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Coupling production networks and regional assets in manufacturing clusters

Luis Carvalho[♣] Willem van Winden

Erasmus University Rotterdam
Department of Regional, Port and Transport Economics *and*
European Institute of Comparative Urban Research (EURICUR)

PO box 1738, room h12-33
3000 DR Rotterdam – The Netherlands
Tel +31 10 4081186; Fax +31 10 4089153
decarvalho@few.eur.nl
vanwinden@few.eur.nl

Abstract

Paradoxically, the ongoing process of globalisation goes hand in hand with a surge of interest in the 'local' sources of firm competitiveness. In this paper, we develop a frame of analysis that helps to understand 'coupling' of production networks and regional development. Our aim is to reflect on the 'spatiality' of different *types* of networks, and to study the dynamic coupling process between these networks and regional assets. We apply the framework to two case studies – shipbuilding in Turku and machine building in Porto. Our analysis points towards the relevance of regional assets facilitating this coupling process and in strengthening regions as magnets for global production networks, reinforcing the long term sustainability of different types of clusters.

Key words: Global production networks, regional assets, manufacturing clusters

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1. Introduction

Paradoxically, the ongoing process of globalisation goes hand in hand with a surge of interest in the 'local' sources of firm competitiveness. In this paper, we develop a frame of analysis that helps to understand 'coupling' of production networks and regional development. Our aim is to reflect on the 'spatiality' of different *types* of networks, and to study the dynamic coupling process between these networks and regional assets. We apply the framework to two case studies. The first is the shipbuilding industry in Turku. Whereas most shipbuilding strongholds in Europe have not survived the increased competition from Asian countries, Turku, located in Southern Finland, is home to a shipyard where the largest cruise vessels on earth are built. In this case study, we analyze the changing spatiality of production and innovation networks, as well as their interaction with regional assets. Our second case study is the machine building industry in the Porto region, in Northern Portugal. This industry has undergone a transition from labor-intensive and low-margin to knowledge based production. In this process, regional technological institutes played a vital role in inserting the increasingly knowledge-intensive regional industry into global production networks.

This paper is organised as follows. Section two presents some recent insights on the nexus between global production networks and regional development. In section 3, we present an alternative frame of analysis, that we use to analyze spatial and functional networks in the shipbuilding industry in Turku (section 4), and the machine building industry in Porto (section 5). Section 6 discusses the link between regional assets and global production networks, for both case studies. Section 7 concludes.

2. Production networks and regions

From various research traditions, there is a surge of interest in the dynamic interplay between evolving global production networks and regional economic development. From a business studies perspective, Santos et al. (2004) describe how front-running 'metanational' companies increasingly exploit local sources of highly specialized knowledge (often accumulated in a long history) in localities outside their home base, and use this knowledge to speed up innovation, just like it has become very common to exploit factor conditions (low unit costs) in low wage countries through global sourcing and off shoring. According with the same authors (Doz et al., 2001), a region or locale is – rather implicitly - depicted as a spatially contained 'mix of assets', the assets being a specific technological knowledge, knowledge on (local) markets and tastes, and access to networks. Clever 'metanational' firms exploit these localised knowledge assets by choosing the right locality, and entering in local partnerships. They recombine localized knowledge with their competences, which helps them to create new products and concepts and/or conquer new markets. "…by sourcing and integrating knowledge from dispersed geographic locations, companies can generate more innovations of higher value and lower costs" (Santos et. al., 2004, p. 31).

In the economic geography literature, we see attempts to synthesize the analysis of production networks and value chains on the one hand and regional development on the other. Coe et al.

(2004) developed an integrative analytical framework for studying the nexus between regional development and global production networks[*]. Like Santos et al. (2004), they presume that transnational companies create value by 'combining' different regional advantages through their international networks, but they elaborate more on the dynamics of regions in relation to the spatial dynamics of networks. Regions are endowed with specific assets, i.e. a specific knowledge base, high-level knowledge institutions, but also 'relational assets', including good working relations between regional actors enabling knowledge transfer and local learning. These assets can produce economics of scale (derived from localized concentrations of specific knowledge and expertise, embodied in local firms and workers) and economies of scope (when there are local learning and spill-over effects, leading to knowledge transfer and innovation). Regional assets are the foundation of value creation, but problems can arise when regional assets become 'out of touch' with global economic realities. This may happen when regional actors or networks become inward-looking and self-contained, and fail to pick up new learning mechanisms, technologies and market developments. Thus, regional assets can yield benefits for the region only when they complement the strategic needs of trans-local actors that operate in global production networks. In other words, regional development depends on a *coupling process* between rapidly changing needs of global production networks on the one hand, and the rather slow transformation in regional assets on the other.

The 'fit' between regional assets and global production networks depends on the adequacy of institutional structures. Regional institutions include local and regional development agencies, training institutes and all sorts of intermediary organisations that facilitate networks. Also relevant are national institutions that affect the region, such as national legislation, labour unions, employer organisations, or tax authorities. Regional institutions can help to strengthen or promote specific regional assets, for instance through training programs, or by fostering entrepreneurship. They may also serve the direct commercial interests of transnational firms, i.e. by investing in specific infrastructure (locations, power supply), by addressing specific human resource needs, or by enhancing local supplier networks.

The challenge for regional institutions is to 'capture' the value that is realised in global production networks. The more a region is 'plugged into' global networks, the more it can capture economies of scale and scope that are realised in these networks, but also, it is less able to control its own fate, as (re)location decisions are taken by far-away headquarters or investors. In some instances, large international firms have a strong bargaining position vis-à-vis regional actors, when they can credibly threat to relocate to regions with better or cheaper assets. On the other hand, the region may have a strong position when it has specific assets that are of great value for the focal firm. The development of regional assets is path-dependent and interacts with the strategies of trans-local firms. Typically, regions develop a relative advantage in a certain segment of a certain industry. This implies that a region can be in trouble when a global crisis hits that particular industry, and the region may be forced to seek alternative development opportunities and pathways.

[*] defined as the globally organized nexus of interconnected functions and operations by firms and non firm institutions through which goods and services are produced and distributed. .

The conceptual framework as proposed by Coe et al. (2004) sheds new light on the complex dynamic link between GPN's and regional development, by conceptually linking the interplay of scale and scope economies on the network level and on the regional level.
A weaker point in their approach is the rather general and undifferentiated treatment of 'global production networks': no further distinctions between activities or types of networks are offered. Furthermore, the authors are somewhat vague about the delimitation of 'the region', and do not elaborate on what exactly the relevant regional assets are.

3. Framework of analysis

In this section, we unfold a modified framework that addresses these points, and helps to apply it more adequately to real world case studies. First, we make a distinction between two types of networks with different characteristics: exploration and exploitation networks. Furthermore, based on a review of recent literature on regional development, we identify a concrete set of 'regional assets' relevant in the coupling process.

Networks of exploration and exploitation

The distinction developed by March (1991) between exploration and exploitation activities helps to refine the analysis of global production networks and their interplay with regional development. As we will explain later, these activities (and the networks that firms organise around them) are very different from each other in terms of their coupling with regional assets.

Exploration activities are directed to discover new things, to develop new products and processes. This is a costly activity, and the outcomes are unsure: you do not know beforehand what the results will be. Exploitation refers to the commercialization of innovations: how can new products be manufactured, sold and distributed, and how can procurement and purchasing be optimized, in order to generate income for the company. Unit production costs are to be minimized; quality control and logistics are important issues.

For both types of activities, firms increasingly engage in networks, but the type of networks maybe different, and so, probably, is the 'coupling' process between networks and regional assets. In various contributions, Nooteboom (1992, 1999, 2005) has reflected on this issue. He argues that exploration requires innovative networks between firms with substantial 'cognitive distance' (Nooteboom, 1992), in other words: a firm needs to work with complementary partner firms with different capabilities. This will generate new ideas and produce innovation. Exploration networks operate in a context of uncertainty of outcomes. The type of knowledge that is exchanged is tacit, the process is creative. Firms prefer to have many (and frequently changing) knowledge partners: you don't know beforehand what the most useful contact will be. Levels of strategic interaction will be high, and trust is needed. To limit the relational risk, firms will invest in mutual understanding. Nooteboom and Gilsing (2004) argue that proximity and local embedding are 'enablers' for exploration networks. Proximity enhances trust (through shared norms and values); it facilitates frequent strategic interaction, and facilitates reputation

mechanisms. However, if relations in become too durable, and there are very few 'outside' contacts, this will be good for trust but bad for learning and innovation.

In the exploitation stage, conditions are different. Exploitation requires a more stable organisational structure, a narrow focus and clear standards. Uncertainty has been reduced (a 'dominant design' has emerged); the focus of activity shifts towards cost-efficient production and distribution. This requires the utilisation of scale economies and the search for cheap supply sources. These changing conditions have implications for the network: The number and scope of 'ties' in the network can be reduced. Strategic interaction is less needed (specifications are clearly set), and relations shift from developmental to transactional. The increased division of labour leads to more specialisation in the networks, with each tie focusing on specific knowledge on a narrow scope of issues. Control becomes more formal (contracts, monitoring of compliance), and trust is less important. The proliferation of electronic networks has enabled the spatial separation of exploration and exploitation. Specifications of a new product can be sent through the wire to the other side of the word, where production can take place.

In our analysis, we have applied March's (1991) distinction between exploration networks and exploitation networks, but we refined both categories further. Within exploration networks, we discern two distinct categories: a) pre-competitive networks, and b) networks for product development. We assume that that these networks are rather different in terms of cooperation rationales and models, predictability of outcomes, time span, selection of partners and governance of the networks. Also, we make a distinction between two types of exploitation networks: upstream networks (purchasing, sourcing of materials and components), and downstream networks (contract manufacturing, sales, distribution and marketing).

Table 1: Different types of inter firm networks

Development Stages	A. Pre competitive (exploration 1)	B. Product development (exploration 2)	C. Exploitation (up-stream + downstream)
Cooperation types	▪ Facility sharing ▪ Business venturing ▪ Cooperation with various universities	▪ Partnerships with industrial partners; ▪ Partnerships with applied R&D institutes; ▪ participation in capital structure of R&D institutes	▪ Contracts with suppliers; ▪ Contracts with contract manufacturers ▪ Deals with distribution networks
Predictability of outcome	▪ Low	▪ Medium	▪ High
Time span	▪ Long	▪ Medium	▪ Short
Partners selection	▪ Research expertise (universities) and firm competence in promising fields	▪ Complementary R&D competences; ▪ Expertise and applied research competences	▪ Based on cost performance given quality standards
Additional drivers	▪ Research grants and subsidies (national, regional, EU research programmes)	▪ Synergies in further stages (exploitation)	▪ Potential learning by interaction and access to tacit knowledge
Governance mechanism(s)	▪ Research agreements with monitoring indicators of output	▪ Trust, reputation, cultural proximity ▪ Research contracts	▪ Detailed Contracts

Source: own elaboration

Regional assets

As the aim of this paper is to analyse the 'coupling processes between evolving global networks and regional assets, we identify four groups of regional assets:

- Regional assets related to the knowledge base: these include the technological infrastructure (universities, research institutes), but also assets related to the regional labour market (availability of skilled labour).

- Regional assets related to the economic base: these assets refer to the industrial mix in the region. We asked our interviewees how they rate and value the presence of complementary business partners in the region, as well as the availability of capital.

- Institutional and relational assets: these assets refer to the co-operative culture, and the assessment of industrial policies.

- Environmental assets: these assets include accessibility (for goods and passenger transport), as well as quality of life (amenities, housing, recreation, crime).

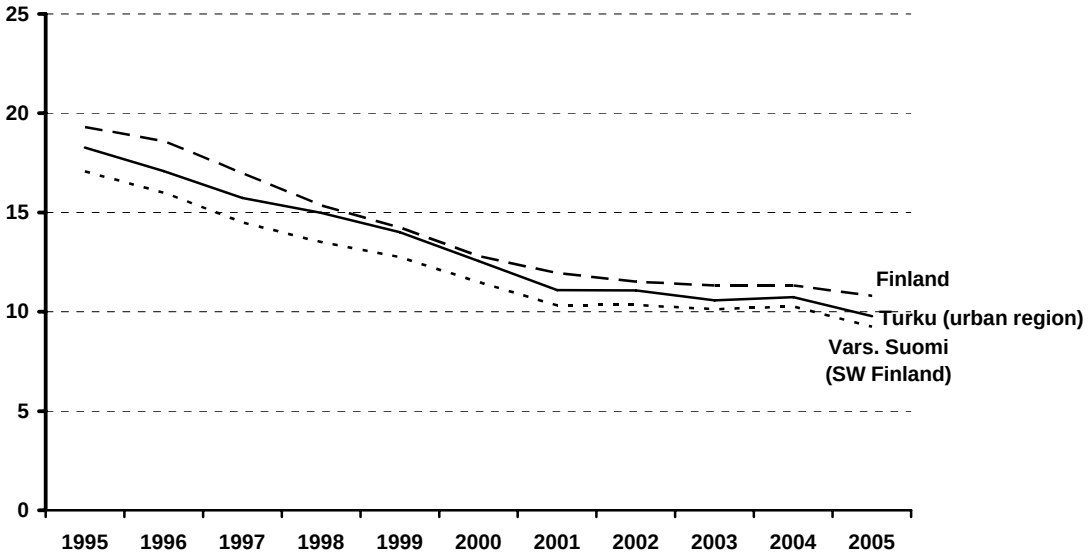
Set up of the case studies

To test our framework, we conducted an in-depth case study analysis in two industrial regions: the Porto region in Portugal, and the Turku region in Southern Finland. In each region, we selected a representative manufacturing industry. In Porto, we studied the machine building cluster, and in Turku we analysed the shipbuilding industry. In both regions, we have interviewed a dozen of key firms, knowledge institutes, intermediate organisations, and policy makers. We focused on 'bridging' firms and institutes, with substantial operations and linkages in the home region, as well as a presence in several countries or with strong international linkages. We asked firms about their choice of network partners, their 'wherabouts', and their rationale for collaborating with partners on various spatial scales. Also, we explicitly asked their assessment of the 'assets' in the region, and the degree to which firms are capturing value from these assets. In addressing this issue, we did not pre-define the geographical borders of the region, but let firms reflect on the question what are functionally relevant regions from their perspective.

4. The shipbuilding cluster in Turku

Turku is a medium sized city of 300 thousand inhabitants, located in the Southwest of Finland. Like other Finnish cities in early 90's, after the collapse of the soviet block, Turku face a period of economic downturn, with high unemployment rates. However, during the last decade, the economic performance of Turku (in terms of value added and unemployment) was good, and the region outperformed the Finnish average – see figures below.

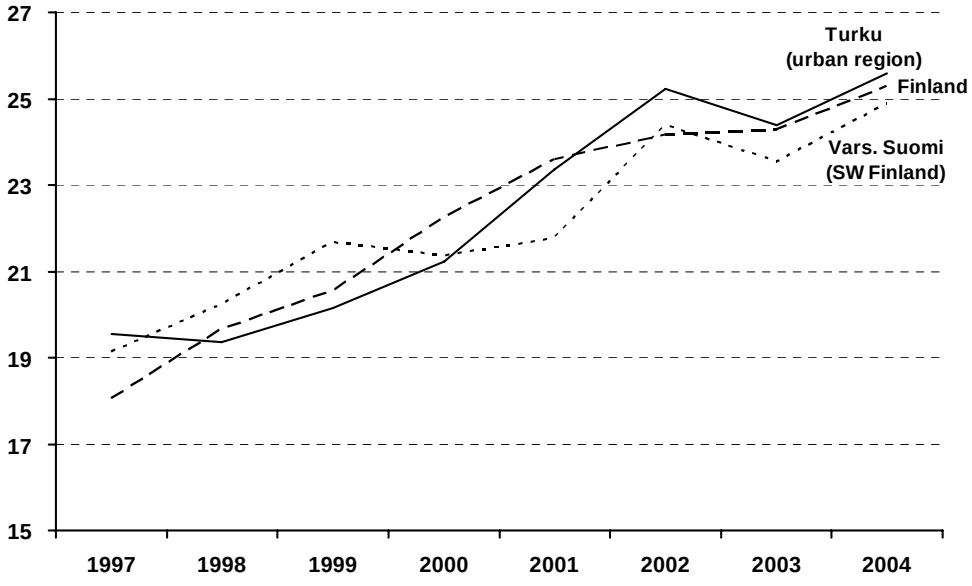
Figure 2. Unemployment rate, annual average, %, 1995- 2005



Source: Employment and Economic Development Centre of Southwest Finland, n.d.

(Note: Data on South West Finland corresponds to the NUTIII Varsinais Suomi)

Figure 3. Value added per capita, current euro, 1997-2004



Source: Statistics Finland, n.d

(Note: Data on South West Finland corresponds to the NUTIII Varsinais Suomi)

Nowadays, Turku is a dynamic service centre, concentrating many producer services, banking and insurance services, as well as "creative" services like design. The city has 3 universities and 4 technical schools that 'churn out' significant numbers of graduates each year. Despite its medium size, the city has a diverse and strong economic base, with fast growing sectors like ICT or biotech, linked with the local university and research facilities. Nevertheless, at the same time, metal and marine activities are still responsible for a very large share of industrial employment and value added, not only in the city but in the whole region (see table below).

Table 2. Traditional and emergent sectors in the Southwest of Finland, 2005

Sector	**Turnover (Meuro)**	**Companies**	**Personnel**
Biotech	500	60	3000
ICT	8.700	100	14.700
Metal and Marine	8.800	1.200	16.300

Source: Centres of Expertise Finland, n.d.

The metal and marine sector is closely linked with the shipbuilding tradition in Turku. Ships have been built in the region since 1700. More recently, whereas many traditional shipbuilding strongholds in Europe have been driven out of the market by Asian rivals, the sector in Turku has prospered. Today, large luxury cruise ships are produced in Turku and its region, and the full order book for new cruises and non customized vessels is responsible for many jobs and income in the region – in 2006, the ship orders accounted for more than 4 billion euro, corresponding to 18 new ships, with Royal Caribbean Cruise as one of the main clients.

In Turku, many firms and specialized providers interact in the production process of the ship. The shipbuilding network in Turku is organized around a key flagship firm - AkerYards Turku. The yard used to be 100% Finnish but has become part of a large multinational group, after a merger with Kvaerner Masa Yards. It nowadays is one of the largest, most modern and innovative in Europe, producing breakthrough ships ("floating cities" for roughly 4000 passengers and a crew of 1500). AkerYards´ is specialized in overall design, assembly, and project management – namely the technical and organizational coordination of the many actors involved in the shipbuilding process. The Finnish headquarters of the group moved recently from Helsinki to Turku, in order to be close to its main production centre.

According to AkerYards estimation, the vast network of suppliers and subcontractors, mainly innovative small and medium sized firms, is presently responsible for roughly 85% of the ship's

value added. They can be classified in four broad groups: 1) automation and machinery suppliers, composed by companies producing and supplying customized parts for the ship - engines and propulsion drives, power systems, but also robots and production lines for the yard and for the shipbuilding process; 2) Specialized bureaus and service providers: very specialized and "creative" services, needed in different stages of the value chain and ship's production and assembling - consultancy, planning, R&D, engineering and design bureaus, software designing firms, etc: 3) Turn-key suppliers: a growing number of suppliers are ready-to-install suppliers, providing very specific and specialized parts of the ship, needed to satisfy the needs of increasing innovation, safety, comfort and leisure in the ship, being some of this firms unique in the world - p.e., cabins and bathroom units, furniture, restaurants, swimming pools, theatres, gambling rooms: 4) other components and work capacity, not directly produced/employed by the shipyard - besides diverse undifferentiated components, the ships need a large amount of steel and metal work, namely related with the big parts of the ship (including the hull) and welders. In order to make capacity more flexible, some specialized welding and metal firms are also subcontracted, with qualified welders, working directly in the yard. Moreover, capacity and undifferentiated work is also usually subcontracted, rendering the yards' structure more flexible.

In this case study, and on the basis of our framework, we analysed the main networks evolving around the Yard and representative firms in the cluster.

Exploration networks

In the pre competitive stage, there is a substantial density of cooperation between firms and top expertise centres in shipbuilding related issues. The yard and other high tech equipment producers have been developing research agreements with different universities aimed to discover new breakthroughs to be used by the maritime industry (engines, safety and environment are presently hot research agendas). Spatially, the main knowledge partners are not confined to the Turku urban region, but are found in a broader scale - the South West of Finland. In particular, there is substantial cooperation with the Helsinki University of Technology, the only university in the country with a dedicated shipbuilding department. Several firms interviewed also indicated the importance of Tampere as a knowledge centre - especially the technical university is highly valued, and several companies have strategic relations with it. Moreover, AkerYards is also involved in several pre competitive research programmes with other research centres, namely in Europe (through EU research funding programmes). In order to get the most out of all those networks, Turku will soon host the *Meritech* centre, an excellence centre in maritime technology, bringing together Finnish expertise with other knowledge centres worldwide. The centre, a public private partnership, will provide specific training and research facilities for the sector, mixing spread expertise in metal, electronic, safety, water systems, etc, relevant to the maritime industry.

In the pre competitive exploration stage, the number of partners involved tends to be low: is includes the few top expertise centres in specific fields, both from private firms and academia. On the other hand, in the product development stage, the number of players involved, namely firms, tends to increase in Turku. Research centres continue to be important and contracts exist between

the centres in Helsinki and Tampere and local and regional firms, namely the yard and other equipment producers, like for the design of solutions in automation and machinery. According to our interviewees, due to the need for constant interaction, it asks for trust and cultural proximity: they highly value links between local and regionally based firms.

Many suppliers work together with AkerYards, on a regular and stable basis, in order to design tailor made solutions, contributing to fully met quality and innovation market standards of the ship. Many local firms are physically located at the yard's premises in temporary facilities, making it easier to test new solutions and application in fields as diverse as specialized machinery, handling, ventilation, welding, etc. However, also European firms are temporarily attracted to Turku for the same reason. This is true for several specialized suppliers of turn key modules and interior design, like dinning and ball rooms, theatres, cabins, etc. While the ship is being assembled, some of these firms move their staff to Turku for design, project and assembly of these components, in strong interaction with the yard and other regional suppliers, contributing to the innovativeness of the final product. In this sense, the AkerYards plays a central role as "bridging enterprise" – it links external knowledge with the regional and local firms, providing the basis for new possible network activation.

Exploitation networks

Networks for exploitation are also vital for the yard's efficiency, contributing for the long term sustainability of the cluster. Here we could distinguish between up stream networks ("selling") and downstream networks ("purchasing/sourcing").

The yard is particularly active in sourcing components and materials from other partners. Specialized and/or sophisticated parts are typically outsourced to regional suppliers, but other new geographies are emerging as relevant in order to source and achieve the best possible cost-performance. The Baltic Sea region, geographically and culturally close to Finland, is of increasing relevance to the yard (but also to other local firms), for the supply of undifferentiated components and raw materials (like steel), as well as capacity supply (blue collar work: hundreds of temporary workers from the Baltic States work in the yard). AkerYards, being part of an international conglomerate, also sources from 'sister' yards in Romania for labour intensive assembly and welding of basic parts.

Local and regional suppliers also engage in exploitation networks: like the yard, many of them outsource simple components and other production work. Moreover, many suppliers are also active in "selling" present capabilities worldwide - some of our interviewees in the automation field not only supply the yard, but have diversified towards other global production networks: they sell their products and expertise for example to the oil industry in Russia, or to shipbuilding yards in Asia. This way they fight to avoid the regional lock-in effect, launching 'exploitation' networks and relationships worldwide.

In the case study, we found that exploration and exploitation networks (both upstream and downstream) tend to overlap, and reinforce each other. Our examples are illustrative. The sourcing of the yard in Turku from Romania yields engineering and tacit knowledge inputs to be

used back in Turku. At the same time, and from regional supplier's perspective, the yard's sourcing in Turku provides the stage for the development of new capabilities - diverse suppliers of services, machinery and tailor made solutions.

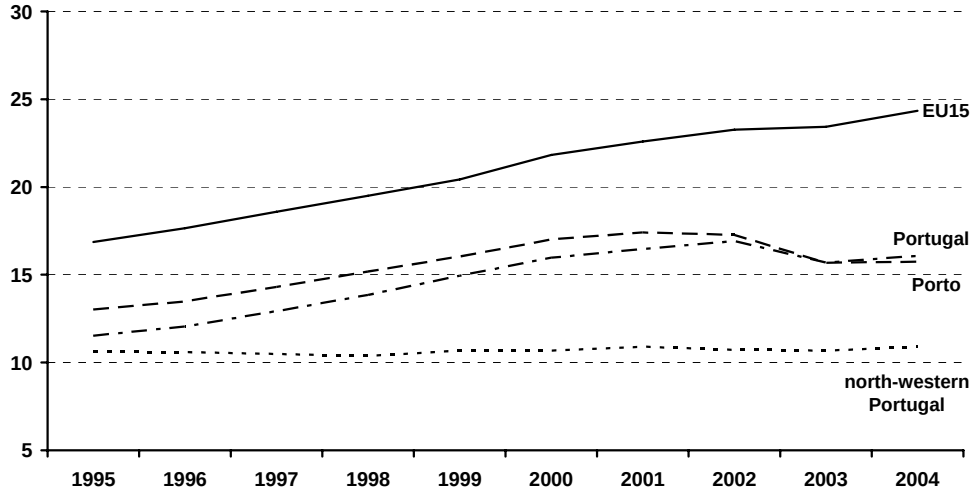
Also, suppliers learn from selling worldwide: working for new clients, sometimes in different industries, leads to the development of new competences that can be used 'at home'. This not only reduces their dependence on the yard but also has positive effects on firms' innovative potential, from which the yard also benefits.

5. The machine building cluster in Porto

Porto has traditionally been the economic heart of the Portuguese north-western region. Its immediate urban agglomeration counts roughly 1.5 million inhabitants, but more than 3 million (30% of the Portuguese population) live in a diffuse and broader urban region, including nearby cities of Guimarães or Braga.

Porto's economy is service oriented, namely advanced services and education (the University of Porto is the biggest in the country), but the agglomeration is still one of the most industrialized regions in Portugal. The industrial sector is facing a structural economic transition. Former labour intensive industries in the region, like textiles or footwear, have been declining in the last decade, and many jobs were lost. At the same time, many advanced services have moved to the capital Lisbon, which nowadays concentrates the vast majority of high tech foreign direct investment and headquarters in Portugal.

Figure 4. Gross Domestic Product per head, 1000 euros purchasing power standard, 1995-2004



Source: INE, Portuguese Statistics Bureau, n.d.

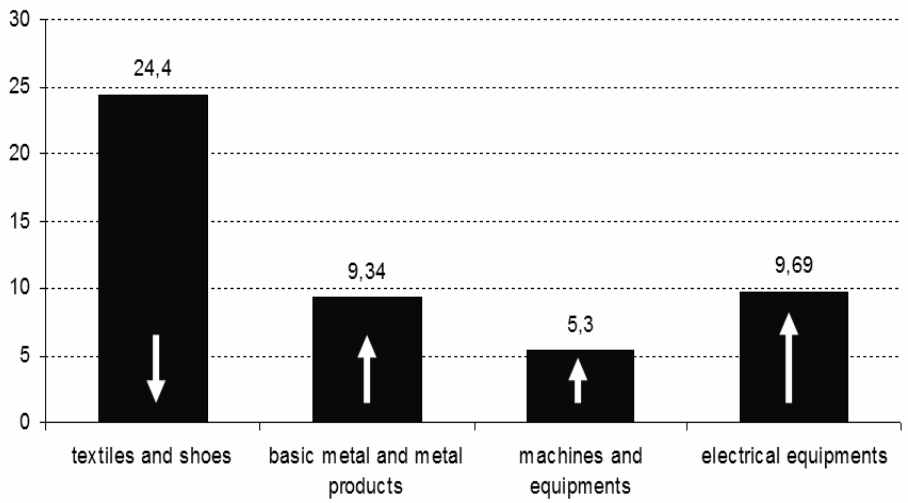
(Note: Data on Porto corresponds to its administrative metropolitan area; north-western Portugal corresponds to the aggregation of the NUTS III Grande Porto, Ave, Cavado, Tamega and Entre Douro e Vouga).

At the moment, new sectors are slowly developing, mainly at the crossroads of knowledge-based sectors such as ICT, new materials, nanotechnology, biotech and medical equipment. Also, the traditional sectors like textiles or footwear are becoming more knowledge intensive and niche specialized. Nevertheless, the newly emerging economic and industrial base is unable to absorb low qualified workers that used to be employed in manufacturing. But it also still offers insufficient employment opportunities for the rising numbers of university graduates in the region.

Like other industrial sectors, the production of basic and undifferentiated metal components and tools has been also declining in the region, under influence of stronger competition from Asian and Eastern European economies; however, during this painful process, many local firms, mostly SMEs, have reinvented themselves and now produce specialized components, tailor made machinery and industrial equipment.

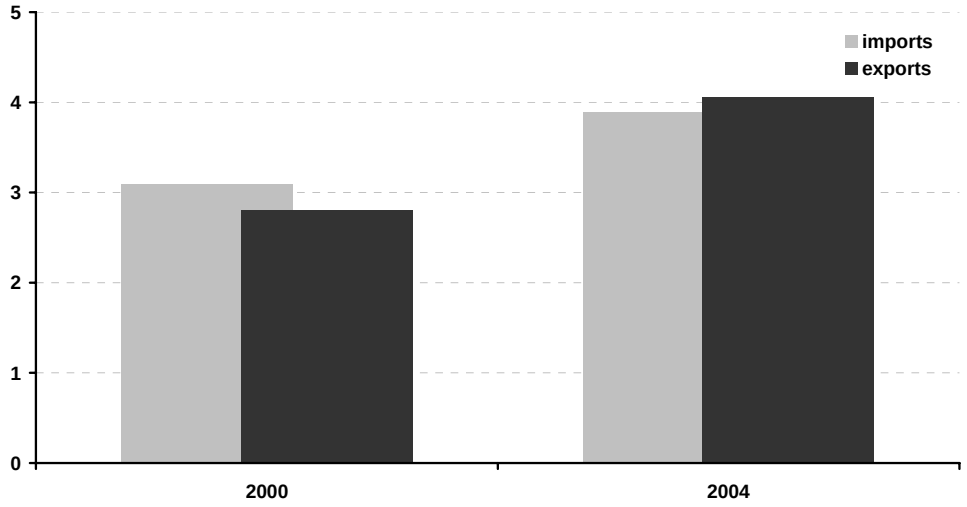
Currently, the sector of machine building and metal tools is well rooted in the whole region and represents a substantial (and growing) share of the industrial turnover in Porto and in the Northwest of Portugal (see figure 5). The exports of the sector have been evolving very positively – in 2004, the exports of machinery equipments and apparatus from the Norte and Centro Regions of Portugal overtook the imports (see figure 6).

Figure 5. Share of Turnover, north-western Portugal, 2004



Source: INE, Portuguese Statistics Bureau, n.d. Own elaboration.

International trade of machinery equipments and apparatus (section XVI), Norte and Centro regions,10^9 euros



Source: INE - Portuguese Statistics Bureau, n.d

The machine building sector benefited from the regional presence of relevant engineering knowledge infrastructure. Two research institutes, from the University of Porto, have assumed a leading role in the regeneration of the industry: INESC and INEGI. Both were – independently - founded in the 1980's by Portuguese PhDs' that returned from the United States and United Kingdom, where they had learned about the potential of university-industry co-operation for both sides. Both institutes acknowledged the need for internal interaction (between the competences of the different engineering departments of the University of Porto), and external interaction with the national and regional industrial fabric. Nowadays, the two institutes count together with almost 400 researchers.

INESC is the Institute for Systems, Engineering and Computers, and it combines competences in energy, engineering and production, ICT, optical and electronic technologies. These competences became increasingly relevant for the regional machine building sector, given the relevance of ICT solutions and embedded systems in industrial production. INEGI stands for Institute of Mechanical Engineering and Industrial Management. It is the 'interface organisation' that links the department of mechanical engineering (University of Porto) to industrial firms. It has competences in several fields, namely instrumentation, automation, rapid tooling, industrial management, sheet metal technologies, coatings, energy and composite materials. Moreover, also the engineering departments of University of Minho (Guimarães and Braga) have been participating in the sector's development – they are particularly good in new materials and nanotechnologies.

In our analysis, we focus on the industrial networks of regionally based machine building and metal tools suppliers. The role of the research institutes is highlighted as "bridging institutions" and important knowledge players in the sector's evolution.

Exploration networks

Our interviews revealed that the most knowledge intensive machinery and equipment producers in the region of Porto, despite their small and size, are increasingly engaging in pre competitive cooperation, and jointly develop new technologies. Cooperation with potential clients in different sectors (mainly other industrial firms) has been central in the process. A recent European funded project (FATEC - Footwear Active technology) in the region is an illustrative example. In order to develop new technologies to produce niche footwear, the project brought together 5 R&D institutes, 5 machinery producers and 9 footwear firms as partners. A large majority of then were found in the urban agglomeration around Porto, but some others closer to Lisbon. In this project, the partners developed a variety of new high tech equipment and machinery that enables to manufacture small series of footwear: prototyping, laser cutting, logistics, automatic painting, robots, weaver technology and ICT solutions. Presently, many of these jointly developed technologies are exported and used worldwide, not only in footwear, but in diverse sectors like food or automotive. The regional presence of the footwear producers was an essential condition for the technological learning of the specialized machinery suppliers.

There is a variety of national and European policy measures that aim to foster regional co-operation. A common goal is also to link metal tools and machine building firms with players of emerging sectors (like energy, medical equipment or marine activities) in order to mix competences and produce similar virtuous dynamics. To this aim, cluster platforms are being developed by the Regional Development Bureau, in order to facilitate actors' meetings, produce intelligence and joint apply for funding sources, namely National and European.

The main research engineering institutes of the region, like INESC or INEGI, are usually involved as scientific partners. However, local and regional machine builders also develop pre-competitive research in cooperation with international players, in the fields of new materials, engineering processes, logistics and aeronautics. Once again, the influence of the local research institutes is central, now as "bridging institutions" – many of the research agreements derived from previous research contacts of the knowledge institutes, which opened the way for local and regional firms to participate in those research networks. Some pre-competitive networks evolved towards product development contracts and, eventually, to the international exploitation of competences (like for instance in aeronautics and aerospace, sectors for which some firms in the region are supplying tailor made metal tools and specialized machinery).

During the product development stage, many firms in our sector also develop partnerships with other firms in order to find non-customized and innovative combinations. Some networks are local and regional, but some others are global and, just like in Turku, tend to come in the form of "temporary projects". This is for example the case when a specific technology or competence is not available in the region, like laser technology. Foreign firms bring in their equipment and

competences, namely from Switzerland and Australia, in order to test and develop tailor made solutions for locally based precision cutting machines in Porto. However, other components are often developed jointly with local partners. That is for example the case in sensorsing and image technology, used in the tailor made energy solutions of EFACEC - a large Portuguese group of electro mechanics, based in Porto - in which the region has been developing competences through university spin offs.

Depending on the technological demands and novelty of the product, contracts for product development might involve also research institutes. Trust, technological quality and complementary competences are determining factors for the establishment of stable and solid partnerships with the local and regional institutes. An increasing number of regional firms are members of the associative structure of INEGI – mechanical engineering. In this way, they directly fund its research budget and contribute to the definition of the institute's research programme.

Some specialized tool producers have product development contracts with the University of Minho. The automotive industry is an important client of the products jointly developed by the University of Minho, the moulds sector and other regional metal electro firms. Tool and machine builders in the region are active in automotive related technology and products, developed through CEIIA – Centre for Innovation and excellence in automotive – based in Porto. The region does have an "original equipment manufacturer – OEM", but some important ones are locate closed by – Volkswagen in Palmela/Lisbon and PSA in Vigo/Spain.

Exploitation networks

For the firms we interviewed, cutting costs, finding market opportunities and the achievement of maximum efficiency are vital endeavours. Concerning sourcing networks, many of the studied firms increasingly buy customized components nationally and worldwide, like metal or undifferentiated tools and apparatus. Non-customized components are also sourced from non local firms (like laser solutions), evolving from a previous product development network. Moreover, many services and production tasks are outsourced on a project basis, regionally, in order to increase flexibility. EFACEC for example has outsourced the manufacturing of (parts of) products it previously developed in house, usually to national firms. However, some service components, like after-care of machines are internalised – this is understood as a core component of EFACEC products.

For 'downstream' exploitation networks (sales, distribution), our interviewees are increasingly engaging in diverse partnerships to sell their products and competences abroad, through different approaches. EFACEC has its own production facilities worldwide, like in China and Brasil – in this sense they are close to potential clients and partners in fast growing economies, which is important not only for logistics and access to cheaper inputs, but also to access to potential partners and clients and the availability of 'local' market information. EFACEC is a paradigmatic case of a network manager. The group subcontracts and is subcontracted, and takes part in different international consortiums, namely for the supply of specialized machinery, energy and

automation solutions for large infrastructure, like airports or metro rails. Here, global and local interaction for exploration and exploitation are increasingly intertwined. Production challenges imposed by clients are central in the group's learning and evolution. Despite its highly international approach, the group is strongly rooted, anchored, in Porto – decision making, capital, knowledge, and competence centres - and does not intend to relocate.

Moreover, also smaller firms of machine producers are active in selling their competences worldwide. Typically, they engage in partnerships with distributors in other countries, but also with partners they worked with in the product development stage. Some partnerships with external distributors are being developed in order to overtake image disadvantages of Portuguese manufacturing products: 'made in Portugal' is not an endorsement. Therefore, many high tech machines built in Porto and its region are being sold worldwide by distributors in France and in the United Kingdom.

The Sector Association of the metal and electrical firms, based in Porto, has been particularly active in fostering the external contacts of its firms, namely the smaller ones. Many joint missions have been developed in order to find external partners to support the exports and international contacts of the firms in the sector.

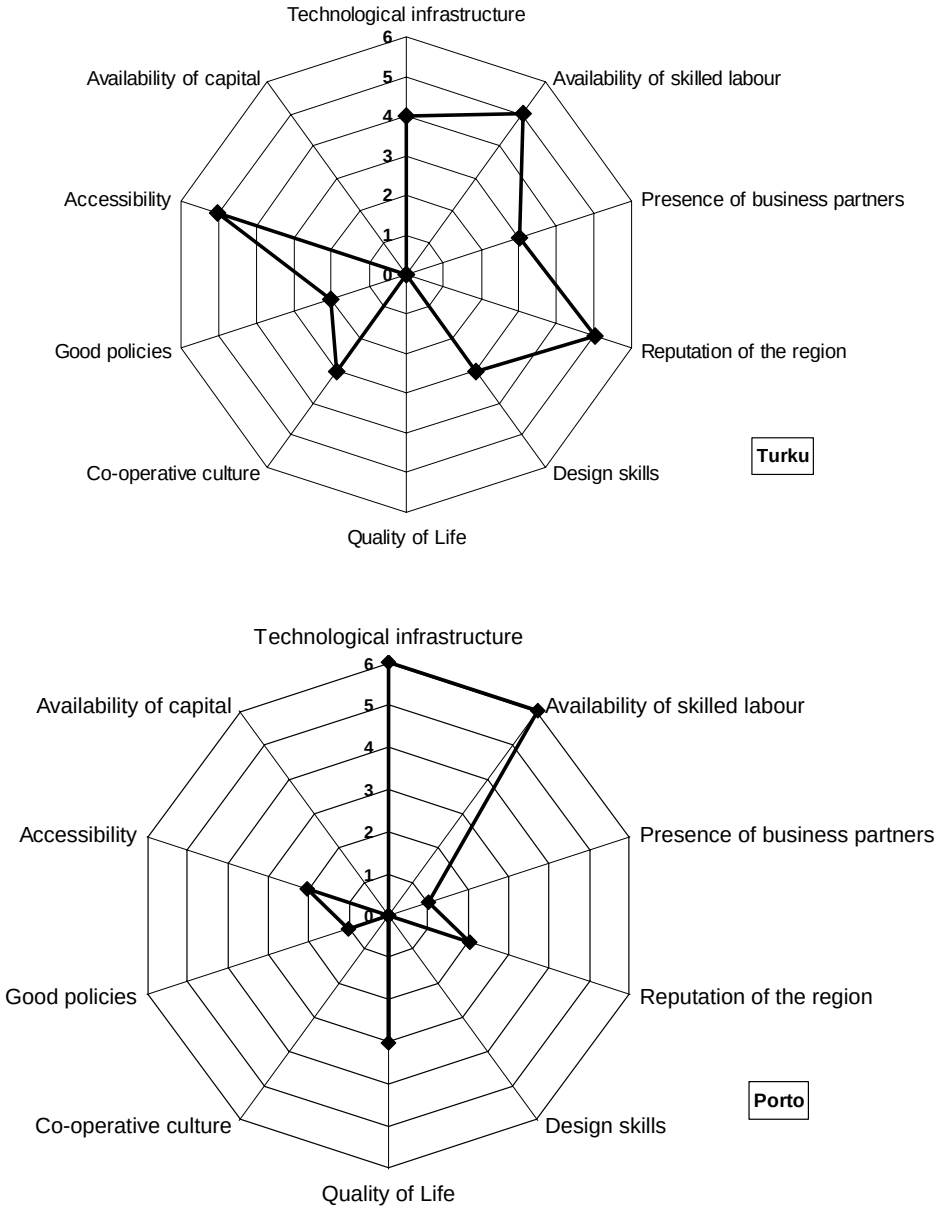
6. Regions in the global production system: passive takers or active players?

In the previous section, for our two case studies, we depicted the broad and diverse geographical span of our cluster's networks, for the different value chain stages considered in the integrative framework. We could not find a clear pattern linking the type of network (pre competitive, product development, upstream and downstream exploration) with any correspondent relevant spatial scale. The networks at all different stages were found at diverse geographies: both regional and wider networks proved to be relevant to the innovative potential and efficiency of firms in both clusters, by participation in new discoveries, product development in "temporary" formats and exploitation of present capabilities through sourcing and selling.

The relevance of regional assets

Nevertheless, our intuition was that the regional dimension is not just "one more dimension" Therefore, we asked our interviewees to give their perception concerning the regional strengths that favored the development of the respective clusters. In other words, we were interested in assessing the influence of different collections of regional assets in the cluster's development, and see to which extend those assets created the conditions to develop the mentioned and factual global networks - figure 7 presents the aggregated results, for the two analyzed clusters.

Figure 7. Why this sector is so strong in this region?



Source: in depth interviews with key players (questionnaire)

In Turku, three regional attributes scored high: the presence of skilled labour, the effective reputation of the region as a shipbuilding and specific technology supplier, and accessibility. From our analysis, the reputation of the region appeared as important in the attraction of networks in pre-competitive research, and as a trustworthy place to do related business. The presence of

skilled labour contributed not only to the indigenous development of the cluster, but also makes nowadays the region an attractive spot for more tacit knowledge transfer networks – that's what is happening through temporary projects of local and European firms. The accessibility of Turku, despite its peripheral location in Europe, also scored high – the city has a secondary airport and is well linked to Helsinki, which has become important for the development of external projects and networks. Moreover, the region is developing projects to foster logistical improvements linking air and sea cargo, rail and road.

In Porto, our interviewees had no doubt pointing towards two major sources of "regional rent", that clearly help their firms keeping competitive advantage: "availability of skilled labour" and "technological infrastructure". Indeed, the region produces annually a vast number of graduates in engineering and technology and some firms have specific training facilities for their employees, resulting in very specialized workers. Two important institutions present in Porto – the sector association and its technological centre - also provide courses that contribute to the upgrading of the sector's workers, endowing them with specific competences in metal and electrical work.

The technological infrastructure, as depicted, has been one of the strongest assets for the cluster's development – it supports the indigenous development of the cluster through pre-competitive research and joint product development, but also links the region with external knowledge and access to privileged external networks. Quality of life also obtained a high score: partners value the low cost of living and good natural amenities present in the region, and see it as a factor that helps to tie globalised activity to the region.

How to define the relevant regional dimension?

Our research showed that the relevant linkages for exploration and exploitation cover different spatial dimensions, both regional and wider. However, focusing on the regional assets, we tried to analyse the perceptions of our interviewees concerning the size of their perceived relevant region. In both cases, Porto and Turku, the relevant regional assets were found in geographical configurations that do not coincide with any administrative division and far exceed the cities boundaries.

In the case of Turku, some other regional assets that scored high, like design skills, technological infrastructure and cooperative culture are found in a larger discontinuous 'urban space', perceived by the stakeholders as the triangle Helsinki – Turku – Tampere, in the South-West of Finland. This region is the stage for very dense exploration (innovation) and sourcing networks for the marine and shipbuilding industry.

For Porto, despite a strong concentration of relevant assets in the immediate metropolitan area, like research institutes and amenities, many firms and other business partners are located in a functionally integrated larger urban region around Porto, called the North-Western arch, encompassing namely the University of Minho and research institutes in Braga and Guimarães. Good internal connections make this area increasingly well integrated, allowing for very frequent contacts and a larger labour market.

7. Conclusions

The interplay of the global production systems' reality with the regional dimension leads us to consider cities and regions as collections of assets that influence both the indigenous innovative potential of the clusters at the regional level – a topic widely studied in the cluster literature - but also creates the conditions for the cluster to assess the pool of projects and network possibilities worldwide, in different stages of the respective value chains.

The division of global production networks in exploration and exploitation networks (March, 1991) helps us to better understand and frame their different dynamics and drivers. In our paper, we contributed to fine tune that division, dividing exploration in pre-competitive and product development stages, and exploitation in upstream networks (sourcing, supply) and downstream networks (sales, distribution).

In our case studies, we found many links between these networks – partnerships in the pre-competitive stage set the scene for new product development agreements: at the same time, sourcing networks come from previous joint product development, like the suppliers of the yard in Turku or the laser technology suppliers of Porto's machine builders. Sourcing networks also have a feed back on innovation – many of our interviews refer the value of the learning by interacting with different partners.

In our analysis, we could not find a unique or 'typical' spatial pattern of the different types of production networks. The depicted networks of our studied clusters are organized at the most diverse geographical spans, and they all proved to be relevant for the clusters' innovative potential and efficiency in the medium and long term. In this context, the role of "bridging institutions" assumes particular relevance. In Turku, the flagship AkerYards links the regional suppliers around the yard to external sources of knowledge, through research agreements but also by the contacts with the Yard's European suppliers. In Porto, the engineering research institutes assume this role – they support indigenous development of the cluster, but also make possible the participation of regional firms in external research and knowledge platforms, through their network of contacts.

Moreover, we analysed which regional assets support our case clusters' development, and play a role in the regional value capturing process. Our cases showed that some regional specific assets pointed in the literature remain central in dealing and capturing value from the new dimensions of the global production system (like knowledge infrastructure, presence of business partners, accessibility, etc.). However, in our cases, these assets were found (and perceived by the stakeholders) in larger urban regions or even city systems; furthermore, our analysis confirms the relevance of this assets not only for the clusters' indigenous development, but to a large extent to facilitate the participation of the region in external networks, as attractive spots.

This analysis has policy implications. The increasingly conventional policies of promoting regional and cluster's development by fostering internal institutional linkages (firms, associations,

knowledge producers) needs a new functional orientation. As our case studies show, fostering external linkages and access to external sources of knowledge is increasingly critical for the long term development of the cluster. Here, local and regional institutions have an important role, which should be complemented by the appropriate development of other assets – in other to match the demands of global production networks. Moreover, and according to stakeholders' perceived relevant region for the cluster and assets, there it appears to be also room for the consideration of wider urban region when defining policies to promote clusters align assets' development. Current incentive mechanisms of policymakers – related to the performance of administrative regions - are an important barrier in this process.

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