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Global R&D in the Aerospace and Defence Industry. Knowledge Creation with Local Firms in Host Countries

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In recent years, firm's R&D activities have experienced a significative geographical expansion due to the impact of globalization, and particularly, the development of IT and the reduction of transport costs. In this sense, there is a growing concern of firms with the existence of international knowledge spillovers which could be appropriated by foreign firms in order to increase their productivity of knowledge (Thomson, 2013; Dunning and Lundan, 2009; Guimon, 2008; Florida,1996; Florida,1996).

The new form of geographic organization of R&D expenditures in the Aerospace industry is a good evidence of this process, since it has gone from being an industry located in very few countries to one having a high degree of globalization (Butterworth-Hayes, 2007). It evolves from a heavy concentration in Europe and the United States towards an increasingly global distribution of production and R&D activities, in which emerging powers (Brazil, Russia, India and China) are acquiring significant weight (McGuire, 2014; ECORYS, 2009; Moser, Heiko and Gnatsy, 2010; Polak and Belmondo, 2006; Parr, 2006). The reason behind is the growing presence of related industries like automotive and shipbuilding in emerging countries, as well as the growth of military expenditure, big local markets for civil transport, and a successful direction from local institutions in the aforementioned countries. It is, therefore, a sector with a production chain that is becoming more complex, and more geographically fragmented (McGuire, 2014; ECORYS, 2009; Hollanders, Cruysen and Vertesy, 2008). This degree of dispersion varies depending on whether we are dealing with the civil or military sub-sector (Mowery, 2012; Healey, 1999).

Moreover, although there is a broad conceptual framework that addresses the causes behind other countries' R&D offshoring (knowledge sourcing) processes through technological collaborations, very few studies analyzed the specific case of aerospace industry y. Thus, this paper analyzes knowledge appropriation, adapting the theories that have studied knowledge spillovers and R&D offshoring to the case of the aerospace and defense industry. Therefore, the main aim of this study is to examine the appropriation of aerospace international knowledge spillovers produced in the HC by aerospace firms. Particularly, we examine

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the impact of three kind of spillovers at host country (HC), from Aerospace R&D Military R&D and University research. To do that, we use a sample of aerospace firms for knowledge creation and collaboration with local HCs inventors.

We proposed seven hypotheses related to the three main factors, as following:

— *H1: The R&D effort of firms and the aerospace R&D effort of the HC has a positive impact on knowledge production via technological alliances.*
— *H2: The R&D effort of firms and the R&D effort in all industries of the HC has a positive impact on knowledge production via technological alliances.*
— *H3. The quality of the institutions of the HC has a positive impact on the acquisition of knowledge spillovers generated in the HC.*
— *H4.1 The production of high impact aerospace scientific literature in the HC has a positive effect on knowledge creation in firms.*
— *H4.2 The production of high impact scientific literature related to engineering in the HC has a positive effect on knowledge creation in firms.*
— *H5: The military R&D undertaken in HCs has a positive relationship with knowledge production in firms.*
— *H6: The location of assembly plants for military projects in HCs is positively related to knowledge production in firms.*

Testing the hypotheses required the prior development of a database that included information on 65 firms in the aerospace sector, selected from the list drawn up by PwC (PWC, 2016). The sample includes the main AI corporations by revenue for 2016. Information was introduced on each international plant of each company in the sample according to the host country where they are located. Besides the unit of spatial observation considered in the sample is the HC of international plants, regardless of the number of plants that each country may host. A company that has several plants in a country will therefore just count as one in this HC.

Therefore, a database of 874 international plants corresponding to a sample of 65 firms was built. However, in order to test hypothesis on both groups firms (OEM and TIER) this database was split into two databases with 159 and 701 observations. These plants are located in 52 countries, distributed over the five continents, and which fall within the main geopolitical blocs (Table 1). The dependent variable was defined as the number of patents that have been formed jointly between a firm and another entity located in one of the countries where this firm has established a plant which include activities like manufacturing, assembly or R&D. Furthermore, in order to study the impact of the variables over time with greater precision, the patents selected were produced during a 5-year period (2012-2017) with regard to the explanatory variables, as innovations in the AI have a long development period (ECORYS, 2009; Hollanders Cruysen and Vertesy, 2008). All this information was obtained from the European Patent Office database.

The independent variables introduced in the model in order to demonstrate the research hypotheses were the following:

— LnRDintra: Total aerospace R&D investment in the HC, in USD billions, for the year 2012 and in natural logarithmic form.
— LnRDextra: total R&D investment in the HC, in USD billions, for the year 2012 and in natural logarithmic form
— QI: Quality of scientific research institutions on the Likert scale (1-7) for the year 2012
— ScAERO. Number of research papers published in the aerospace field by authors from the HC, for the years 2007 to 2012 and in natural logarithmic form.
— ScExtra. Number of research papers published in the engineering field by authors from the HC, for the years 2007 to 2012 and in natural logarithmic form.
— LnMR&D: Investment in military R&D in the HC, in USD billions, for the year 2012 and in natural logarithmic form.
— MP: Existence of an assembly plant of a military project located in the HC 1, 0 otherwise (dummy variable) (Corporate information).

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Finally, we also controlled for geopolitical barriers between host and home countries, firm R&D expenditure, size of the firms and the number of patents as a proxy for knowledge production in each firm.

The results for the OEM group were that H1 is supported, but on the contrary, H2 was rejected in model 4, and it was significant in model 3 with an unexpected negative sign. The analysis of spillovers from research institutions in the HC showed that only H4.2 was significant. Which means that HC's research institutions have an impact on the generation of technological alliances when there is a significative production of scientific knowledge in fields of engineering related to AI. The analysis of spillovers from the military industry revealed that they are not significant.

As for the control variables results were that the Geopol variable has a positive sign and strong significance, as expected. And R&D intensity variable also has a positive sign and shows a notable significance.

In regard to the TIER group, H1 showed a significant and positive importance as expected, however H2 was rejected in model 7 and was weakly significant in model 8. Spillovers from research institutions were positive and significant as expected, and spillovers from the military industry were rejected in both hypotheses. It should also be noted that neither the size of the firm variable nor the geopolitical relationship nor the R&D intensity between the home country and the HC were significant in models 7 and 8. The TC variable, on the contrary, is very significant and positive.

The aims of this research have been partially achieved, on the one hand, the split of the data set into the OEM and TIER group was justified since both groups proved to have different pattern of knowledge spillover appropriation consistent with their distinct nature. In the OEM group, knowledge appropriation is related to a strong inhouse investment in R&D, while the in the TIER group it is rather explained by the experience of the corporation in the specific field they work in, and they are more prone to establish international technological alliances.

This study confirmed part of the hypotheses proposed although with different impacts for the OEM and TIER group. The research has confirmed the appropriation of knowledge spillovers from aerospace R&D in the HC, the acquisition of knowledge spillovers from the HC's education and research institutions as well, both in their role as labor trainers and in their function of scientific literature production, and the appropriation of knowledge spillovers from the R&D performed in defense has been discarded. Finally, geopolitical match between the home country and the HC has been proved an important factor which contributes to knowledge appropriation.

Therefore, the results of this paper suggests that firms must take HC's universities, research centres and investment in aerospace R&D into account as source factors of knowledge spillover. Policymakers as well should plan geopolitical relations having in mind the importance of HC's Universities, research centres and corporations as a source of knowledge spillovers.