The role of organizational networks in the development of technological capabilities

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Abstract

The development of technological capabilities in a region is achieved through coordinated efforts from networks of organizations, including government agencies, research institutions, industrial associations and companies. The objective of this study is to identify the initiatives promoted by organizational networks to support the development of technological capabilities for the aeronautic industry, a sector experiencing fast growth. Semi-structured interviews conducted among organizational networks of two countries developing strategies to increase local aeronautic activity indicate commonalities of initiatives.

Keywords: Organizational networks, Technological capabilities, Aeronautic industry

Introduction

Continuous technological development is a crucial element for a company to sustain competitive advantage (Chiesa, 2001). Indeed, companies with demonstrated capabilities in a number of technologies that meet demand requirements are in a better position to ensure the sustainability of their business (Burgelman et al., 2001). Networks play a role in the development of technological capabilities of companies through knowledge sharing (Mentzas et al., 2006; Trkman and Desouza, 2012) and the promotion of collaborative working (Hagedoorn et al. 2006). Collaborations between industry, government agencies and academia have been considered as vital for technology development in regions (Hendry et al., 2000; Johnson, 2008).

Although instruments available to networks and their outcomes have been studied (Pilbeam et al., 2012), there has been limited focus on the development of technological capabilities. This paper investigates the initiatives used by organizational networks to create the necessary dynamics to stimulate the development of technological capabilities in companies of a region for a specific industrial sector.

The organizational networks considered in this study are formed by companies, industry associations, research institutions, and government agencies, since these have been considered the critical stakeholders for the development of technological capabilities in a region (Bales et al., 2004). In order to study the phenomenon of technological development of a region, we selected two regions where this phenomenon recently occurred, namely the development of technological capabilities for the production of aero-structures in Portugal and the development of technological capabilities for the design & engineering services, build-to-print aero structures in Malaysia. The aircraft industry is an adequate context to study the development of technological capabilities in regions because worldwide aircraft demand is increasing at approximately 2% a year till 2033 (Deloitte, 2015) and therefore, several regions in the World are trying to enter the industry. Within this context we formulate our research as follows: "How do organizational networks influence the development of technological capabilities in a region to supply the aeronautic industry?"

Literature Review

The literature review is divided in two sub sections: the first discusses the literature of technological capabilities development in organizational networks, the second, analyses a number of studies about the role of organizational networks in different regional aeronautic sectors.

Technological capabilities development in organizational networks

Organizational networks have been defined as a group of organizations whose relationships are primarily non-hierarchical and trust-based, and often formally established and governed for the purpose of achieving a common goal (Provan et al., 2007). Depending on the nature of these goals, networks have been classified in numerous types, including innovation networks (Rycroft and Kash, 2004; Salavisa et al. 2012), collaborative networks (Camarinha-Matos et al., 2009) and knowledge networks (Anderson and Parker, 2013).

Literature has focused in the role of networks in the diffusion of technological innovations and, at this level of analysis, studies have addressed the formation of partnerships for R&D (Hagedoorn et al., 2006), outsourcing of innovations (Baloh et al., 2008), among others. Under this research stream, organizations may decide on the adoption of a technology by: (1) imitating the practices and behaviour of organizations perceived to be successful (a mimetic process), (2) being pressured by other organization(s) to adopt a technology (a coercive process), and (3) following professional associations that establish norms and rules to force pertaining organizations to adopt a technology so to be seen as legitimate (a normative process) (Robertson et al., 1996).

Technological capabilities have been defined as the resources required to manage technical changes in processes, products, equipment, which are embodied in the knowledge, skills and experience of individuals and of organizational structures and their linkages with other institutions (Bell et al., 1995). The development of technological capabilities can be understood as an organizational learning process (Keeble and Wilkinson, 1999; Beeby and Booth, 2000; Liu et al., 2006; Bolívar-Ramos et al., 2012), where organizational networks play an important role in supporting knowledge sharing, thus enabling organizations to react faster to external risks and opportunities and building network effects that create a wider pool of users of a technology (Teece, 2007). However, local capability building only takes place when organizations have developed their own individual and organization learning capabilities (Ernst and Kim, 2002).

Steensma (1996) suggested that there is a close relationship between the attributes of a technology, which includes its technical complexity and the systemic shift for the organization, the collaboration method and the organizational learning capabilities. The heterogeneity and complementarity of actors in networks in terms of capabilities and competences contribute to innovation success (Corsaro and Cantù, 2015).

In his study about clusters, Porter (1998) emphasized that not only companies, but also government agencies, universities and research institutions have a role in the competitiveness of regions, namely in providing specialized training, technical and market information, R&D services and technical support. Kerr and Newell (2003) suggested, based on their study on the US petroleum industry in the early 2000s that economic policy instruments can provide more efficient incentives for technology adoption than conventional regulations, implying that instruments can affect the direction of technological change significantly.

Although the importance of organizational networks has been considerably discussed, the influence of the initiatives available to organizational networks to promote technological capabilities development in specific industrial sectors has been less explored. The case of the aeronautic sector is discussed in the next section.

Technological capabilities development in the aeronautic industry

The global aeronautic industry has some distinctive characteristics, which in turn have serious implications to policy making towards the development of technological capabilities. First, the aeronautic industry is heavily regulated with high entry barriers for newcomers (Braddorn and Hartley, 2007). In this sense, the aeronautic sector is commonly analysed in a broader perspective, which spans not only buyer-supplier relationships but also other network entities, namely government agencies, industry associations, research partners and others. Second, the geographical distribution of the technological capabilities of the global aeronautic industry has been dominated by the most industrialized economies. Few countries or regions have developed indigenous technological capabilities, especially concerning systems design and integration. According to Eriksson (2010), for a country or region to develop aerospace technological capabilities - through the stages of assimilation, implementation and improvement - they need to stay in close contact with international scientific communities, to monitor the progress of technology development, and with major industry players and government bodies, to delineate strategies for offset agreements which are known to leverage technology transfer to developing regions. These issues highlight the role of organizational networks in this process.

For example, Prencipe (2001) in his study about the aerospace industry argues that in multi-technology industries, organizations need to develop capabilities that are not self-contained but rather multi-faceted as they require the integration and coordination of multiple technological streams. In this sense, Prencipe identified four types of technological capabilities: *absorptive*, the ability to monitor, identify and assess new technologies, *integrative*, the capabilities related to specification of requirements, materials, systems, components and their integration into products' architecture, *coordinative*, the capabilities to coordinate (with internal and external entities) the development of technological innovations and *generative*, related to the capabilities to develop technological innovations.

From the buyer point of view, inter-firm learning and its implications to technological capabilities development is observed among aeronautic suppliers, Rebolledo and Nollet (2011) found that knowledge from OEMs and prime contractors have not been properly propagated through the value chain, suggesting that knowledge sharing networks in

aeronautic still remain under-developed. Despite the "deverticalization process of production" observed in the global aeronautic industry, where OEM delegate non-core competencies and require direct suppliers (mostly Tier 1) to actively participate in the design and development of aircrafts' systems and components (Figueiredo et al., 2008), formal suppliers development programs were found to have marginally contributed to develop technological capabilities in aeronautic suppliers (Reed and Walsh, 2002). In another study about anchor tenants in aeronautics – organizations heavily engaged, including firms, universities and laboratories– Niosi and Zhegu (2010) argues that effective knowledge and technology transfer takes place only when favourable regional and market conditions are present in the long term.

The technological challenge is first and foremost, fundamental to the aircraft design requirement, since only proven technologies that comply with international regulations and standards should be considered for inclusion from the conceptual design level (Beaugency, et. al., 2015). The technological challenge is also closely related to the need for substantial continuous funding in the aircraft development projects, especially when the development timeframe typically spans over ten to fifteen years (Pritchard and MacPherson, 2007; Rose-Anderssen et al., 2011). Therefore, aircraft development programmes depend on government influence and funding support in order to succeed.

Despite the recognized role of organizational networks in the development of the aeronautic sector in different regions, their influence in the development of technological capabilities of their members has been poorly explored in the literature. This paper presents a preliminary study about the initiatives put in place by organizational networks towards the development of technological capabilities in the aeronautic industry.

Research methods

Given the exploratory nature of the research, case research is an appropriate method for this study (Voss et al., 2002; Yin, 2003; Ketokivi and Choi, 2014). Two countries with strategic aspirations in developing technological capabilities in the aeronautic sector were chosen for analysis, namely Portugal and Malaysia. As an industry extremely regulated and with high entry barriers, the role of organizational networks formed by a mix of private and public institutions is of great relevance in the global aeronautic industry. Furthermore, the need for the development of technology capabilities in the aeronautic industry is clear from the fact that its end product is classed as high value manufacturing, the technologies involved are those of advanced manufacturing, and it has some of the most demanding quality standards of any industry.

Table 1 presents the case evidence collected by means of semi-structured interviews carried out in each country. The unit of analysis is the network of organizations involved in the development of the technological capabilities in each country.

Table 1. Case data

Country	Portugal	Malaysia
Technology	Machined parts and composites for aero-structures	Design & engineering services, build-to-print aero structures
Network of organizations (number of interviews carried out in each type of organizations)	Government Agencies (1), Industrial associations (3), Training Centres, Research Institutions (1), Companies (2)	Government agencies (3), Industrial association (1), Training centre (1), Research Institution (1), Companies (1)

Portugal

Portugal entrance to the aeronautic industry occurred through the creation of a Maintenance, Repair and Overhaul (MRO) company in 1918. After a period of strong growth during the 1960s, driven by the Defence, the sector witnessed a sharp decrease in business volume with the end of the Colonial Wars. It was only in the 1980s, with the renewal of the military fleet, and the cooperation agreement signed with the European Space Agency (ESA) in 1996, that the sector has experienced some resurgence. Currently, MRO remains the most important segment, in terms of business volume, in the Portuguese aeronautic sector (INE, 2015).

Manufacturing activity of aircraft parts is dispersed in a fragmented value network composed of several small and medium enterprises (SMEs) in lower Tiers of the supply chain delivering typically low value high volume parts. Still, since 2012 this activity has been extended by the installation of production facilities of an anchor company in the country. However, the low volumes characteristic of this sector presents some challenges for most Portuguese firms, which are used to more volume intensive industrial sectors such as the automotive. Furthermore, qualified human resources for the production of aircraft structure parts did not exist in Portugal before the installation of the anchor company and therefore the creation of these technological capabilities in the country has been promoted by a network of public and private organizations. Therefore, this research reached out to these organization in order to identify the initiatives needed to create technological capabilities for the aeronautic industry in Portugal.

Malaysia

Malaysia's First Industrial Master Plan (IMP1), encompassing the period from 1986 to 1995, focused on the manufacturing sector to lead as a growth sector. The government saw increased investments in high technology and capital-intensive projects, together with an increased demand for skilled workers during this period, signalling a shift towards high technology adoption. Malaysia's interest in the aerospace manufacturing sector during that decade was represented by the focus on "transport equipment".

According to Szirmai (2012), industrialisation as a strategy for economic growth and development has propelled manufacturing as a major activity in many developing countries, creating the race for technological leadership. The government ministry official cited tremendous progress in technology and heightened business competition, both regionally and globally, as key challenges to the successful implementation of the industrial master plans. She recalled instances of urgent policy adjustments for the electronics industry, for instance, and expects a similar challenge as aerospace OEMs began to address growing demands for aircrafts from the Asia Pacific region. In order to address the mounting competition from within the Association of South-East Asian Nations (ASEAN), the government ministry had had to establish a national-level coordinating agency to ensure real-time alignment of aerospace industry development activities.

Although Malaysia proceeded to introduce IMP2 (for the period from 1996 to 2005) and introduced key initiatives to develop the manufacturing sector further by "strengthening industrial linkages, increasing value-added activities and enhancing productivity" (MITI Malaysia, 2006), the government was suddenly faced with various structural and regulatory issues. For instance, economic policy instruments had to adjust for attracting foreign direct investments in high technology sectors, while encouraging the development of local enterprises. When the appropriate incentives produced lacklustre results in local industry creation, the government had to revise the policy instruments before the start of IMP3 (for the period of 2006 to 2020).

Findings

The empirical data collected from the organizational networks analysed in the two countries enabled the identification of a number of initiatives being taken to promote the development of technological capabilities in the aeronautic sector. These are described below:

- **Industry-academia collaboration through R&D projects:** partnerships driven by collaborative projects are important mechanisms for knowledge exchange. While in Portugal aeronautic R&D activity is dispersed in a handful of research institutions, in Malaysia, an innovation centre was set by the Government in 2010 to coordinate collaborative research and technology projects between aeronautic industry and academia. Collaborations for knowledge sharing, as stated by one of the interviewees of a Portuguese research institution, even the preparation of applications allows members of an organizational network to have knowledge about the technological capabilities of each other, a mutual learning process on the potentialities of each partner. This process also supports the identification of knowledge gaps within the network and thus helps narrowing the scope of projects and the positioning of the network in terms of technological capabilities. As relationships deepen through time, organizational networks tend to be formatted to certain type(s) of aeronautic project(s), and may motivate members to begin establishing relationships with other partners to widen the scope of projects. Particularly important for "latecomers" such as the two regions analysed, the participation in international R&D projects with major OEMs may be an opportunity to enter the global aeronautic value chain, since there is a natural tendency for aeronautic manufacturers to continue with the partners with proven technical expertise when they decide to move forward with the industrialization and formation of the local supply chain, as stated by one of the interviewees.
- **Shared services centres:** equipment necessary for testing, diagnostics, metrology and others can be an onerous cost to manufacturers, which is aggravated by their punctual utilization. Some associations of the countries analysed formed shared service centres where, by paying an annual fee or at reduced prices, manufacturers have access to testing services. In addition to freeing manufacturers from the burden of having to manage costly testing facilities, thus enabling them to focus on high value added technological capabilities, the shared services centres constitute an important knowledge repository about materials' behaviour in simulated conditions in aircrafts.
- **Support in the implementation of aeronautic certification:** the certification of manufacturing technologies is a lengthy process in the aeronautic sector, which may span a number of years. This is often observed as an obstacle for manufacturers, especially smaller ones, to introduce technological innovations in the aeronautic sector. Organizational networks from the two regions analysed provide support for companies to obtain necessary aeronautic certifications, for example, the AS9100. In Portugal, an industrial association has offered specific training for professionals leading the process of aeronautic certification implementation. In the case of Malaysia, government agencies have launched a series of initiatives to provide subsidized funding for product and process certification required by OEMs and industry regulators.
- **Training centres:** the development of an aeronautic supply chain in a region depends on a number of conditions and, with respect to aircraft structures manufacturing, qualified human resources are required. Organizational networks from Portugal are developing specific training programs with technical schools which include on-site

learning to improve the specialization level of their workforce. There, two training centres dedicated to the manufacturing of aircraft structure parts have been created through coordinated efforts of companies, government agencies and industrial associations. Initially, since the country faced a considerable gap in terms of aeronautic technological capabilities, there was no qualified training personal for the training centres and they were trained by collaborators from the companies, which was only made possible with the support of the network of organizations. The need to improve technical expertise of the human resources to leverage the local aeronautic sector was also observed as a serious issue by the Malaysian government, which supported the opening of industry skills training for aircraft maintenance technicians and the opening of graduate aerospace engineer programs at five leading Malaysian research universities.

- **Coordinated participation in aeronautic international events:** fairs and exhibitions are a relevant showcases for the visibility of aeronautic industry from different regions. This visibility can draw the attention of global manufacturers and thus attract foreign investments for the development of local technological capabilities. Organizational networks from both countries organize and coordinate the participation in several aeronautic conventions and fairs, for example in the Singapore, Farnborough, Paris, and Dubai airshows. Both countries also brought international events to their countries, as for example the ASD Annual Convention that was held in Lisbon in 2012 (the largest edition of the convention so far) and the International Aerospace Business Convention in Kuala Lumpur in 2016.

Conclusions

This study reinforces the importance of organizational networks for the development of technology capabilities in regions and identifies the initiatives these networks may carry out towards achieving this goal. Case research in two countries developing strategies to increase local aeronautic activity, namely Portugal and Malaysia, has shown that the initiatives carried out by organizational networks in these two countries are quite similar in nature. The main difference observed was that in Portugal organizational networks have organized themselves to respond to the needs of foreign companies or Portuguese companies entering the aeronautic sector, whereas in Malaysia the organizational networks are moved by the government defined formal strategy for the aeronautic sector.

Future research may study the design and impact of the initiatives identified in this study towards the effective development of technological capabilities in regions. From a practitioner point of view, our results may help the development of lines of action of companies, governmental agencies or industry associations for enhanced collaboration in the development of technological capabilities.

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