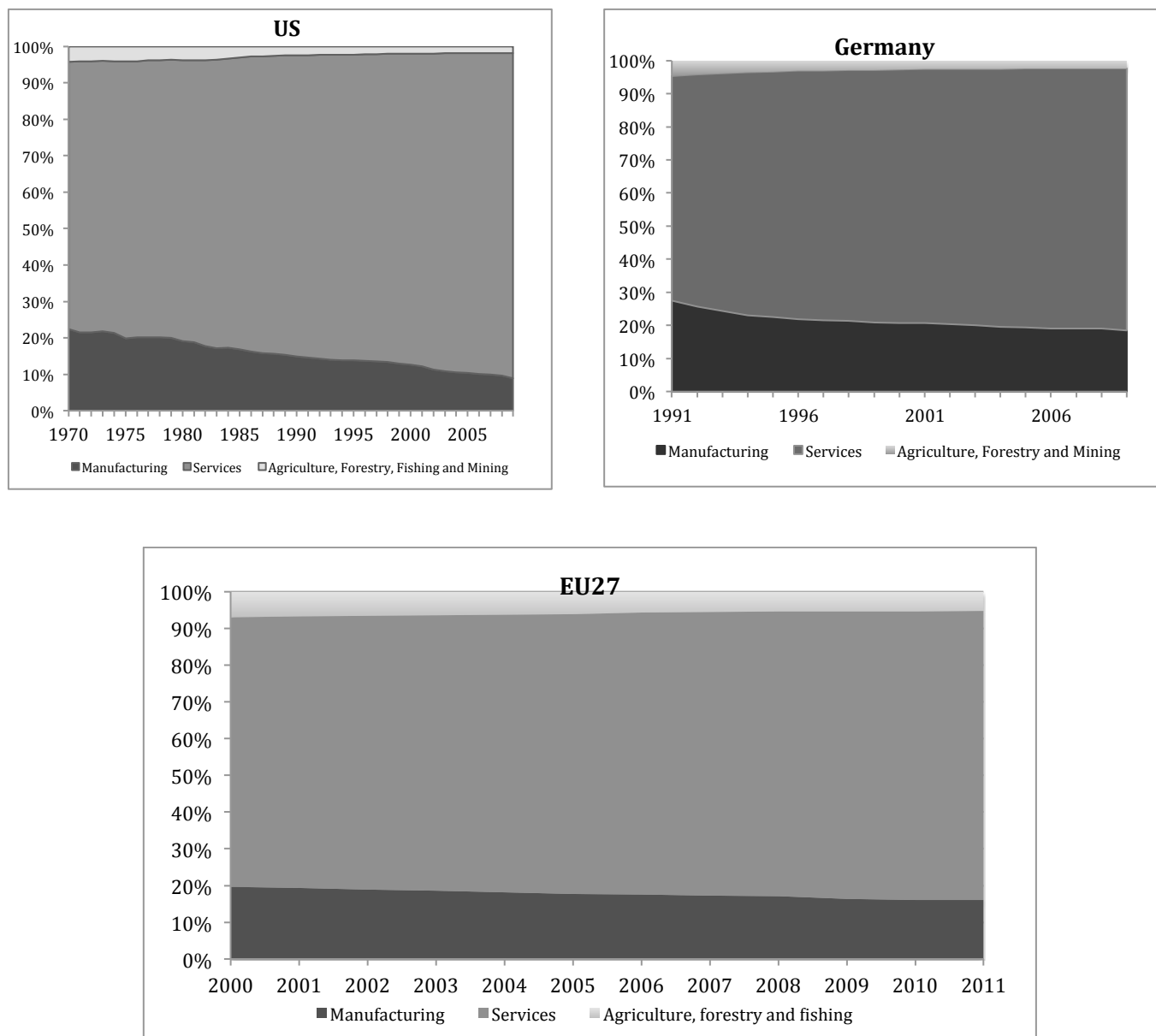


Source: Atlas of economic complexity

In the US, the weight of manufacturing in the job distribution has decrease around 40% since the 1980's, as the number of U.S. manufacturing jobs declined from 20 million in 1979 to about 12 million 30 years later (OECD, 2010 and Tassej, 2010). The loss of employment in manufacturing in the US, illustrated in figure 2, was caused by out-migration of functions in global supply chains, associated with lower value added per job (Spence and Hlatshwayo, 2011). One of the issues resulting of the changes in geographic location is that, as the emerging markets grow, they also start to compete for more sophisticated functions, allowing the out-migration of more valuable parts of the supply chain and increase competition for higher paid jobs. In fact, firms from these emerging economies are growing and moving upstream in the value chain (Hollanders and Soete, 2010).

Several authors argue that the evolution in Germany has been different, as they have been relying more on manufacturing, with a lower impact on job distribution. In fact, Germany experience a lower reduction of people employed, but still showing a 30% decrease in the number of people employed in manufacturing. But naturally, the evolution of Germany has to be seen in the context of the European Union, where employment in manufacturing decreased slightly in a 10-year period.

Figure 2 - Evolution of job distribution by sector in the US (1970-2010), Germany (1991-2010) and the EU 27 (2000-2011)



Source: OECD - STAN

At the same time, the total employment grew substantially in the US, based mainly on the non-tradable sectors, with government and health leading this generation of new jobs (Spence and Hlatshwayo, 2011). This was a result of “policy shifts” from manufacturing industries to knowledge-intensive services in developed regions worldwide (Ghani and Kharas, 2010 and Hepburn, 2011), including the US, but with the notable exception of countries such as Germany.

Evidence shows that an over-reliance on services, without an adequate balance with industrial activity, damages export performance, reduces labor productivities and favors

inequality (Sirkin *et al.*, 2011), and that consequently, deindustrialization may lead to increases in unemployment and export capacity, becoming a social economic risk. In fact, considering that jobs in services are not likely to continue its increasing pace, and given the increased global competition for employment in manufacturing, this (des)equilibrium between sectors may lead to major employment problems (Spence and Hlatshwayo, 2011). Cowie (2001) has shown that the end of deindustrialization is usually social turmoil, triggering other systemic risks related to Social Unrest (Jovanovic *et al.*, 2012).

These two risks have a reciprocal causal relation between them since deindustrialization leads to social unrest and the latter leads to deindustrialization while socially instability hinders attracting and retaining industrial activities. This is an issue not only for developed and industrialized countries, such as the US, which is losing ground to other economies, or European peripheral countries which are increasingly focused in services; but this is an issue also for developing countries such as Brazil, for example, where there are few world-class industrial “islands” disconnected from the rest of the country.

Nevertheless, industry production in the world has increased. Evidence shows that, when compared to services, manufacturing activities are associated with higher productivity levels, and more balanced income distributions, higher income growth rates, and more ability to generate exports (Fingleton, 1999; Sirkin *et al.*, 2011). In addition, manufacturing activities today require the existence of a group of services provided to manufacturing, which leads to the generation of more jobs and a higher diversification on job requirements. Given the changes of the nature and complexity of manufacturing and localization of production, and the ability to react to exiting economic changes, the future of manufacturing is developing in an environment of far greater risk and uncertainty than ever (Manyika *et al.*, 2012).

3. Knowledge capabilities

Endogenous growth theories treat R&D investment and education as endogenous variables in the long run of economic expansion, placing strong emphasis on the role played by knowledge creation and commercialization in promoting economic growth (Romer, 1990; Aghion and Howitt, 1998). The commercialization of knowledge depends on knowledge generation by universities and public R&D labs, as well as on R&D activities by firms, (Jaffe, 1989; Cohen and Levinthal, 1989). Also, formal training in science and engineering has become essential to gain command over industrial technology (Ostry and Nelson, 1995). In this context, the development of the scientific knowledge with the ability of valuing it economically is particularly important, allowing the use and advantage of the spillover effects, essential for economic growth.

Spillovers occur whenever a firm shares knowledge with other institutions performing R&D, such as other firms, universities and government institutions (Griliches 1992). If information about new technologies, goods and processes flows locally more easily than over great distances, then establishing direct contact with entities that can produce knowledge which is valuable for a firm’s activity should be one of the main driving forces leading to the

geographic concentration of both production and innovative activities. As new knowledge can spill over, it is possible that one person may discover an opportunity and different person may use the opportunity to exploit it. Such knowledge may be more than just about products and processes, and it can include also organizational forms, management procedures, or other industry trends (Anselin *et al.*, 2000; Gilbert and Kusar, 2006). In addition, Murphy *et al.* (1989) argue that there are spillover effects of industrialization, that is, that industrialization in one sector can increase spending in other manufacturing sectors by altering the composition of demand.

Processes related with diversification and industrial specialization are complex and essentially related with learning processes and incorporation of knowledge and technology in people and organizations. Research and development has become the primary means by which firms gain understanding over new products and processes, which allow them at least to keep up with the technology evolution (Ostry and Nelson, 1995). Consequently, the competitiveness of industries lies in the ability to produce and use knowledge and technologies mostly developed in a wide network of institutions consisting on a distributed knowledge base (Conceição and Heitor, 2005).

Important factors to manufacturing industries include access to low-cost and/or high-skill labor; proximity to demand; efficient transportation and logistics infrastructure; availability of inputs such as natural resources or inexpensive energy; and proximity to centers of innovation (Manyika *et al.*, 2012). Employment and its skills are paramount to ensure the sustainable development of industries and the socioeconomic impact of industrialization, and this is also true at firm-level. However, as reported by Sirkin *et al.* (2011), firms tend to focus on short-term results, not providing appropriate training of their own employees, not using their workforce inputs, and not applying technology to develop or improve products. According to Sirkin *et al.* (2011) “Japanese manufacturers were far more likely than U.S. companies to apply the concept of continuous improvement, seeking to make frequent, incremental changes to their products and production lines.”

Certainly, innovation and ultimately competitiveness require knowledge boundaries to be much wider than the production ones (Brusoni *et al.*, 2001), exploring historical perceptions of the utility of scientific knowledge, labor division and the shape and emergence of contemporary institutions of knowledge and innovation (Baark, 2007). The production, acquisition, absorption, reproduction and dissemination of knowledge are crucial in determining competitiveness and fostering innovative activity (Audretsch *et al.*, 2004). The most decisive input in the knowledge production function is new economic knowledge; however, the generation of new economic knowledge requires a high degree of human capital, a skilled labor force and a high presence of scientists and engineers (Audretsch, 2002).

In addition, the success of this knowledge absorption requires qualified human resources able to, acquire the knowledge, use it, and diffuse it. As established by Cohen and Levinthal (1989), firms differ in their ability to absorb the pool of new knowledge resulting from research that becomes accessible, independently of the degree or nature of its

development. This is relevant not only to firms, but to other forms of organizations and contexts, such as regions and countries. Previous research also shows that local access to knowledge and human capital significantly influence entry of knowledge-based firms into regions (Baptista and Mendonça, 2010).

Also, Borrás and Domingo (2007) argue that innovation in a region depends on its own R&D efforts, its innovative tradition and its human capital endowments, and that the composition of economic activity has a positive effect on innovation, and the more specialized regions are, the more innovative activity they have. Accordingly, Acs and Armington (2004) found evidence that cities with higher average levels of human capital and with more knowledgeable people grow faster, confirming the need to look at (de)industrialization processes with a regional focus, without losing sight of the context and taking into account knowledge and innovation capabilities of countries and regions.

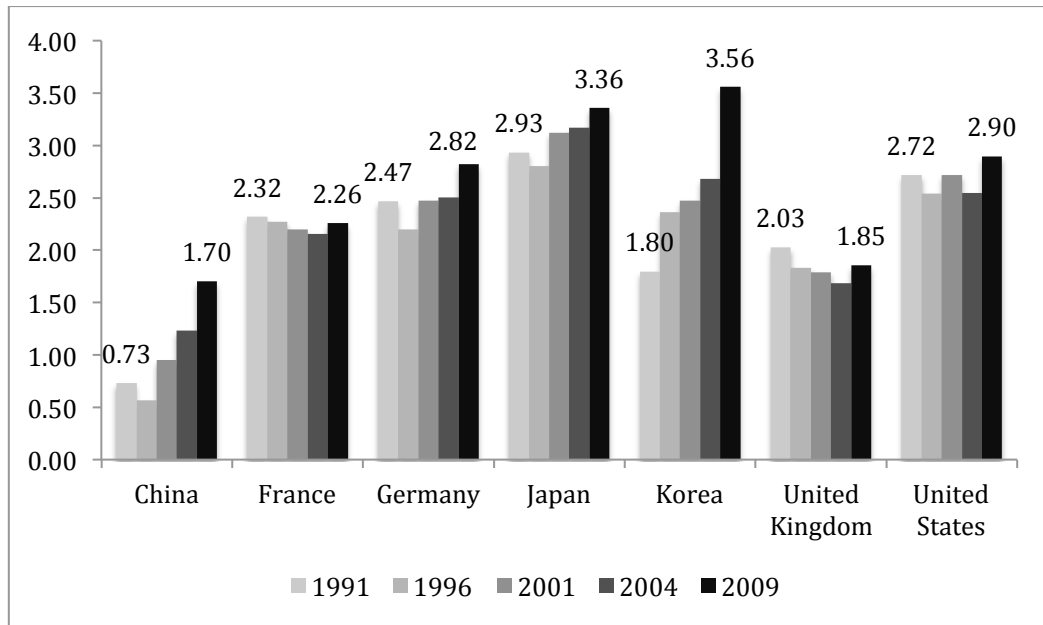
Regions and countries with more human capital will tend to be more innovative and entrepreneurial, thereby growing faster. Also, according to Hausman and Hidalgo (2009) more diversified countries produce more complex products, in the sense that they require a wider combination of human capabilities, and higher complexity is associated with higher economic growth. In addition to the presence of strong industrial bases, most of the well performing economies share other common features. One is diversification of activities, meaning that the economic output and that of industrial manufacturing in particular is distributed across a broad set of activities, which allows for mitigating risks but also for enhancing the capacity of the innovation system and the growth potential of the economy as a whole. This diversity can be found in countries such as Korea or Taiwan (Amsden, 2001; Berger, 2005).

Other common feature is supply chain and knowledge networks' complexity, related to the interactions between people and organizations measured in terms of the activities and job positions needed to produce and certain good within an economy. In fact, one possible explanation for differences in GDP between countries is that some of the individual activities that arise from the division of labor, such as property rights, regulation, infrastructure, specific labor skills, cannot be imported, which implies that countries need to have them locally available in order to produce. Therefore, countries' productivity resides in the diversity of its available nontradable "capabilities," and therefore, cross-country differences in income can be explained by differences in economic complexity, as measured by the diversity of capabilities present in a country and their interactions (Hausman and Hidalgo, 2009).

Despite the evident benefits from industrialization and the success of many countries in achieving it, numerous other countries remain unindustrialized and poor, and processes allowing some countries to industrialize but not others are not completely understood (Murphy et al, 1989). Part of the explanation is the ability to create and produce knowledge, and to invest in knowledge in a sustained way. Several authors have argued that there is a relationship between the R&D investment and economic growth, and Ostry and Nelson (1995) discuss that the high R&D investment explained the American lead in high-technology

products in the 1960s. Figure 3 shows the evolution of R&D expenditure in several countries since 1991 to 2009. In this time period, the share of GERD in GDP increased substantially in Japan (from 2.93 to 3.36 %), more than doubled in China (from 0.73 to 1.70), and doubled in Korea (1.80 to 3.56%), the last overtaking the investment of UK, US, Japan, France and Germany. For the same time period, the investment in US and Germany was stabilized, and France and the UK showed a slight decrease.

Figure 3 – GERD as share of GDP - 1991-2009



Source: OECD-MSTI

As emerging economies increase their R&D investment and their knowledge capabilities, multinational companies will tend to decentralize their research activities also to these locations, with clear benefits in reducing labor costs and increasing access to markets, local human capital and knowledge in all their locations (Hollanders and Soete, 2010). In addition, firms from emerging countries are acquiring firms in developed regions, gaining their knowledge capital in the process, also contributing to the global changes on the distribution of R&D (Hollanders and Soete, 2010).

Hausman and Hidalgo (2009) suggest that changes in countries' productive structure can be seen as a combination of the process by which countries find new products as unexplored combinations of the capabilities they already possess, and the process by which countries accumulate new capabilities and combine them with other previously available capabilities to develop yet more products. China and Korea for instance, have successfully changed their industrial structure, with a significant increase in investment in knowledge creation (figure 3).

According to them, cross-country income disparities can be explained by differences in economic complexity, as measured by the diversity of capabilities. Therefore, diversity of capabilities can explain differences in economic performance of countries and regions, and

the productivity of a country resides in the diversity of its available nontradable “capabilities” (Hausman and Hidalgo, 2009). Thus, diversification is associated with socioeconomic resilience, or the capacity of firms, regions or countries, to recover following a disturbance or disruption, coming from a crisis, for example. Investment in R&D may provide firms, and regions, the capabilities needed for diversification and the to becomes more resilient. If this is true, changes in R&D performance should affect the ability to compete. However, additional research is needed to clarify how this relationship truly develops.

4. A strategy for action a research

For many developed regions deindustrialisation trends resulted from the emergence of new and fast-expanding markets; the surge of new pools of cost-efficient workforces, as well as emerging countries aggressive development policies.

The consequences for developed economies’ competitiveness and social well-being have been studied by historians, economists and engineers (e.g. Nairn (2002), Fingleton (1999)) and the over-reliance on services has been shown to damage export performance and favour ill-balanced social development, among other claims. Following this literature, we propose a new research agenda, integrating a strategy following different complementary directions.

On the one hand, acknowledging the lack of existent indicators allowing for an understanding of the industrialization phenomena in a multi-scale perspective, leads us to the need for research analyzing existent data and understanding of the best measures and indicators to be used in this context. Another gap that needs to be addressed is related to the inadequacy of the existing framework to capture the complexities of current supply chains and competitive environments.

Following this argument, we propose an approach focused on people and competences, not common in the existent research, and aim to focus on specific sectors. The role of new technology based firms should be integrated, as part of the analysis on the emergence on new industries. In the end, we wish to build on visualization and communication methods to allow comprehension of this issue and public debate. The proposed strategy is detailed further in this section.

Applying Indicators and measurements

Following the Marshallian specialization argument, regions specialized towards a particular industry may be more innovative in that industry because knowledge may spill over easily between similar firms which can be assumed to have higher absorptive capacities in that particular industry. Andersson *et al.* (2005) find that the level of innovation is positively influenced by the diversity of the employment base, providing support to the specialization

hypothesis. The local levels of knowledge creation and acceptance of new ideas will depend on the local human capital, not just the levels of education, but also on the diversity of skills.

One of the common issues when looking at industrialization is the need to use a set of indicators to fully characterize industrial activity in regions and countries. Grimpe and Mendonça (2010) propose a measure accounting for the specialization of skills in a region, based on a simple concentration measure. Heitor *et al.* (2012) focus on the flows and movement of people. Making use of additional concentration and diversity measures, such as Herfindhal type of measures, new indicators should be developed to help characterize industries in regions and countries. These indicators should allow, for instance, the analysis of the evolution of diversification of industrial activity in different geographic areas, such as regions and countries, based on the export evolution, or the profile of human capital, thus allowing to capture a picture on world level of diversification, in an evolutionary way.

Considering different scales

Research shows that deindustrialisation is hampering growth and undermining the competitiveness of developed economies, leading to loss of jobs and increased exposure to phenomena like the current economic crisis. In fact, countries in which the effects of the crisis were more severe are among the ones showing stronger deindustrialisation trends over the last decades (e.g. Greece, Ireland, Italy, Portugal and Spain). Nevertheless, existing research lacks a comprehensive approach to industrialisation and its effects on socioeconomic development that builds on the historical evolution of the geographies of industry and innovation to understand the dynamics of these processes at the different scales.

The overall issue of a necessary industrial base to foster socio-economic resilience requires engaging main stakeholders on driving innovation policies. First, most of the existing international comparative assessments provide a rather “techno-nationalistic” approach, ignoring the increasing internationalization of private business strategies over the last decades, while government innovation polices remain overwhelmingly national.

Second, most of the comparative analysis available in the literature is missing a correct international context. For example, the case of Germany (or Flandres, or other central European regions) competitiveness, which is so correctly applauded, can only be discussed in the current European and, above all, EURO-region context. This is because understanding the continuous strengthening of Germany (or central European) industry over the last decades of European economic integration requires a broader view of the parallel de-industrialization of European peripheries, namely in the south and eastern parts of Europe.

Therefore, the analysis should include several geographic scale, including:

- Macro-level geographies, to characterise the dynamics, relations and geographies of the system industry-knowledge-people;

- Regional geographies, for comparative analysis on the evolution of industrial diversification and complexity, trade flows between regions and sectors, and existing public policies;
- Industrial geographies, for encompassing the specificities of different industrial sectors and how they are affected by relative globalisation, capital intensity, technological dependence and resource base.

In addition, a time dimension should be added to these spacial dimensions, to allow consideration of path dependence processes.

Looking at people, skills and competences

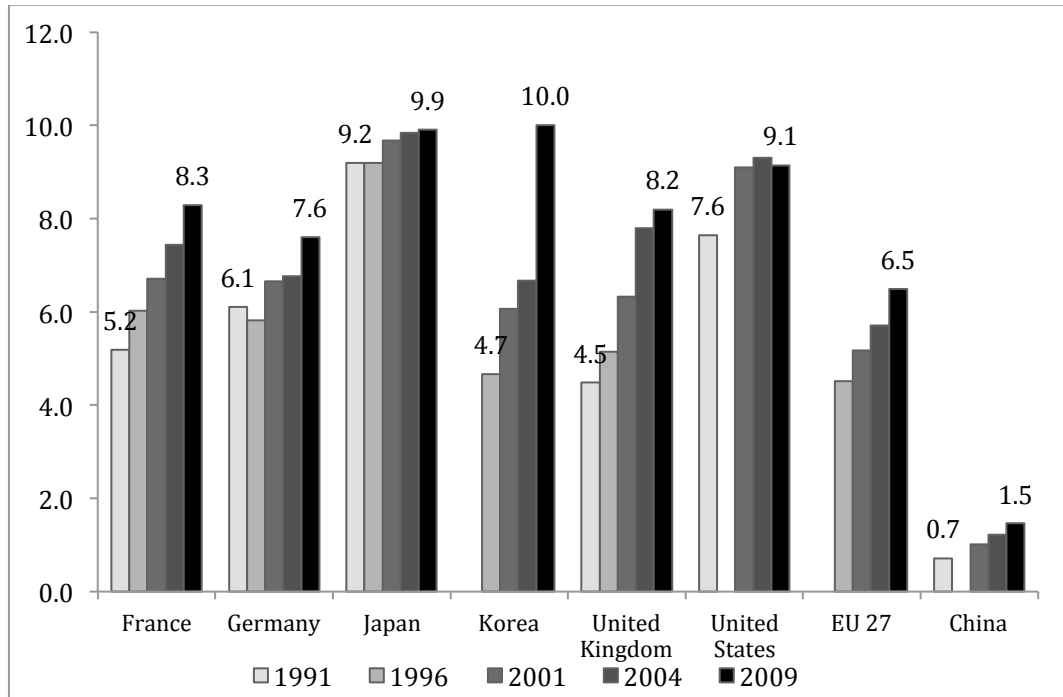
It has been long acknowledged that human capital is central to our understanding of technological change and economic growth (Lucas, 1988) and human capital investments, namely expenditure in formal education and training, can explain the production advantage of the most advanced countries (Schultz, 1961).

Knowledge, embodied in individuals, can build the sources of competitive advantage by firms and regions (Teece, 1998). Also, the number of people skilled in the appropriate fields, and the state of knowledge, are amongst the most important factors determining innovation (Nelson, 1962). In fact, one possible explanation for differences in GDP between countries is that some of the individual activities that arise from the division of labor, such as property rights, regulation, infrastructure, specific labor skills, cannot be imported, which implies that countries need to have them locally available in order to produce.

Countries' productivity resides in the diversity of its available nontradable "capabilities," and therefore, cross-country differences in income can be explained by differences in economic complexity, as measured by the diversity of capabilities present in a country and their interactions (Hausman and Hidalgo, 2009). Therefore, the issue is how regions and economies develop processes of transforming human capital into competitive advantages in different sectors, are able to contribute to knowledge generation and commercialize technology and from there acquire socioeconomic resilience.

Figure 4 illustrates the number of researchers in the working population of several countries, showing growth in the number of researcher for most countries, except a stable number in Japan, which already had a high share of researcher in the labor force. Again, this figure shows the increase effort of Korea in R&D, and the more recent growth of China, which doubled its proportion of researchers in the population.

Figure 4 – Researchers per thousand workforce



Note: Last Data for the US refers to 2007

Source: OECD-MSTI

The issue is certainly how far we all take advantage of opportunities that arise with the increasingly dynamic and globally distributed geography of innovation, as well as how it fosters a new global order and help others to use similar advantages at local levels. Certainly, availability of human capital plays a key role.

This is because one must take up the challenge of probing deeper into the relationships between knowledge and the development of our societies at a global scale. Our inspiration comes from, among others, the seminal work of Lundvall and Johnson (1994), who challenge the commonplace by introducing the simple, but powerful, idea of learning. Lundvall and Johnson (1984) speak of a “learning economy”, not of a “knowledge economy”. The fundamental difference has to do with a dynamic perspective. In their view, some knowledge does indeed become more important, but some also becomes less important. There is both knowledge creation and knowledge destruction. By forcing us to look at the process, rather than the mere accumulation of knowledge, they add a dimension that makes the discussion more complex and more uncertain, but also more interesting and intellectually fertile in an international context.

This view follows closely the lessons Eric von Hippel, at MIT, has provided in recent years based on the American experience that user-centered innovation is a powerful and general phenomenon. It is based on the fact that users of products and services - both firms and individual consumers - are increasingly able to innovate for themselves. It is clear that this is growing rapidly due to continuing advances in computing and communication technologies

and is becoming both an important rival to and an important feedstock for manufacturer-centered innovation in many fields.

Eric von Hippel has also shown that the trend toward democratization of innovation applies to information products such as software and also to physical products, and is being driven by two related technical trends: first, the steadily improving design capabilities (i.e., innovation toolkits) that advances in computer hardware and software give to users; and second, the steadily improving ability of individual users to combine and coordinate their innovation-related efforts via new communication media such as the Internet. More educated people have a higher ability to generate and create their own products, as users. So, the focus on people and competences needs to take into account the existence of users with the ability to create and commercialize products, thus engaging directly in the production processes, and contributing to new industrialization processes.

In other words, beyond suitable technical infrastructure, the process of “democratization of innovation” at a global scale requires people with the ability to engage in knowledge-based networks without borders. It is about people and knowledge beyond national borders, and this constant interaction has gained particular importance in recent years.

We argue that to add to this analysis and truly contribute to the literature, we must look in more detail to people and competences, and make efforts to understand the role of people and knowledge in fostering socioeconomic resilience.

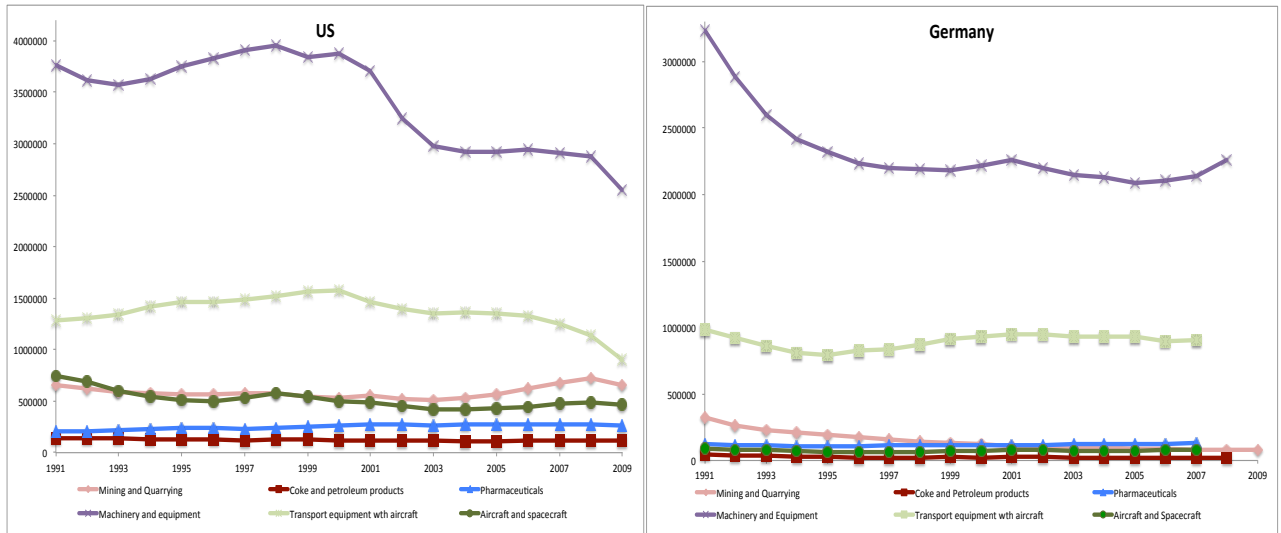
Industrial case studies

According to Spence and Hlastshwayo (2011), “Nonauto transportation equipment production was a major contributor to job losses in the tradable sector in the US since 1990, and the vast majority of the loss occurred in the aerospace”, mainly due to relocation of production and shifts in investment in certain fields.

Looking at the evolution of jobs in manufacturing in the US using a standard NACE classification, and narrowing in a few selected industries, as shown in figure 5, air and spacecraft have lost 30% of their jobs in a 30 year period, and machinery and equipment, including computer, electronic and electric products and instruments have lost 45% of the number of jobs in the same time period. This decrease was followed by a growth in the number of jobs in certain tradable services, such as the computer systems design and related services, and management, scientific and technical consulting (Spence and Hlastshwayo, 2011). This evolution in Germany is different; machinery and equipment suffered a decrease in the early 90’s, but was then stabilized, employment in the transports, Oil and Pharmaceutical have remained stable to a certain extent.

In addition to employment changes, evolution in value added, can provide information of the position of the sectors in the economy. Decreases in value added of a certain industry in a country may mean that the industry is in decline, or that value added is being created in different countries.

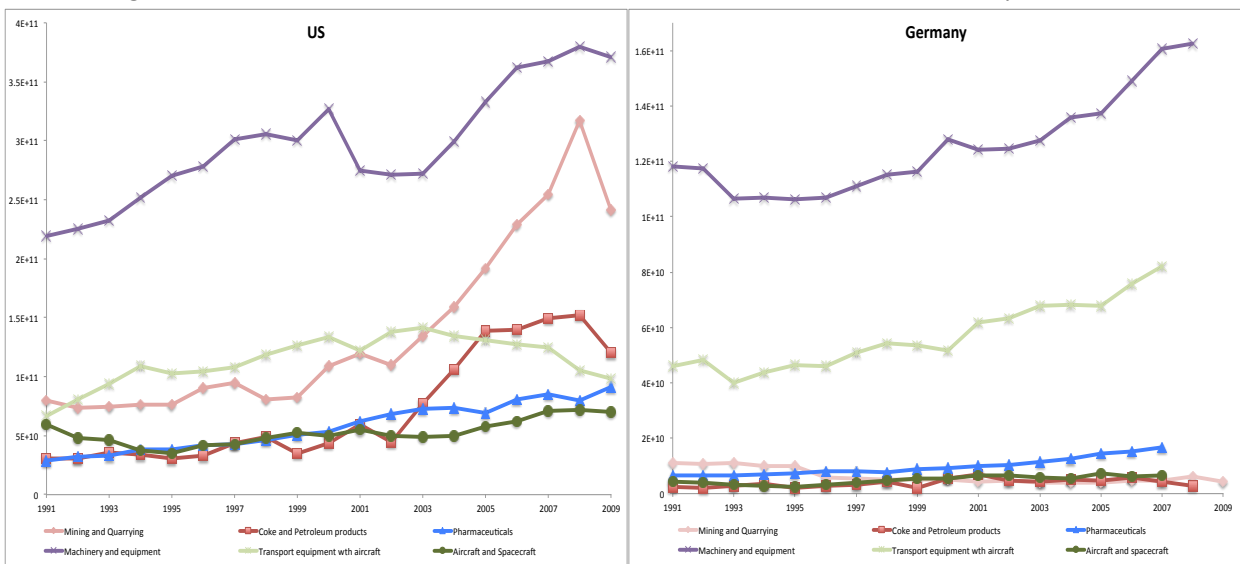
Figure 5 – Evolution of jobs in selected industries – US and Germany - 1991-2010



Source: OECD/STAN

Information of value added for the US in figure 5 tell us that even though sectors such as machinery, which includes computer, electronic and electric products and instruments, where employment decreased, show an increase in value added for the same time period. This is explained by the relocation of parts of the value chain with lower value-added (Spence and Hlastshwayo, 2011). Comparing with Germany, differences appear mainly in the Oil sector, likely due to differences in industrial structure. The issue is, as emerging economies grow and begin to have other competences and availability of knowledge and human capital, they start to be able to host more valuable parts of the value chain.

Figure 6 – Evolution of added-value in selected industries – US and Germany- 1991-2010



Source: OECD/STAN

These analyses are very important for an overview of manufacturing in general, but do not allow going deeper in details, such as the level of local content in supply chains of sectors. Therefore, it becomes necessary to study industrialization and deindustrialization processes, by developing a systematic analysis of local content and supply chains in specific sectors, looking at the international evolution and industrial geography in more detail, and look at the evolution of competence availability in different economies. Given the scaling up of manufacturing in emerging economies in the supply chain, jobs in these strongly knowledge intensive sectors have a greater risk, and their relocation may have stronger impact by moving the need for very highly skilled competences in other regions, thus losing human capital and knowledge creation potential.

It is clear from this general view, that sectors differ in their degree of complexity and the configuration of their supply chains, and the extent to which parts of their activity can be relocated, and the degree of knowledge complexity and production. For instance, focusing on the internet industry, Jansson (2008) finds that firms tend to locate in close proximity to each other because of the importance of dense informal interpersonal networks that facilitate the search for new customers and collaborators.

In the biotechnology sector, Bagchi-Sen (2007) concludes that most of the relationships are not confined to the local area and that the main local attributes are the science base or the labor market. In a different context, Alecke *et al.* (2006) explore the geographic concentration of German manufacturing industries, and relate it to industry characteristics and agglomeration forces proposed by theory, finding that there is no general relationship between agglomeration and R&D or high-technology related activities, suggesting that the desire to develop of high-tech clusters might not always be fruitful. Markusen *et al.* (1986) argue that high-tech firms are likely to locate in areas that are attractive to highly skilled professional and managerial talent, or to areas that offer a pool of weakly organized, poorly paid assembly workers.

The different literature mirrors industry idiosyncrasies, thus sustaining the need to look in detail to specific sectors, without which it is not possible to understand issues related with the supply chains of sectors and competences associated with them. Labor productivity growth is increasingly being concentrated in knowledge intensive activities, ICT services and high technology and medium high technology manufacturing. Trade in high technology goods, such as aircraft, computers, pharmaceuticals and scientific instruments, accounts for more than 25% of total trade, which represents a significant increase over the last two decades. This trend is followed by an increase in the generation and use of knowledge through investments in R&D, use of ICT, patenting, and development of scientists and engineers in the OECD countries (OECD, 2003). Thus, analysis should focus on strategic industrial sectors among these, such as Aerospace or Biotechnology, since they have complex supply chains, are knowledge intensive and very sensitive to public policies. In contrast, analysis should include sectors where delocalization is not possible, but have a high degree of complexity, and knowledge and technology dependency for the future, such as Oil&gas and pharmaceuticals, which may allow for comparison and inclusion of different factors.

In addition, we argue for the need to build a new methodological framework able to grasp the complexities of the current competitive environments, which should be build on the work of Pavitt (1984) and further developments (See Archibugi, 2001). Much of the information characterizing industrial activity is based on classifications allowing to group production in classes for a better understanding of the entire industry. However, as Spence and Hlastshwayo (2011) state, “Tradable and nontradable parts of the economy do not line up perfectly with conventional industry definition” and complex value-added chains usually include tradable and non-tradable components. For sure, the existing NACE classification does not allow for a meaningful categorization of industrial sectors, in a way that captures the complexity of current supply chains since. In addition, many of the so called “low tech” sectors have incorporated highly complex technology in their production methods, which makes them highly technology intensive, which is not portrayed by classifications in use. Pavitt’s taxonomy was developed on the basis of empirical evidence of firms’ innovative activity, classifying firms within sectors by their technological competence (Archibugi, 2001). Naturally, his proposed taxonomy has evolved over the years, and many authors have contributed to these developments. What we propose is to add to this research with the collection of empirical observation, looking at different firms and sectors, and adding to the technology a dimension on competences and skills, as Archibugi (2001) suggests, an evolution based on value added and employment. This analysis will allow for an understanding of industrial activity far beyond the existing classifications, and provide the basis for a new evolved taxonomy.

Engaging new technology based firms

Technology-based entrepreneurship is increasingly seen as a key element of regional competitiveness and that has been taken as “the model” for many other regions and countries worldwide. Knowledge creation and knowledge spillovers are essential elements in stimulating economic development, and technology based firms are seen as an important source of new employment and important promoters of technological change (Feldman and Audretsch, 1999). Silicon Valley and Route 128 in the Boston-Cambridge area, the most dynamic regions in the world today in terms of growth and innovation, were propelled mainly by new technology and the creation of startups - Apple, HP, Google, and Intel, to name a few. Naturally, the formation of Silicon Valley cluster did not occur suddenly; it was a process that evolved over 40 years and it was a process that was only possible due to a set of condition that came together, such as new ideas, creative people and a culture of risk taking (Venkataraman, 2004).

Start-up companies are also becoming global enterprises and engage in services, manufacturing, and research throughout the world, with strong links to universities and research groups. Others are going beyond their borders to procure products and services at lower prices, often from new companies or subsidiaries in countries like China, India and Brazil. Well-trained engineers and computer scientists from Bangalore and Shanghai are competing for jobs that traditionally went to their counterparts in Europe and the US. At the same time, research universities worldwide are attempting to “emulate” their US counter

parts and foster a range of technology transfer offices and commercialization activities, together with industrial liaison programs, mostly intended to foster entrepreneurial environments and the launching of technology-based start-ups. Bringing ideas to the market is their main goal.

Notably, beyond the concentration of people and skills in a number of regions, a key issue that has differentiated North America from many other countries and regions is the availability of a mix of public and private funding sources, in a quite diversified pattern and, most of them, of easy access to SME's. It is in this context that a few countries have tried to emulate the SBIR program ("Small Business Innovation Research"), which remains unique in many of its characteristics. Although many difficulties have been found in the public support to continue SBIR (as well as that of TIP at NIST), its enormous success and impact should be further acknowledge. This is a program of the outmost importance and relevance that has helped American innovative firms to growth. In addition, many other schemes to fund and support new technology-based firms have been used in America in quite original ways, namely through public procurement through the Defense and Energy Departments.

It is clear that the issue of industrialization cannot be addressed without having into account the role of new firm creation on the development of new industries, namely those coming from the academic environment and built from highly qualified individuals. Nevertheless, their role in the building of new industries and their potential contribution to industrialization processes are yet to be understood.

Visualization: Seeing the results

Development of this research strategy will produce information characterizing industrial activity, especially concerning people and industries. Thus, based on location and distribution of the sectors value chain we wish to develop a map of industrial activity, starting with specific industries, as a means to develop a broader conceptual framework to apply to all industries. In addition, visualization mechanisms will be developed to include competences for industrialization in different regions. This will lead to the elaboration of a web-based which will enable the analysis of the evolution of the geographies of industry, innovation, science and competencies/human capital.

This tool is also intended to play a visible role in the global development of a better understanding of the role of science and technology and innovation in industrial development processes and their impact on fostering economic competitiveness, social well-being to ultimately develop socioeconomic resilience. New geo-referenced maps will be produced and made publicly available to facilitate the public discussion of deindustrialisation risks and their impact on regional economic competitiveness, human capital and social well-being.

Summary

The literature suggests that industrialization leads to more well paid jobs, better economic performance, and consequently higher socioeconomic resilience, thus implying that more industrialized counties and regions have a higher ability to adapt to changes and shocks in competitive market, technological, policy and related conditions (Simmie, 2010). In this paper, we propose the development of a new research agenda addressing deindustrialization as a social and economic risk, as it leads to loss of jobs and lower economic growth, and consequently lower socioeconomic resilience. As Spence and Hlastshwayo (2011) “Expanding employment in the tradable sector almost certainly has to be part of the solution. Otherwise, the US will have a longer-term employment problem”, and this is true for other developed regions in the world. This also applies to more emergent economies, as the advantages of location are not straightforward, and depend greatly of the way countries and regions incorporate knowledge and people in the region, and have the capability to integrate value in the supply chain of the industry (Amaral Filho, 2001).

Even though even though we live in a global economy, innovation and industry policies are developed on a national base, that is, even though companies are global, universities are global, we still have industrial national policies not integrated in international networks. Thus, it is clear that the emerging patterns of innovation require new perspectives for public policies, which have in the past, in the US and in the EU, relied on supporting manufacturers and their intellectual property. Certainly we need to move on from those days and consider better ways to integrate policies, as well as to diversify them at a global scale to better consider “win-all” approaches. A potential way to achieve this is to avoid overemphasizing current rivals sectors and competitive strategies, but rather to look at science, education and innovation policies towards new challenges that require a strong collaborative and pre-competitive approach.

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