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MNEs SUBSIDIARIES AND UNIVERSITY COLLABORATION IN MODERATE INNOVATIVE CONTEXTS: DOES MNEs SUBSIDIARIES' STRATEGIC NATURE MATTER?

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Biographic note

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Passionate about the business world, she grew up as a versatile, proactive and willing to learn person. As a federated basketball athlete from an early age, concepts as teamwork and persistence were always part of her daily life.

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Abstract

With the increasing globalization, universities have gained momentum as sources of external knowledge, attracting attention by academics, governments, and businesses. Within the latter, subsidiaries of multinational enterprises (MNEs) seem to be in a privileged position as they are likely to combine knowledge from the internal network (of the MNE) and the host country environment. As such, these subsidiaries tend to collaborate more with other entities and be involved in complex innovation networks. However, the capacity they have to establish and benefit from these innovation networks in general, and from university-industry (U-I) relationships in particular, is likely to depend on their strategic nature.

Despite the large existing research on U-I collaborations, few studies focus on MNEs subsidiaries, and no empirical evidence exists on the influence of subsidiaries' strategic nature on such collaborations. Additionally, the extant literature typically explores countries with high levels of innovation performance, which are likely to have state-of-the-art technology endowed universities.

Thus, the present investigation intends to fill in the above mentioned gaps by analysing the impact of MNEs subsidiaries' strategic nature on U-I collaborations, considering the context of a moderate innovator, Portugal. In methodological terms, we resort to a double hurdle model, based on data from the latest available Portuguese Community Innovation Survey (CIS 2014), involving 7,083 firms, out of which 736 were classified as subsidiaries of foreign MNEs.

Estimation results demonstrate that the strategic nature of the subsidiary is relevant for explaining both the collaboration with universities and the importance attributed to that collaboration. Specifically, more innovative subsidiaries tend to collaborate more and to attribute higher importance to universities as partners. This seems to be an interesting outcome for governments of moderate innovative countries, suggesting the development of foreign direct investment (FDI) attraction policies related with the nature of the investment that they intend to attract.

Keywords: U-I collaboration; Multinational enterprises; Local subsidiaries; Portugal.

JEL codes: F23; O30.

Resumo

Com a crescente globalização, as universidades têm ganho força como fontes de conhecimento externo, atraindo a atenção de académicos, governos e empresas. Em relação às últimas, as subsidiárias de multinacionais parecem estar numa posição privilegiada, pois tendem a combinar conhecimento da rede interna (da multinacional) e do ambiente do país anfitrião. Assim, essas subsidiárias tendem a colaborar mais com outras entidades e a envolver-se em redes de inovação complexas. No entanto, a capacidade que têm para estabelecer e beneficiar dessas redes de inovação em geral, e das relações universidade-indústria (U-I) em particular, provavelmente dependerá da sua natureza estratégica.

Apesar da vasta pesquisa existente sobre colaborações U-I, poucos estudos focam o caso das subsidiárias e ainda não existe evidência empírica sobre a influência da sua natureza estratégica nessas relações. Além disso, a literatura tipicamente explora países com elevados níveis de desempenho em termos de inovação, nos quais é provável que existam universidades com tecnologia de última geração.

Assim, a presente investigação pretende preencher as lacunas acima mencionadas, analisando o impacto da natureza estratégica das subsidiárias de multinacionais nas colaborações U-I, considerando o contexto de um inovador moderado, Portugal. Em termos metodológicos, recorremos a um modelo duplo *hurdle*, baseado em dados do último Inquérito Comunitário à Inovação em Portugal (CIS 2014), que envolveu 7,083 empresas, das quais 736 foram classificadas como subsidiárias de multinacionais estrangeiras.

Os resultados da estimação demonstram que a natureza estratégica da subsidiária é relevante para explicar tanto a colaboração com as universidades como a importância atribuída a essa colaboração. Especificamente, subsidiárias mais inovadoras tendem a colaborar mais e a atribuir maior importância às universidades enquanto parceiras. Este parece ser um resultado interessante para os governos de países moderadamente inovadores, sugerindo o desenvolvimento de políticas de atração de investimento direto estrangeiro ligado à natureza do investimento que pretendem atrair.

Palavras-chave: Colaboração U-I; Empresas multinacionais; Subsidiárias locais; Portugal.

Códigos JEL: F23; O30.

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1. Introduction

In an increasingly globalized world, universities as sources of external knowledge attract many business people and the study of relationships between foreign subsidiaries and universities has gaining great importance to multinational enterprises (MNEs) that intend to absorb knowledge abroad (Suzuki, Belderbos, & Kwon, 2017; Teixeira & Mota, 2012).

Despite the large and high-quality research on university-industry (U-I) collaborations, very few of these studies involve multinational subsidiaries. Those few studies focusing on the relation between subsidiaries and universities (e.g., Guimón & Salazar-Elena, 2015; Sánchez, Molero, & Rama, 2016; Suzuki et al., 2017) evidence that foreign subsidiaries have a higher propensity for local cooperation for innovation, with that propensity being higher in sectors where the recipient country has indigenous technological capabilities and a large home market. Indeed, the emphasis has not been put on the benefits that firms may obtain from those linkages (e.g., Broström, McKelvey, & Sandström, 2009; Ferraris, Santoro, & Bresciani, 2017; Ferraris, Santoro, & Dezi, 2017; Guimón & Salazar-Elena, 2015; Sánchez et al., 2016), rather on the characteristics that make them more prone to collaborate with universities (e.g., Guimón & Salazar-Elena, 2015; Sánchez et al., 2016; Suzuki et al., 2017). Additionally, the studies that address the benefits that subsidiaries may get from external knowledge sources, not necessarily universities, emphasize the benefits linked with R&D (Broström et al., 2009).

To the best of our knowledge, the influence of subsidiaries' business strategic nature (Manolopoulos, Papanastassiou, & Pearce, 2005) on such relations has not yet been tackled. Additionally, extant literature on university-subsidiaries collaboration typically explores European countries with high levels of innovation performance – e.g., United Kingdom (Broström et al., 2009; Ferraris, Santoro, & Bresciani, 2017), Switzerland (Broström et al., 2009; Ferraris, Santoro, & Bresciani, 2017), Sweden (Broström et al., 2009), Austria, Belgium, Denmark, Finland, Germany or the Netherlands (Ferraris, Santoro, & Bresciani, 2017) –, which are likely to have state-of-the-art technology endowed universities. In contrast, the case of moderate innovators has not yet been fully explored. It is likely that laggard innovative contexts involve distinct patterns of collaboration between subsidiaries and universities. In this vein, it would be scientifically pertinent to gathered evidence on such contexts.

Thus, the purpose of the present investigation is to analyse the impact of MNEs subsidiaries' strategic nature on U-I collaborations, considering the context of a moderate innovator (Portugal). The main research question is:

Does the strategic nature of MNEs subsidiaries impact on the universities collaboration and the importance these firms attribute to that collaboration?

To answer this research question, we resort to a quantitative approach involving double hurdle regressions (Cragg, 1971; Engel & Moffatt, 2014), which consider the fact that collaboration entails two steps/hurdles (to collaborate or not, and, contingent to collaboration, the importance attributed by the firms to the collaboration). The estimations are based on latest available data from the Portuguese Community Innovation Survey (CIS), which focus on the innovation activities carried out in the period 2012-2014 by 7,083 firms, 736 of which are subsidiaries of foreign multinationals, that is, they belong to a group headquartered outside Portugal.

The present dissertation is structured as follows. Section 2 presents the literature review. Section 3 details the methodology and data. Section 4 describes and details the empirical results. Finally, Section 5 presents the main contributions, policy implications and limitations of the study.

2. Literature review

The literature review is organized into three major parts. First, it is essential to define the main concepts that this topic involves. As such, it becomes important to understand how the literature defines and typify U-I collaborations, as well as explain what is meant by local MNEs subsidiaries. Second, the literature about U-I collaborations in general is analysed. In this part, the determinants of such relationships, including both firms' and universities' perspective, are explored, as well as the various benefits that they may generate. Third, we reach the focus of the study, which refers to U-I collaborations involving local MNEs subsidiaries. Here are discussed some specificities of these relations, considering the type of subsidiary.

2.1. Main concepts

2.1.1. U-I collaborations

In contemporary societies, universities have a key role in educating people and generating knowledge through research (Perkmann et al., 2013). In addition, they are increasingly embracing the development and implementation of knowledge by collaborating with public and private organizations (Aguiar-Díaz, Díaz-Díaz, Ballesteros-Rodríguez, & De Sáa-Pérez, 2016). In recent years, collaboration between universities and firms has gained great importance and it is considered critical for the stimulation of R&D within countries (Aguiar-Díaz et al., 2016).

U-I links include formal and informal activities (see Table 1) and there are different channels available for the knowledge transfer (Capaldo, Costantino, Pellegrino, & Rippa, 2016). Among these channels, there is a distinction between commercialization of academic knowledge and academic engagement (Perkmann et al., 2013). Commercialization refers to an exploitation that seeks to obtain financial rewards, while academic engagement may be pursued for several purposes (Perkmann et al., 2013). Academic engagement often precedes commercialization and it may also accompany it.

Table 1: U-I linkages by type and level of commitment

Type	U-I linkage	Description	Level of commitment
Formal	Research partnership	"Inter-organizational arrangements for pursuing collaborative R&D"	High (Relationships)
	Research services	"Activities commissioned by industrial clients including contract research and consulting"	
	Academic entrepreneurship	"Development and commercial exploitation of technologies pursued by academic inventors through a company they (partly) own"	Medium (Mobility)
	Human resource transfer	"Multi-context learning mechanisms such as training of industry employees, postgraduate training in industry, graduate trainees and secondments to industry, adjunct faculty"	
	Commercialization of property rights	"Transfer of university-generated intellectual property (such as patents) to firms, e.g. via licensing"	Low (Transfer)
	Scientific publications	"Use of codified scientific knowledge within industry"	
Informal	Informal interaction	"Formation of social relationships and networks at conferences, etc."	

Source: Adapted from Perkmann & Walsh (2007), pages 262-263.

Among these U-I links, the literature defines two main forms of research collaboration: research partnerships and research services (Perkmann et al., 2013). Research partnerships are formal collaborative arrangements that intent to cooperate on R&D activities (Perkmann & Walsh, 2007). Normally, they are assisted by public funding. On the other hand, research services represent activities given by firms to universities, regulated by specific contracts with clear objectives and available financial resources. They include both research contracts and consulting. Research contracts refer to research commercially relevant to firms and normally ineligible for public support. Consulting refers to research or advice-giving services provided by academic researchers (Perkmann & Walsh, 2007).

Both research partnerships and services involve high levels of commitment of the parties. However, research services usually imply a more limited period of collaboration when compared to research partnerships (Capaldo et al., 2016). The outcomes of such activities allow firms to solve possible technological problems and give researchers the opportunity to apply their knowledge into new cases and contexts (Capaldo et al., 2016).

2.1.2. Local MNEs subsidiaries

Multinational enterprises are considered one of the most powerful kinds of organizations, since they represent a significant share of intellectual property rights (IPRs), employ many people and contribute significantly to the economic development of the countries where they operate (Williams, 2009). A subsidiary is a firm owned and controlled by another firm, which can be the parent firm or another subsidiary named holding firm

(Bouquet & Birkinshaw, 2008), and localized outside the home country (Birkinshaw, 1997). Thus, local subsidiaries of MNEs are distinct legal entities that embody subdivisions of the multinational enterprise, which operate locally and have specific tasks (Madhani, 2015).

In this specific type of firms, the parent firm takes control in decision-making, whether it is directly through itself or through other subsidiaries. Such control exists when the parent firm holds more than 50% of the capital or voting rights or when it has the power to name and dismiss administration members (UNCTAD, 2007). When the parent or holding firm owns 100% of the subsidiary, it is called a wholly owned subsidiary, otherwise it is a joint venture (UNCTAD, 2007).

2.2. U-I collaborations and linkages: determinants and benefits

Universities are considered important sources of external knowledge for firms that seek to act abroad (Johnston & Huggins, 2017) and U-I relationships have been in the center of increasing investigation (Suzuki et al., 2017; Teixeira & Mota, 2012). According to the literature (e.g., Guimón & Salazar-Elena, 2015; Perkmann et al., 2013; Sánchez et al., 2016), determinants can be specific to university or industry.

From the university side, there is a wide range of determinants that can influence U-I collaborations (Perkmann et al., 2013). Such determinants may be categorized into three major types: individual, organizational, and institutional (see Table 2).

According to Perkmann et al. (2013), individual determinants are important predictors of academic engagement, since this latter is typically preceded by personal interactions. For instance, male academics are more prone to engage with industry than female ones do (Boardman, 2008; Giuliani, Morrison, Pietrobelli, & Rabellotti, 2010). Then, seniority is positively correlated with collaboration (Boardman, 2008; Bozeman & Gaughan, 2007; Haeussler & Colyvas, 2011) and it is more likely to observe cooperative activities when academics have previous commercialization experience (Bekkers & Bodas Freitas, 2008). Moreover, researchers that are well-succeeded in fund raising acts are perceived by firms as potential collaborators, which leads to more engagement activities (Bozeman & Gaughan, 2007). At last, researchers' scientific productivity is also positively linked with intense U-I collaborations, as it allows them to easily identify engagement opportunities (Bekkers & Bodas Freitas, 2008; Haeussler & Colyvas, 2011).

Table 2: U-I collaboration determinants related to the University

Type	Determinant	Global effect	Empirical evidence
Individual	Male	+	Boardman (2008) Giuliani et al. (2010)
	Seniority	+	Boardman (2008) Bozeman & Gaughan (2007) Haeussler & Colyvas (2011)
	Previous commercialization experience	+	Bekkers & Bodas Freitas (2008)
	Public grants	+	Bozeman & Gaughan (2007)
	Contracts with industry	+	Bozeman & Gaughan (2007)
	Scientific productivity	+	Bekkers & Bodas Freitas (2008) Haeussler & Colyvas (2011)
Organizational	Quality university/department	-	Ponomariov & Boardman (2008)
	Organizational support	+	Bozeman & Gaughan (2007)
	Organizational commercialization experience	+	Bekkers & Bodas Freitas (2008)
Institutional	Applied disciplines	+	Bekkers & Bodas Freitas (2008) Boardman (2008) Bozeman & Gaughan (2007)
	Life-science/biotech	+	Bekkers & Bodas Freitas (2008)
	Country regulations/policies	+	Grimpe & Fier (2010) Haeussler & Colyvas (2011)

Source: Adapted from Perkmann et al. (2013), page 426.

Organizational factors also explain U-I collaborations. In particular, the effect of the quality of the university or department appears to be negative (Ponomariov & Boardman, 2008), which seems to contrast the results about the effect of individual scientific quality. However, Perkmann et al. (2013) suggest that lower levels of resource munificence at lower quality universities may stimulate collaborations with industry in order to obtain research funds. By contrast, the support from certain entities within universities, such as research centers, tends to have a positive influence in engagement (Bozeman & Gaughan, 2007). Also, the previous existence of formal technology transfer mechanisms is normally positively linked with commercialization (Bekkers & Bodas Freitas, 2008).

Finally, institutional factors are related with the affiliation with specific disciplines and the impact of domestic regulations and policies (Perkmann et al., 2013), which shape the norms and rules significant for researchers' activities and incentives. The evidence suggests that applied fields of research (e.g., chemical engineering or biotechnology) are more prone to collaborate due to its intrinsic nature (Bekkers & Bodas Freitas, 2008; Boardman, 2008; Bozeman & Gaughan, 2007). Regarding to national policies, extant literature mainly focuses on countries from North America and Europe (e.g., Grimpe & Fier, 2010; Haeussler &

Colyvas, 2011) and suggest that improved academic engagement motivates academics to get resources from industry in order to climb their career ladder.

From a firm's perspective, which is the focus of the present study, several internal and external factors may influence U-I collaborations (see Table 3).

Table 3: U-I collaboration determinants related to firms

Type	Determinant	Global effect	Empirical evidence
Internal	Belonging to a group	+	Guimón & Salazar-Elena (2015)
	Foreign ownership	+	Guimón & Salazar-Elena (2015) Sánchez et al. (2016)
	Size	+	Guimón & Salazar-Elena (2015) Sánchez et al. (2016) Suzuki et al. (2017)
	Innovation expenditure	+	Guimón & Salazar-Elena (2015)
	Training expenditure	+	Guimón & Salazar-Elena (2015)
	Basic research	+	Guimón & Salazar-Elena (2015) Suzuki et al. (2017)
	IPRs protection	+	Guimón & Salazar-Elena (2015) Suzuki et al. (2017)
	Strategy	n/a	Manolopoulos et al. (2005)
External	Public funding	+	Guimón & Salazar-Elena (2015)
	Collaboration with other partners	+	Guimón & Salazar-Elena (2015)
	Sector	n/a	Sánchez et al. (2016)
	Market size	n/a	Sánchez et al. (2016)

Note: n/a: not applicable, the corresponding study is theoretical.

Source: Adapted from Guimón & Salazar-Elena (2015), page 453.

In what concerns the internal determinants, the study developed by Guimón & Salazar-Elena (2015) evidences that firms are more prone to collaborate with local universities when they belong to a group, which is the case of MNEs subsidiaries. Similarly, foreign subsidiaries present higher levels of local cooperation when compared with affiliates of domestic firms (Guimón & Salazar-Elena, 2015; Sánchez et al., 2016). Also, larger firms (Guimón & Salazar-Elena, 2015; Sánchez et al., 2016; Suzuki et al., 2017) and firms with higher intensity of innovation and training expenditures (Guimón & Salazar-Elena, 2015) are more likely to collaborate. Furthermore, the empirical evidence suggests that basic research and the protection of firm's intellectual property increase the probability of establishing a relationship with a university (Guimón & Salazar-Elena, 2015; Suzuki et al., 2017). Also, as

stated by Manolopoulos et al. (2005), the strategy adopted by the firm may give place to distinct types of U-I collaboration.

Regarding external factors, getting public funds for R&D and cooperating with any other partners seem to impact positively on U-I collaborations (Guimón & Salazar-Elena, 2015). Additionally, according to Sánchez et al. (2016), the sector also matters for U-I relationships. Specifically, collaborations occur more frequently in sectors in which the recipient country has native technological capabilities and a large home market (Sánchez et al., 2016).

According to Ankrah & Al-Tabbaa (2015), U-I collaborations might bring to firms benefits at three levels: economic, institutional and social (see Table 4).

Table 4: U-I collaborations – benefits for the firms

Type	Description	Possible benefits
Economic	Feed into the overall economy	Product and process innovation
		Patents and other IPRs
		More cost-effective research
		Improve competitiveness
		Obtain public grants
		Contribute to economic growth and wealth creation
Institutional	Derived by industry	Innovative ability and capacity
		Advance new technology
		Accelerate technology commercialization
		Reduce conflicts of interest between firms
		Provide needed legitimacy for industry products
		Access to new knowledge and technology
		Influence new programs for industry good
		Access to consultancy and problem-solving skills
		Credibility in product testing
		Training and professional development
		Reach a broader international network of expertise
		Lead to other collaborative ventures
		Joint publications
		Access to talented human resources
Social	Related to communal and social activity	Improve reputation through social responsibility

Source: Based on Ankrah & Al-Tabbaa (2015), page 398.

2.3. U-I collaborations and linkages involving local MNEs subsidiaries: specificities

In comparison with domestic firms, MNEs subsidiaries may face some additional challenges that would not occur in the home market. Externally, they have to deal with completely distinct economic, political, legal and cultural environments from their home country (Madhani, 2015). On the other hand, internally, they have to manage larger knowledge networks and more complex resource flows (Volkmar, 2003).

Nevertheless, as part of a multinational enterprise, subsidiaries are in a privileged position that allows them to combine knowledge of their internal network and the external host country environment (Ferraris, Santoro, & Dezi, 2017). Thus, in comparison with domestic firms, MNEs subsidiaries tend to present higher levels of collaboration, although domestic firms can also establish intricate innovation networks (Sánchez et al., 2016).

The parent firm has operations of its own, and the subsidiary may carry on a related business. Subsidiaries may pursue different business strategies and can be distinguished depending on their product, market and value added scopes (White & Poynter, 1984). The market scope concerns to the variety of geographic markets accessible to the subsidiary, whereas the product scope refers to the amplitude and extension of product lines and areas. At last, the value added scope has to do with the diversity of ways and activities through which a subsidiary can add value.

A revised version of the scope typology, originally proposed by White & Poynter (1984), divides subsidiaries into three broad types (Pearce, 2001): Miniature Replica (MR), Rationalized Product Subsidiary (RPS), and World Product Mandate (WPM).

A Miniature Replica (MR) can be considered a replication of the parent firm (Manolopoulos, 2008). It has a quite extended product scope, since it commercializes a substantial part of well-established products, but only for the host country (Pearce, 2001). As the products are standardized, this type of subsidiary has no innovative activity and low autonomy, being only capable to adapt products to the local market (Cantwell & Iguchi, 2005). Thus, the MR can be compared to both the adapter and adopter variants of White & Poynter's (1984) original model (Cantwell & Iguchi, 2005). Later, Taggart (1999) proposed a distinct variant for the MR, named Enhanced Miniature Replica (EMR) in the present study. The EMR contrasts with the MR in the level of autonomy ascribed by the parent firm. Specifically, the autonomy is higher and the subsidiary has significant product-related R&D (Taggart, 1999). It can thus be compared t

The Rationalized Product Subsidiary (RPS) assumes a special position within the MNE network and global strategy (Pearce, 2001). It produces a set of component parts of group's final products for assembly by other group subsidiaries elsewhere in the global market (Manolopoulos, 2008). Being part of a vertically integrated production process, this type of subsidiary has low autonomy and has to adopt processes, not having basis for product innovation (Cantwell & Iguchi, 2005).

Finally, the World Product Mandate (WPM) seeks to become the international centre for a narrowly focused product scope, through exclusiveness and differentiation (Cantwell & Iguchi, 2005). These subsidiaries have high levels of autonomy, being responsible for products' design, manufacturing and marketing (Manolopoulos, 2008). As such, the need to innovate leads to a strong R&D commitment (Cantwell & Iguchi, 2005).

The four-dimensional typology, depicted in Figure 1, distinguishes subsidiaries' strategic nature through their market scope (local or global) and product innovation (whether it exists or not). It allows us to infer about the role of subsidiaries in the technological development of the host country and their potential to collaborate with other institutions (Manolopoulos et al., 2005).

		Market scope	
		Local	Global
Product innovation	No	**Miniature Replica (MR)**	**Rationalized Product Subsidiary (RPS)**
	Yes	**Enhanced Miniature Replica (EMR)**	**World Product Mandate (WPM)**

Figure 1: Subsidiaries' strategic nature framework

Source: Own elaboration, based on Pearce (2001), pages 54-59, Taggart (1999), page 35.

It is likely that the distinct types of subsidiaries establish different types of U-I collaborations. Indeed, in comparison with miniature replicas (MRs), more innovative (EMRs and WPMs) and, to some extent, efficiency-seeking subsidiaries (RPSs) are more likely to collaborate intensively with local firms and scientific institutions such as universities, as the need and the access to external sources of knowledge is noticeably larger (Manolopoulos et al., 2005).

Thus, we conjecture that

H1: *The strategic nature of the subsidiary is relevant for explaining the collaboration with universities.*

H1a: Subsidiaries with more innovative strategic nature (e.g., Enhanced Miniature Replica (EMR) or World Product Mandate (WPM)) are more likely to collaborate with universities.

H2: *The strategic nature of the subsidiary is relevant for explaining the importance attributed to the collaboration with universities.*

H2a: Subsidiaries with more innovative strategic nature (e.g., Enhanced Miniature Replica (EMR) or World Product Mandate (WPM)) tend to attribute higher importance to the collaboration with universities.

Besides the subsidiaries' strategic nature, we would expect that, similarly to other firms (see Section 2.2), other factors influence the propensity to collaborate and the importance attributed to the collaboration with universities, including: the size and sector of the subsidiary, its human capital endowments (schooling and training), subsidiary's knowledge base (indigenous R&D, external knowledge acquisition), intangible capital (intellectual property rights and licensing), and access to public funding.

3. Methodology

3.1. Selecting the methodology

The choice of the research method determines the reliability and validity of a research (Yang, Wang, & Su, 2006), and quantitative approaches grow out of a strong academic tradition in International Business that places large trust in numbers (Dilanthi, David, Marjan, & Rita, 2002). Quantitative methods seek to confirm an hypothesis about a phenomenon and tend to measure 'how much' and 'how important' (Dilanthi et al., 2002).

The central topic of the present investigation concerns the determinants of U-I collaborations. Particularly, we aim at analysing the influence of MNEs subsidiaries' strategic nature on such collaborations. As such, since our purpose is to estimate an impact, the most suitable methodology is the quantitative (Yin, 2014).

It is important to acknowledge that the majority of studies that analyse U-I collaborations use the quantitative methodology (see Table A1 in Annexes). Indeed, 8 out of the 10 studies selected use quantitative methods in their research (Aguiar-Díaz et al., 2016; Bozeman & Gaughan, 2007; Grimpe & Fier, 2010; Haeussler & Colyvas, 2011; Johnston & Huggins, 2017; Sánchez et al., 2016; Suzuki et al., 2017; Williams, 2009). Out of those 8 studies, 5 are related with the determinants of U-I collaboration (Bozeman & Gaughan, 2007; Grimpe & Fier, 2010; Haeussler & Colyvas, 2011; Sánchez et al., 2016; Suzuki et al., 2017). Guimón & Salazar-Elena (2015), who also investigated U-I determinants, opted for a mixed research. In contrast, (Broström et al., 2009) resorted to qualitative methods, most notably case studies given that their research question refers to the analysis on how the subsidiaries derived benefits from university collaborations.

3.2. Econometric specification and estimation technique

Based on the literature reviewed (Section 2), we argue that the collaboration with universities and the importance attributed to that collaboration depend on subsidiaries' strategic nature. Thus, our dependent variable entails two steps/hurdles: 1) the subsidiary collaborates or not with universities; 2) contingent that it collaborates, it discloses the degree of importance the subsidiary attributes to university collaboration.

The Hurdle model is the more appropriate estimation technique since the explanatory variables can have dissimilar effects on U-I collaboration propensity and the

importance attributed to that collaboration (Liu & Bray, 2017). The Hurdle model proposed by Cragg (1971) and developed by Mullahy (1986) has two steps. First, a binary Probit regression estimates the parameters of decision to collaborate with universities (see Eq. (1)), and then a linear regression model estimates the parameters of the importance attributed by the subsidiary to university collaboration (see Eq. (2)).

$$ln\left(\frac{p_i}{1-p_i}\right) = \beta_1 \ + \beta_2 \ Subsidiary\ Strategy_i + \beta_3 \ X_i + e_i \qquad \text{Eq. (1)}$$

$$Y_i = \beta_1' + \beta_2' \ Subsidiary\ Strategy_i + \beta_3' \ X_i + u_i \qquad \text{Eq. (2)}$$

where

p_i in Equation (1) is the probability of subsidiary i to engage with universities. The variable was coded as 1 when the subsidiary collaborates with universities, and 0 otherwise.

Y_i in Equation (2) is the importance attributed by the subsidiary i to university collaboration. In the Community Innovation Survey, firms indicate whether university is the most important external partner (1 = collaborates with universities being these not the most important partner; 2 = collaborates with universities being these the most important partner).

Subsidiary strategy is a vector of variables that includes four main business strategies: Enhanced Miniature Replica (EMR), Rationalized Product Subsidiary (RPS), and World Product Mandate (WPM), with Miniature Replica (MR) as the default strategy.

X is a vector of control variables including subsidiary's size and sector, human capital endowments (schooling and training), knowledge base (indigenous R&D, external knowledge acquisition), intangible capital (intellectual property rights and licensing), and access to public funding.

3.3. Data source, proxies for the relevant variables and sample

The database that is used for analysis is the latest available Community Innovation Survey (CIS 2014) which provides information on the innovation activities of firms located in Portugal, over the period 2012-2014.[1] This survey is carried out at every two years by EU

[1] CIS 2014 is a survey undertook in the context of the national statistical system (Law nº 22/2008 of 13 May) with compulsory response, registered at INE (*Instituto Nacional de Estatística*) with the number 10243.

member states, which can decide voluntarily to participate or not. The harmonized survey is designed to provide information on the innovativeness of sectors, on the different types of innovation and on several aspects of the development of an innovation.

In Portugal, the CIS 2014 involves 7,083 firms, from which 736 were part of an enterprise group with the head office located outside the country. By definition, and according to the Portuguese statistical office (INE, 2015), a foreign subsidiary is a firm resident in Portugal, owned and controlled by an unit not resident in Portugal. In the CIS database, the ownership is found through a variable that indicates whether the firm belongs or not to a group. Then, other variable identifies the home country of the parent firm, which may not correspond to the origin of the control. Thus, similarly to other authors using the CIS database (e.g., Dachs, Ebersberger, & Lööf, 2008; Sánchez et al., 2016; Veugelers & Cassiman, 2004), those 736 firms were considered foreign subsidiaries and have shaped our sample.

Regarding the subsidiaries' strategic nature, we had to find a proxy by adapting the original model (Pearce, 2001; White & Poynter, 1984), which distinguished subsidiaries into three categories through their market, product and value added scopes – Miniature Replica (MR), Rationalized Product Subsidiary (RPS), and World Product Mandate (WPM). In the CIS database, it was not possible to directly measure subsidiaries' autonomy or product and value added scopes. However, there are other characteristics that are intrinsically associated with each type of subsidiary (Cantwell & Iguchi, 2005), most notably the innovation activity, whose information is provided by the CIS survey. As discussed in Section 2.3, MRs and RPSs have no product-related innovative activities, whereas WPMs do (Cantwell & Iguchi, 2005). We thus classify subsidiaries according to their market scope and product innovation, adapting the original model by adding another category of subsidiaries, the Enhanced Miniature Replica (EMR). Operating in the local market, the EMR has a higher level of autonomy than the MR, being capable to innovate on product (Taggart, 1999). With this adaptation, it was possible to classify the 736 subsidiaries into one of the four types considered.

Table 5 presents the matching between the variables of the model and the CIS questions.

Table 5: **Variables and corresponding questions in CIS which provide the corresponding proxies**

Type	Determinant		CIS question	
Dependent variables	Collaboration with universities and importance attributed to that collaboration [Univ_d, CO_Imp]		7.1	"During the three years 2012 to 2014, did your enterprise co-operate on any of your innovation activities with other enterprises or organisations?"
			7.2	"Please indicate the type of innovation co-operation partner by location: universities or other higher education institutes (your country)".
			7.3	"Which type of co-operation partner was the most valuable for your enterprise's innovation activities?"
Core independent variable	Strategic nature [EMR_d, RPS_d, WPM_d]	Market scope	1.3	"In which geographic markets did your enterprise sell goods and/or services during the three years 2012 to 2014?"
		Product innovation	2.1	"During the three years 2012 to 2014, did your enterprise introduce: goods innovations; service innovations."
Control variables	Size [SzM_d, SzL_d]		14.3	"What was your enterprise's average number of employees in" 2014? *(in the database, this variable was categorized into three possible categories: small enterprise; medium-sized enterprise; large enterprise)*
	Human capital	Schooling [ln_HC]	14.4	"Approximately what percent of your enterprise's employees in 2014 had a tertiary degree?" *(in the database, this variable was categorized into seven possible categories: 0%; 1% to less than 5%; 5% to less than 10%; 10% to less than 25%; 25% to less than 50%; 50% to less than 75%; 75% or more)*
		Training expenditures [ln_TE]	5.2	"How much did your enterprise spend on each of the following innovation activities in 2014 only: all other innovation activities including design, training, marketing, and other relevant activities."
	Knowledge base	Indigenous R&D [IRD_d]	5.1	"During the three years 2012 to 2014, did your enterprise engage in the following innovation activities: in-house R&D."
		Expenditures on knowledge acquisition [ln_EK]	5.2	"How much did your enterprise spend on each of the following innovation activities in 2014 only: in-house R&D; external R&D; acquisition of machinery, equipment, software and buildings; acquisition of existing knowledge from other enterprises or organizations; all other innovation activities."
	IPRs protection	Submission [IPRS_d]	11.1	"During the three years 2012 to 2014, did your enterprise: apply for a patent; apply for a European utility model; register an industrial design right; register a trademark."
		Licensing [IPRL_d]	11.2	"During the three years 2012 to 2014, did your enterprise: license in or buy a patent, industrial design right, copyright or trademark owned by another enterprise, university or research institute."
	Public funding [PF_d]		6.1	"During the three years 2012 to 2014, did your enterprise receive any public financial support for innovation activities from the following levels of government: local or regional authorities; central government (including central government agencies or ministries); the European Union."
	Sector [Manuf_d, KIBS_d]		1	"Main activity."

Source: Own elaboration.

Through this matching, we were able to build the variables and characterize the sample. In Figure 2, by unfolding the sample, we found that 446 out of 736 firms (61% of the sample) were involved in product and/or process innovation activities. Within this innovative group, 152 firms (21% of the sample) have cooperated for innovation with other enterprises or organizations, from which only 69 (9% of the sample) had universities as partners.

In addition, the survey allows us to perceive the degree of importance that each firm attributes to its partners. Among firms that had more than one partner, only 19

considered universities as the most valuable partner for their innovation activities in that period.

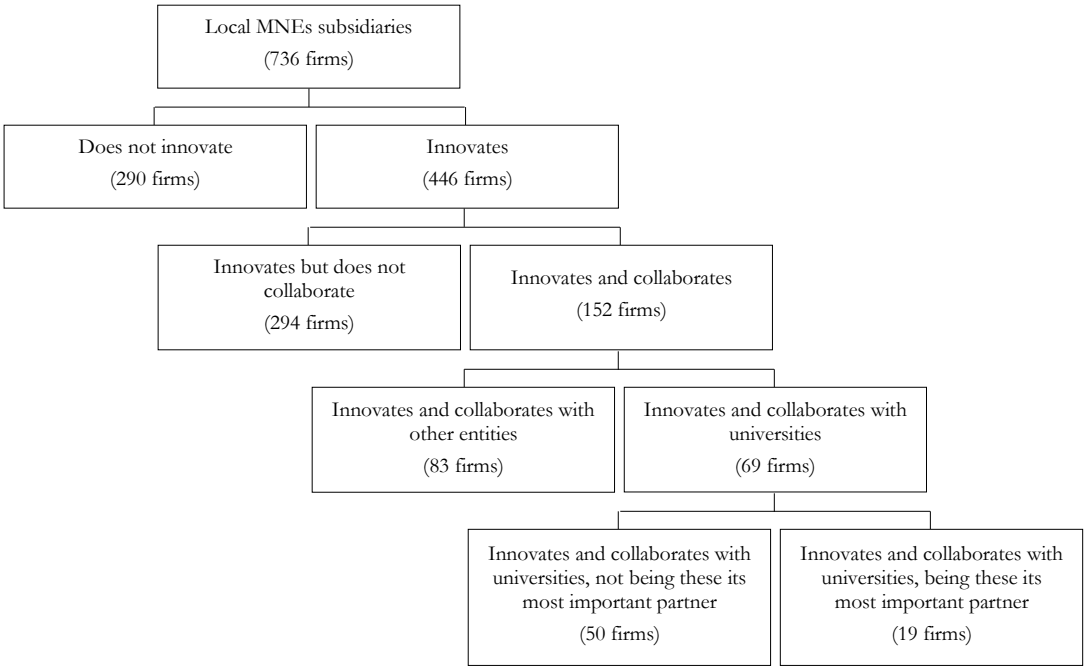

Figure 2: Main traits of the sample of subsidiaries operating in Portugal, 2012-2014

Source: Own elaboration.

4. Empirical results

4.1. Descriptive statistics

Considering the whole sample of 736 subsidiaries operating in Portugal (see Table A2 in Annexes), 49% are non-innovative firms operating for the home market (Miniature Replicas – MRs) and 42% are innovative firms with a local market scope (Enhanced Miniature Replicas – EMRs). Then, 6% are non-innovative firms operating globally (Rationalized Product Subsidiaries – RPSs) and 3% are firms operating for the global market but with product innovation (World Product Mandates – WPMs).

In terms of size, there is a high concentration of small firms (41%), followed by large firms (33%) and then medium-sized firms (27%). On average, human capital data reveal that subsidiaries have between 25-50% of their collaborators with a tertiary degree and the expenditures on training are about 48,719 €. Concerning the knowledge base, 30% of the whole sample has engaged in indigenous R&D and the average expenditures on knowledge acquisition (whether through in-house/external R&D, the acquisition of assets, the absorption of existing knowledge from other organizations, etc.) is about 327,886 €.

A rather low share of firms protects the intellectual property rights (IPRs), with about 10% investing in IPRs submission and 4% in IPRs licensing. The majority of subsidiaries (56%) received some public financial support for innovation activities, regardless of the level of government (local/regional authorities, central government or the European Union). With regard to the sector, most of subsidiaries operate in the manufacturing sector (79%), with the Knowledge Intensive Business Services (KIBS) representing only 5% of the total sample.

The group of subsidiaries that collaborates with universities is quite distinct from the one that does not collaborate (see Table A3 in Annexes). Indeed, 81% of subsidiaries that collaborate with universities are EMRs, that is, firms which act local and have product innovation, being this the most representative strategic nature in this group, whereas in the group of subsidiaries that do not collaborate the corresponding percentage is 38%. Through the analysis of the Kruskal-Wallis test (p-value < 0.01), we are able to affirm that the distribution of EMRs between categories is clearly different.

Large firms constitute the most representative group among firms that collaborate with universities (65%). In contrast, the share of large firms in the non-collaborative group

is 29%. This difference is significant since the distribution of large firms in each category is statistically different according to the Kruskal-Wallis test (p-value < 0.01).

This distribution is also distinct in what concerns training expenditures, indigenous R&D and expenditures on knowledge acquisition (Kruskal-Wallis test with p-value < 0.01). Non-collaborative firms spend about 40 thousand € in training activities, whereas collaborative firms spend more than 136 thousand €. Regarding indigenous R&D activities, 87% of the subsidiaries that collaborate have engaged in this type of activities, whereas for those that do not collaborate the corresponding percentage is 24%. The expenditures in knowledge acquisition for the collaborative group amounts to 1.2 million €, which contrasts the 0.2 million € spent by the non-collaborative group.

Additionally, we found that about one third of the subsidiaries that collaborate were involved in IPRs submission and almost 12% in IPRs licensing. For the group that does not collaborate, the corresponding percentages are 3% and 8%, respectively. Once more, these differences are statistically significant for both cases (Kruskal-Wallis test with p-value < 0.01). Similarly, the public funding has a different distribution in each category (Kruskal-Wallis test with p-value < 0.10). About 67% of the firms that collaborate received some public financial support, whereas only 55% of non-collaborative did. Regarding the sector, we found that collaborative firms are heavily represented by manufacturing firms, with a 71% share. In contrast, the distribution of this sector in non-collaborative firms is statistically different (Kruskal-Wallis test with p-value < 0.01), with a corresponding share of 41%.

Now considering the importance attributed to that collaboration, within the group of EMRs, around 74% of the firms collaborate and consider universities as their most important partner (see Table A2 in Annexes). In the other strategic groups, most notably WPM and RPS, the corresponding percentage is rather low, respectively 16% and 0%.

With regard to the size, the collaboration and importance attributed to universities is significantly different among firms. It is possible to conclude that 68% of the large firms collaborate and consider universities the most important partner, whereas for medium-sized firms that percentage is only 16%.

The average of training expenditures differs significantly among groups (Kruskal-Wallis with p-value < 0.01) – see Table A2 (in Annexes). In concrete, the group of firms that do not consider universities important partners invested more in training activities (more than 180 thousand €) than the one that attributes them more importance (22 thousand €).

In knowledge base, we observe that firms engaging in indigenous R&D or investing in knowledge acquisition tend to collaborate more with universities and to attribute those latter entities higher importance (Kruskal-Wallis with p-value <0.01). The same happens for IPRs submission, with about 30% of firms collaborating with universities or collaborating and attributing these entities the highest importance, whereas in the other groups (those collaborating with other entities and not collaborating at all) these percentages are below 15%. In the case of IPRs licensing, the corresponding percentages are, approximately, 11% and less than 4%. For public funding, the discrepancies are even more pronounced with the percentages being 84% for the group that collaborates with universities and consider them the most important partner, 60% for the group which collaborates with universities, between 28% and 19% for those that collaborate with other entities or do not collaborate at all, and 100% for those that do not innovate or collaborate.

The portion of firms in the manufacturing sector is higher when the level of collaboration with universities and the importance attributed to these entities is higher. In the case of KIBS, the results are the opposite.

Observing the correlation matrix (see Table A3 in Annexes), we find that EMRs and WPMs related subsidiaries tend to collaborate more with universities and to consider them as the most important partners. Additionally, larger, manufacturing firms, with higher levels of investment in training, knowledge and IPRs protection tend to collaborate more with universities.

4.2. Model estimation

The standard diagnosis tests, most notably regarding the heteroscedasticity and multicollinearity, indicate that errors are heteroscedastic (Breusch-Pagan/Cook-Weisberg chi2(1) = 228.17, p-value = 0.0000), but no problems of multicollinearity emerge – the Variance Inflation Factors (VIF) associated with the independent variables are below 3.00. [2]

[2]. VIF shows which percentage of the variance is inflated for each coefficient. For example, a VIF of 1.50 informs that the variance of a particular coefficient is 50% bigger than what we would expect if there was no multicollinearity – that is, if there was no correlation with other predictors. Thus, as a 'rule of thumb', VIF=1: not correlated; 1<VIF≤5: moderately correlated; VIF>5: highly correlated. (see http://www.statisticshowto.com/variance-inflation-factor/, accessed on 2nd June 2018).

In global terms, the estimated double hurdle model is statistically significant and the R squared is high, suggesting that the fit of the model is adequate. The first hurdle is a binary Probit regression, which estimates the parameters of decision to collaborate with universities, whereas the second hurdle consists in a linear regression model that estimates the parameters of the importance attributed by the subsidiary to university collaboration, conditioned to that collaboration (see Table 6).

Table 6: **Cragg double hurdle model of collaboration with universities (robust standard errors)**

Variable			**Estimates**	
			1st hurdle (collaborates with universities vs does not collaborate)	**2nd hurdle (importance attributed to universities)**
Strategic nature (default: miniature replica)	Enhanced Miniature Replica (EMR)	Dummy variable for Enhanced Miniature Replica (EMR)	0.4614*** (0.1665)	0.2678*** (0.0228)
	Rationalized Product Subsidiary (RPS)	Dummy variable for Rationalized Product Subsidiary (RPS)	0.1482 (0.3422)	-0.0443** (0.0327)
	World Product Mandate (WPM)	Dummy variable for World Product Mandate (WPM)	0.4377 (0.3126)	0.1994*** (0.0546)
Size (default: small)	Medium-sized firm	Dummy variable for medium-sized firm (50-249 employees)	0.0650 (0.1739)	0.0102 (0.0193)
	Large firm	Dummy variable for large firm (250 or more employees)	0.3843** (0.1621)	-0.0132 (0.0205)
Human capital	Human capital	Percentage of employees with a tertiary degree (in ln)	0.3897* (0.2174)	0.0048 (0.0212)
	Training expenditures	Training expenditures (in ln)	0.0408*** (0.0135)	0.0073*** (0.0023)
Knowledge base	Indigenous R&D	Dummy variable for indigenous R&D (R&D activities undertaken by the firm itself)	0.7161*** (0.1628)	0.1137*** (0.0266)
	Expenditures on knowledge acquisition	Expenditures on knowledge acquisition (in ln)	0.0432*** (0.0138)	0.0196*** (0.0020)
IPRs protection	IPRs submission	Dummy variable for IPRs submission (applying for a patent, utility model, industrial design right or trademark)	0.4738** (0.1918)	0.0189 (0.0321)
	IPRs licensing	Dummy variable for IPRs licensing (licensing/buying a patent, industrial design right, copyright or trademark)	0.2030 (0.2982)	0.0380 (0.0504)
Public funding	Public funding	Dummy variable for public funding (any public financial support received for innovation activities)	-0.1658 (0.1452)	-0.5682*** (0.0204)
Sector (default: Commerce)	Manufacturing	Dummy variable for firm belonging to the manufacturing sector	0.4669*** (0.1842)	0.0560*** (0.0202)
	KIBS	Dummy variable for firm belonging to the KIBS sector	0.2174 (0.1980)	-0.0111 (0.0219)
N			736	
LR chi2(14)			1383.77 (0.000)	
R2			0.8672	

Source: Own elaboration.

Starting with subsidiaries' strategic nature (the core independent variable), it is found that an innovative subsidiary that acts locally (EMR) is 1.6 times more prone to collaborate with universities ($\hat{\beta}$ = 0.4614; $e^{\hat{\beta}}$ = 1.5863; p-value < 0.01) than a firm that acts local but with no product innovation (MR). Assuming that the subsidiary collaborates with universities, we observe that innovative subsidiaries acting locally (EMRs) ($\widehat{\beta'}$ = 0.2678; p-value < 0.01) or globally (WPMs) ($\widehat{\beta'}$ = 0.1994; p-value < 0.01) tend to attribute more importance to universities as partners than the innovative ones that operate locally (MRs).

Thus, both hypotheses (and sub-hypotheses) – *H1: The strategic nature of the subsidiary is relevant for explaining the collaboration with universities (H1a: Subsidiaries with more innovative strategic nature (e.g., Enhanced Miniature Replica (EMR) or World Product Mandate (WPM)) are more likely to collaborate with universities); H2: The strategic nature of the subsidiary is relevant for explaining the importance attributed to the collaboration with universities (H2a: Subsidiaries with more innovative strategic nature (e.g., Enhanced Miniature Replica (EMR) or World Product Mandate (WPM)) tend to attribute higher importance to the collaboration with universities)* – are validated.

Despite the lack of empirical evidence on the association between the strategy of subsidiaries and collaboration with universities, Manolopoulos et al. (2005) suggest in a theoretical basis that more innovative/creative subsidiaries (such as EMRs or WPMs) would be more likely to collaborate with scientific institutions such as universities, which is in line with our results. Due to their high level of autonomy, EMRs are allowed to develop and invest in new products (White & Poynter, 1984), generally related (e.g., product lines extensions). Seeking for exclusiveness and differentiation (Cantwell & Iguchi, 2005), WPMs focus on a narrow product scope, being responsible for products' design, manufacturing and marketing (Manolopoulos, 2008). Thus, the need to innovate leads to a strong R&D commitment. As universities are considered important sources of external knowledge, they may be placed at the centre of the innovation process (Johnston & Huggins, 2017).

In contrast, an MR is characterized by standardized products and a low level of autonomy. As such, subsidiaries with this strategic nature are not able to engage in innovation activities, being only capable to make some adaptations to the product (Cantwell & Iguchi, 2005). Although Manolopoulos et al. (2005) suggest that more efficiency-seeking subsidiaries (RPSs) may be more prone to collaborate with scientific institutions, our results did not emerge as significant in what concerns this particular strategy.

Regarding the control variables – size, human capital, knowledge base, IPRs protection, public funding and sector – the results obtained are in general (excluding the public funding) in line with the literature. Indeed, as predicted by Guimón & Salazar-Elena (2015), Sánchez et al. (2016) – both focused on firms in general, but in a moderate innovative country (Spain) – and Suzuki et al. (2017) – focused on multinational enterprises in Japan – –, we found that larger subsidiaries (that is, with 250 or more employees) are 1.5 times more prone to collaborate with universities than smaller ones ($\hat{\beta}$ = 0.3843; $e^{\hat{\beta}}$ = 1.4686; p-value < 0.05). Yet, nothing can be said concerning the relation between the size and the importance attributed to universities. Moreover, subsidiaries with a higher percentage of employees with a tertiary degree ($\hat{\beta}$ = 0.3897; $e^{\hat{\beta}}$ = 1.4765; p-value < 0.10), and that invest more in training ($\hat{\beta}$ = 0.0408; $e^{\hat{\beta}}$ = 1.0416; p-value < 0.01) tend to collaborate more with universities. In the latter case, the importance attributed to universities tend also to be higher ($\widehat{\beta'}$ = 0.0073; p-value < 0.01), all the remaining factors being held constant. Such results go in line with the study by Guimón & Salazar-Elena (2015).

Additionally, subsidiaries that develop R&D activities themselves ($\hat{\beta}$ = 0.7161; $e^{\hat{\beta}}$ = 2.0464; p-value < 0.01), expend more on knowledge acquisition ($\hat{\beta}$ = 0.0432; $e^{\hat{\beta}}$ = 1.0441; p-value < 0.01), and are involved in IPRs submission ($\hat{\beta}$ = 0.4738; $e^{\hat{\beta}}$ = 1.6061; p-value < 0.01) tend to collaborate more than the others, such as suggested by Guimón & Salazar-Elena (2015) and Suzuki et al. (2017). Considering that a subsidiary collaborates, it tends to attribute more importance to that collaboration when it has indigenous R&D ($\widehat{\beta'}$ = 0.1137; p-value < 0.01), and higher levels of expenditures on knowledge acquisition ($\widehat{\beta'}$ = 0.0196; p-value < 0.01). Contrasting the literature (Guimón & Salazar-Elena, 2015), it is found that getting public funds for innovation activities is negative related with the importance attributed to universities ($\widehat{\beta'}$ = -0.5682; p-value < 0.01).

In what concerns the sector, the probability of subsidiaries from the manufacturing to collaborate with universities is 1.6 times higher than subsidiaries operating in services ($\hat{\beta}$ = 0.4669; $e^{\hat{\beta}}$ = 1.5950; p-value < 0.01). Conditional to collaboration, subsidiaries operating in the manufacturing sector tend to attribute more importance to universities than their services counterpart ($\widehat{\beta'}$ = 0.0560; p-value < 0.01).

5. Conclusions

Subsidiaries assume a strategic role within a multinational enterprise (MNE) as they are able to combine knowledge of their internal network and the external host country environment (Ferraris, Santoro, & Dezi, 2017), namely by engaging on collaborative relationships for innovation with other entities (Sánchez et al., 2016).

In modern societies, universities embrace the development and implementation of knowledge by collaborating with firms (Aguiar-Díaz et al., 2016). The literature in the area, mostly devoted to general firms rather than subsidiaries, suggests various determinants related to firms' characteristics and endowments for explaining university-industry (U-I) collaborations (e.g., size, human capital, knowledge base) (e.g., Ferraris, Santoro, & Bresciani, 2017; Ferraris, Santoro, & Dezi, 2017; Guimón & Salazar-Elena, 2015; Sánchez et al., 2016; Suzuki et al., 2017). Such literature, however, overlooked the potential influence of subsidiaries' strategic nature on the propensity for collaboration with universities, as well as the importance subsidiaries attribute to such collaboration.

Based on data from the latest (2012-2014) Portuguese Community Innovation Survey, we analysed the set of 736 subsidiaries regarding the propensity and importance attributed to the collaboration with universities resorting to double hurdle econometric models.

The main contribution of this investigation is twofold.

First, at a theoretical and empirical level. We tentatively proposed and tested a new theoretical framework involving the relation between subsidiaries' strategic nature and collaboration with universities. Our results clearly evidence that the strategic nature of subsidiaries is relevant for explaining both the collaboration and, contingent to that collaboration, the importance attributed to it. Specifically, more innovative subsidiaries (Enhanced Miniature Replicas and World Product Mandates), tend to collaborate more and to attribute higher importance to universities. Such result occurs in a context of a moderate innovative country, Portugal (European Commission, 2017). This is an interesting and promising outcome. Indeed, in this type of countries, similarly to the case of new industrialized countries (see Bodas Freitas, Marques, & de Paula e Silva, 2013), as indigenous technological capabilities are improved, universities (and other higher education institutions) are expected to become increasingly important for supporting both domestic firms and subsidiaries to move into more dynamic and high-opportunity industries. Given the

noticeable economic, institutional or social benefits that U-I collaborations are likely to produce (Ankrah & Al-Tabbaa, 2015), and the fact that subsidiaries which are more prone to link with universities are the most innovative ones, the incentives for attracting foreign direct investment (FDI) in a moderate innovative country should be linked with the nature of the investment that one wants to attract (Teixeira & Tavares-Lehmann, 2007). Particularly, it would be interesting for governments to develop FDI attraction policies more beneficial to innovative subsidiaries. According to the typology used in the present study, that means to attract more of Enhanced Miniature Replicas (EMRs) and World Product Mandates (WPMs). This would allow the overall economy to improve its competitiveness, economic growth and wealth creation, by accessing new technologies, innovative competences and talented human resources (Ahmad, Draz, & Yang, 2018).

Second, at the methodological level. We resort to a double hurdle model adjusted for heteroscedasticity. U-I collaborations in moderate innovative contexts are characterized by a strongly positive skewed distribution with a large stack of zero counts (Teixeira & Costa, 2006), that is, a large number of firms do not collaborate with universities. Therefore, standard generalized linear models in this context tend to lead to a poor fit (Hofstetter, Dusseldorp, Zeileis, & Schuller, 2016). Moreover, the double hurdle model is the most appropriate methodology in modelling the importance attributed by subsidiaries to university collaboration, conditional on that collaboration. The double hurdle model (Cragg, 1971) assumes that subsidiaries make two decisions with regard to university collaboration, each of which is potentially determined by a different set, or the same set with a different impact, of explanatory variables. In order to observe the importance of collaboration with universities, two separate hurdles must be passed. A different latent variable is used to model each decision process, with a Probit model to determine whether the subsidiary collaborates or not with universities and a Tobit model to determine the degree of importance attributed to that collaboration (Blundell & Meghir, 1987).

In spite of these contributions, the present study presents limitations.

First, by opting for secondary data from the Community Innovation Survey (CIS), we are limited to the information that it provides, inevitably having to define a proxy for the relevant variables in our model. In line with some studies using the same dataset (CIS) (e.g., Dachs et al., 2008; Sánchez et al., 2016; Veugelers & Cassiman, 2004), foreign subsidiaries were identified as firms belonging to a group with the head office located in a foreign country.

The location of the head office, however, may not necessarily be the origin of the control. Notwithstanding, given that the number of MNEs subsidiaries located in Portugal whose global ultimate owner is Portuguese is rather small, the limitation indicated is not likely to bias the results found. Additionally, and regarding the subsidiaries' typology, the information provided by the CIS did not allow us to gauge directly the market or the product scope. We have therefore to consider their innovative nature as proxy for the product scope. Although both dimensions are related, the innovation variable in CIS is a perception based metric and might not fully capture the degree of autonomy of foreign subsidiaries *vis-à-vis* the MNE's headquarter in establishing their product scope.

Second, the results obtained are based on a single country, Portugal, characterized by a particular context in terms of innovation. Although the implications of such results might be shared by other countries with similar characteristics (that is, moderate innovators), they cannot be generalized to other type of contexts. This would, nevertheless, constitute a challenging and interesting path for future research.

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Annexes

Table A 1: Studies on U-I collaborations – main methodologies of analysis

Study	Unit of analysis	Country/ region	Methodology	Data analysis	Dependent variables	Set of independent variables
Aguiar-Díaz et al. (2016)	Research groups	Spain	Quantitative	SLS model	- Scientific production - Contracts	- Area of knowledge - Size - Group age - Leader gender - Leader status - Leader RQ - Theses - Referee - Professional - Research institute - Research center
Bozeman, & Gaughan (2007)	Universities	USA	Quantitative	OLS regression	- Industry involvement on grants activity	- Demographic - Career - Grants activity - Disciplinary affiliation
Grimpe & Fier (2010)	Scientists	Germany	Quantitative	Probit model	- Informal technology transfer	- Faculty characteristics - Scientist productivity - Institutional environment
Haeussler & Colyvas (2011)	Scientists	Germany and UK	Quantitative	Probit model	- Consulting - Patenting - Founding	- Demographic - Material and social resources - Values and orientation towards science
Johnston & Huggins (2017)	KIBS firms	UK	Quantitative	OLS regression	- Geographic proximity of the two partners	- Size - Previous collaboration - IP income - Research intensity - Employment density
Sánchez et al. (2016)	Firms	Spain	Quantitative	Logit model	- Local cooperation for innovation	- Foreign ownership - Size - Exports - New or improved products - EU market - Local market - Number of employees involved in internal R&D
Suzuki et al. (2017)	MNEs	Japan	Quantitative	Probit model	- R&D activities in the host country	- University research strength - Intensity of U-I collaboration - Other variables
Williams (2009)	MNEs subsidiaries	USA, Germany, UK and The Netherlands	Quantitative	Linear regression	- MNE engagement in global initiatives	- Inter-unit networking - Subsidiary learning - Shared strategic goals - Firm size - Industry as services - MNE home country - Importance of the subsidiary within the MNE
Broström et al. (2009)	MNEs subsidiaries	UK, Switzerland and Sweden	Qualitative	Case studies	- Benefits of local interaction with universities	- R&D activities - Perceived effects of the cooperation - Organizational forms of collaboration
Guimón & Salazar-Elena (2015)	Firms	Spain	Mixed	Probit model/ case studies	- Collaboration with universities	- Foreign subsidiaries - Unaffiliated firms - Size - Innovation expenditure - Training - Highly educated employees - Basic research - Intellectual property - Public funding - Collaboration with any other partners

Note: Grey cells identify studies focusing on MNEs subsidiaries.

Table A 2: Means of the relevant variables

	Enhanced Miniature Replica (EMR)	Rationalized Product Subsidiary (RPS)	World Product Mandate (WPM)	Medium-sized firm	Large firm	Human capital	Training expenditures (€)	Indigenous R&D	Expenditures on knowledge acquisition (€)	IPRs submission	IPRs licensing	Public funding	Manufacturing	KIBS
Collaborates with universities vs Does not collaborate with universities														
Other	0.812	0.029	0.058	0.203	0.652	136,768.348	3.739	0.870	1,241,267.174	0.304	0.116	0.667	0.710	0.159
Collaborates with universities	0.378	0.061	0.031	0.274	0.292	39,610.366	3.508	0.238	233,398.105	0.075	0.027	0.552	0.406	0.223
Kruskal-Wallis test (p-value)	**0.000**	**0.274**	**0.248**	**0.202**	**0.000**	**0.003**	**0.329**	**0.000**	**0.000**	**0.000**	**0.000**	**0.067**	**0.000**	**0.220**
Importance attributed to universities as partners														
Does not innovate	0.000	0.103	0.000	0.238	0.248	0.000	3.621	0.000	0.000	0.052	0.014	1.000	0.334	0.245
Innovates but does not collaborate	0.656	0.031	0.048	0.313	0.282	72,022.068	3.415	0.364	280,301.813	0.078	0.037	0.187	0.435	0.190
Innovates and collaborates with other entities	0.711	0.024	0.084	0.265	0.482	63,200.313	3.446	0.627	882,744.615	0.145	0.036	0.277	0.554	0.265
Innovates and collaborates with universities, not being these its most important partner	0.840	0.040	0.020	0.220	0.640	180,239.320	3.820	0.860	884,023.020	0.300	0.120	0.600	0.680	0.200
Innovates and collaborates with universities, being these its most important partner	0.737	0.000	0.158	0.158	0.684	22,371.053	3.526	0.895	2,181,383.368	0.316	0.105	0.842	0.789	0.053
Kruskal-Wallis test (p-value)	**0.000**	**0.001**	**0.000**	**0.190**	**0.000**	**0.000**	**0.295**	**0.000**	**0.000**	**0.000**	**0.002**	**0.000**	**0.000**	**0.149**
Total	**0.418**	**0.058**	**0.034**	**0.268**	**0.326**	**48,718.930**	**3.530**	**0.298**	**327,885.830**	**0.096**	**0.035**	**0.563**	**0.435**	**0.217**

Table A 3: Correlation matrix

Variable	CO_Imp	Univ_d	EMR_d	RPS_d	WPM_d	SzM_d	SzL_d	ln_HC	ln_TE	IRD_d	ln_EK	IPRS_d	IPRL_d	PF_d	Manuf_d	KIBS_d
CO_Imp	1	0.751***	0.565***	-0.122***	0.147***	-0.008	0.252***	0.033	0.320***	0.604***	0.637***	0.229***	0.138***	-0.357***	0.229***	-0.050
Univ_d		1	0.256***	-0.040	0.043	-0.047	0.224***	0.067*	0.114***	0.402**	0.342***	0.226***	0.140***	0.068*	0.179***	-0.045
EMR_d			1	-0.211***	-0.159***	0.059	0.133***	0.055	0.367***	0.436***	0.457***	0.152***	0.061*	-0.457***	0.095***	-0.013
RPS_d				1	-0.047	0.020	-0.025	-0.115***	-0.099***	-0.111***	-0.083**	0.062*	-0.048	0.080**	0.097***	-0.005
WPM_d					1	0.022	0.094**	-0.062*	0.004	0.157***	0.191***	0.015	0.045	-0.046	0.138***	-0.044
SzM_d						1	-0.421***	-0.042	0.111***	-0.044	0.005	-0.052	0.001	-0.067*	-0.023	-0.058
SzL_d							1	-0.099***	-0.007	0.283***	0.252***	0.146***	0.040	0.070*	0.314***	-0.064*
ln_HC								1	0.039	0.021	-0.047	0.100***	0.095**	-0.004	-0.424***	0.415***
ln_TE									1	0.176***	0.258***	0.089**	0.067*	-0.320***	-0.040	0.014
IRD_d										1	0.679***	0.150***	0.133***	-0.127***	0.256***	-0.033
ln_EK											1	0.121***	0.122***	-0.268***	0.301***	-0.090**
IPRS_d												1	0.087**	-0.027	0.038	0.051
IPRL_d													1	-0.024	-0.079**	0.060
PF_d														1	0.099***	-0.046
Manuf_d															1	-0.462***
KIBS_d																1

***. Correlation is significant at the 0.01 level (2-tailed).

**. Correlation is significant at the 0.05 level (2-tailed).

*. Correlation is significant at the 0.1 level (2-tailed).

Listwise N=736