Chapter 10
The Challenge of R&D Offshoring: Implications for Firm Productivity

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Abstract R&D offshoring has been gaining in importance in recent years. Nevertheless, there is as yet a very limited understanding of its implications for firms. This chapter analyzes the potential benefits the offshoring of R&D may have on productivity. We distinguish between two governance modes—captive offshoring and offshore outsourcing, and we analyze their direct and indirect effects through innovation. The empirical analysis is based on an extensive sample of Spanish firms in the manufacturing and services sectors covering the 2004–2007 period. Our results enable us to conclude that offshore outsourcing has a positive impact—both directly and indirectly—on productivity. In turn, captive offshoring has a positive impact on productivity, which is observed insofar as the firm innovates. This research reveals the importance not only of R&D offshoring strategies but also of the choice of one or other governance mode according to a firm's specific goals.

Keywords Offshoring · R&D · Innovation · Captive offshoring · Offshore outsourcing · Productivity

10.1 Introduction

In recent years, offshoring has widened its scope and now also includes knowledge-intensive value-added activities (Lewin et al. 2009). Given that R&D offshoring is becoming ever more commonplace (Contractor et al. 2010a), it is

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T. Pedersen et al. (eds.), *The Offshoring Challenge*,
DOI: 10.1007/978-1-4471-4908-8_10,

essential for firms to be aware of its implications. Despite its growing importance, research in this field remains extremely limited. Indeed, as far as we know, the bulk of today's scholarly contributions focus on the motives for R&D offshoring (Ambos and Ambos 2011) and the choice of location (Jensen and Pedersen 2011; Demirbag and Glaister 2010). Research on the consequences of R&D offshoring, however, remains scarce.

The offshoring of R&D could be beneficial in terms of productivity, as a result of the structural and innovation effects forthcoming from the restructuring of the value chain, learning externalities and technological and knowledge diversity (Amiti and Wei 2009; Tang and Livramento 2010). The potential benefits of obtaining inputs overseas and forging international linkages impel us to discuss the relationship between R&D offshoring and productivity. In particular, we firstly consider the direct relationship between R&D offshoring and productivity, and secondly, we explore a possible indirect effect by analyzing the part played by innovation in that relationship. To this end, we define R&D offshoring as the sourcing of R&D across national borders through activities that are both internal and external to the firm for the purpose of serving the home country or global market. In addition, we identify two governance models: through affiliate firms abroad (captive offshoring) or through arm's length relationships with independent foreign suppliers (offshore outsourcing), and we analyze the potential direct and indirect impact these two modes of offshoring have on firm productivity. This work allows us to cast some light on the potential benefits of developing strategies for offshore knowledge-intensive business services (KIBs). On a theoretical and empirical level, it describes and presents evidence on a little-researched phenomenon such as R&D offshoring, and particularly their effects on productivity. In theoretical terms, we identify and analyze two governance models of offshoring (captive offshoring and offshore outsourcing), as well as discussing their potential implications for firm productivity. The study also considers the direct and indirect effects of R&D offshoring on firm productivity through innovation. In empirical terms, the use of a wide data panel allows performing a rigorous quantitative analysis and providing widely applicable results on a research topic in which the evidence is almost anecdotal. The availability of data for different years allows us to include lagged effects of offshoring on productivity and thereby analyze causality. Moreover, we study small, medium and large firms from very different manufacturing and services sectors.

To the best of our knowledge, the paper by Tang and Livramento (2010) is the only one published that examines R&D offshoring and productivity. These authors analyze the possible impact on the productivity of Canadian manufacturing firms when they opt for the offshore outsourcing of their R&D activities. Although their study finds no evidence of a significant relationship, the authors point out that the work is only able to analyze contemporary correlations as it is based on one-time cross-sectional data. In contrast, the information contained in our database enables us to examine the two types of offshoring, introduce lagged effects and produce results that are generalizable to highly different sectors.

The chapter is organized as follows. Firstly, a theoretical analysis is conducted of the direct and indirect relationships between R&D offshoring and firm productivity, and the research hypotheses are formulated. Secondly, the data, variables and methodology are presented. There follows the disclosure of the results of the empirical analysis. The chapter ends by presenting the discussion and conclusions, limitations and future lines of research.

10.2 R&D Offshoring and Firm Productivity

10.2.1 R&D Offshoring and Productivity: A Direct Effect

Offshoring enables firms to make the most of location-specific, disintegration-related and externalization advantages (Kedia and Mukherjee 2009). These advantages may be extremely beneficial for business productivity. There are currently a growing number of firms that pursue strategies of this nature that involve activities of greater value added such as R&D (Ambos and Ambos 2011; Contractor et al. 2010a). R&D offshoring may be implemented by firms in order to achieve numerous strategic goals (Jensen and Pedersen 2011). Productivity may be one of the goals pursued by the firm.

There are localization advantages because the firm may furnish itself with a wide diversity of knowledge available in geographically dispersed settings. Each setting provides unique knowledge as a result of the interaction between firms in that location (Almeida and Kogut 1999). Technological diversity enables a firm to acquire new expertise and relate it to what it already possesses, thereby permitting it to learn and improve its products and/or processes (Lahiri 2010). Furthermore, a firm engaging in offshoring has access to internationally traded inputs, which may be available with a higher quality than those available domestically (Görg et al. 2008). Accordingly, access to the knowledge and technologies located abroad may provide a firm with better quality knowledge that can pave the way for improved efficiency and productivity. In sum, the incorporation of inputs and expertise imported from abroad may improve productivity through the effects of learning, variety and quality (Amiti and Konings 2007).

The advantages associated with disintegration are related to the improvements brought about by the design and organization of the value chain. Kedia and Mukherjee (2009) single out three distinct sets of advantages that may be attained thanks to the disintegration of the value chain: increased focus on core capabilities and the reallocation of other resources; and modularity-related advantages. In the case of the disintegration implied by R&D offshoring, the cost-related advantages are less important than the other two sets of advantages. It may therefore be that the main benefits stem from the concentration on core activities, grouping certain functions together, and from an increasing modularity form. R&D activities may be core operations for the firm, but it may need to group these functions into

certain locations to be more efficient. Firms can redirect their limited but valuable resources (e.g., human resources) to core areas in different locations, where they can generate value for their customers. On the other hand, a disintegrated, leaner and more modular organizational form allows increased flexibility and a speedier response to changing market needs.

Finally, and assuming the markets perform well for the function to be outsourced, the firm may achieve externalization advantages. In terms of improving productivity, these advantages are associated with both the specialization and scale economies the supplier may have and the organizational learning-related benefits provided by dealings with external providers (Tang and Livramento 2010). R&D activities often require highly specialized know-how and assets and involve major investments. International R&D providers may possess the minimum size required and the innovative talent, which the offshoring firm itself may not have. Offshoring firms benefit from their providers' knowledge, high-end skills sets, global scale and collective domain expertise (Kedia and Mukherjee 2009). Moreover, the benefits arising from offshoring partnerships may be of special significance in the case of R&D activities. The knowledge and experience accumulated by international providers may be conveyed to the offshoring firm, thereby providing it with a potential source of competitive advantage (Kedia and Lahiri 2007). It should be noted, however, that outsourcing activities of such importance that are close to the core competence, as R&D activities, is not exempt from risk. Issues of information leakage and difficulties for specifying contracts and verifying their compliance incur additional costs associated with outsourcing R&D overseas (Ellram et al. 2008). Nevertheless, once an offshoring firm is aware of the risks involved in possible opportunistic behavior by suppliers and has taken suitable measures, it may benefit from the competitive advantage arising from the offshoring of R&D to providers abroad.

In light of the aforementioned advantages, the firm may deem it convenient to offshore R&D in order to boost its productivity. Nevertheless, the firm that decides to engage in offshoring can either embark on offshoring internally by setting up their own centers abroad, or externally by outsourcing activities to independent foreign providers, with this being a very important strategic choice (Kedia and Mukherjee 2009).

The choice between the modes of governance—captive or outsourcing—is affected by, among others, the characteristics of both the operations undertaken abroad and the firm itself (Peeters et al. 2010), and especially by the strategic goal pursued (Metters 2008). If the goal the firm pursues through R&D offshoring is to make gains in terms of productivity, the firm should consider the advantages inherent to each mode of governance in offshoring. This means that of the aforementioned advantages, location, disintegration and externalization can be associated with offshore R&D outsourcing, whereas the company that decides to engage in captive offshoring R&D can benefit only from those of location and disintegration. Therefore, we expect that both governance modes of offshoring provide advantages that deliver productivity gains. In view of all the above, we formulate the first hypothesis as follows:

Hypothesis 1: Both modes of governance of R&D offshoring have a positive impact on firm productivity.

10.2.2 R&D Offshoring, Innovation and Productivity: An Indirect Effect

When analyzing the effects R&D offshoring has on productivity, some scholars suggest that productivity may be affected by the generation of a possible innovation effect (Tang and Livramento 2010). This leads us to consider the existence of two links: (1) offshoring of R&D and innovation and (2) innovation and productivity.

Regarding the first link, the literature indicates that the offshoring of R&D enables firms to obtain inputs from abroad that are of significance to innovation (Couto et al. 2007). Accordingly, those firms that pursue strategies for R&D offshoring have access to key inputs, such as new and diverse knowledge and technology (Maskell et al. 2007) and highly skilled personnel (Lewin et al. 2009), which may contribute to the development of innovations. The results of the research by Nieto and Rodríguez (2011) reveal a positive relationship between R&D offshoring and innovation performance. By differentiating between the two modes of governance of R&D offshoring—captive and outsourcing—they contend that captive offshoring R&D has a greater impact on innovation results than offshore R&D outsourcing. Therefore, if a firm has the necessary capabilities and resources for developing captive centers, it will record better innovation outcomes. Nevertheless, for those firms that are not in a position to implement captive modes, offshoring outsourcing is an attractive alternative, provided they preempt the risks that may arise and take the necessary measures to minimize them.

Regarding the second link, previous research finds evidence to confirm that both manufacturing and services firms may obtain gains in terms of productivity forthcoming from the adoption of new processes and products (Hall et al. 2009; Musolesi and Huiban 2010). The adoption of new processes might lead to enhanced efficiency that allows increasing production and, ultimately, productivity (Parisi et al. 2006). Furthermore, the incorporation of new products enables firms to adapt and reinvent themselves in order to continue being competitive (Brown and Eisenhardt 1995). These possible positive relationships between offshoring and innovation (with a greater impact of captive offshoring) together with the relationship between innovation outputs and productivity lead us to consider the following hypothesis:

Hypothesis 2: R&D offshoring has a positive and indirect impact on firm productivity, with captive offshoring R&D having a greater impact than offshore R&D outsourcing.

Figure 10.1 provides an overview of the relationships considered in the research hypotheses.

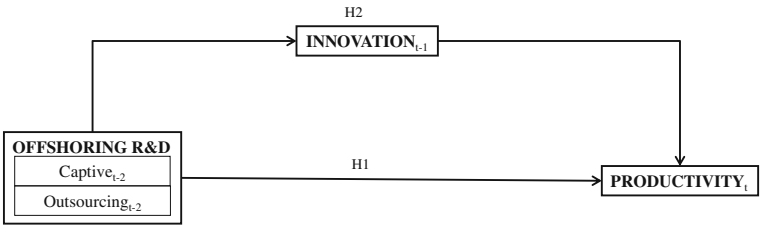

Fig. 10.1 Offshoring R&D and productivity

10.3 Empirical Analysis

10.3.1 Sample

The empirical analysis conducted here uses the technological innovation panel (TIP). This panel is compiled by Spain's National Statistics Institute, Science and Technology Foundation, and Foundation for Technical Innovation. The panel provides information on different aspects of a firm's innovation and internationalization strategies, ownership structures and other general and economic information. The TIP collects data on firms from all sectors of the Statistical Classification of Economic Activities in the European Community (NACE) for different years. The empirical analysis uses an unbalanced panel of around 12,000 Spanish manufacturing and services firms for the period from 2004 to 2007, compiled on a yearly basis.

10.3.2 Variables

The *dependent variable* is *Productivity*, which is measured as the logarithm of sales per employee (Bloom and Van Reenen 2010; Hall et al. 2009; Konrad and Mangel 2000).

The *independent variables* are described as follows: *Captive offshoring R&D* is a dichotomous variable that takes the value 1 when the firm acquires R&D services from an affiliate; and *Offshore R&D outsourcing* is a dichotomous variable that takes the value 1 when the firm buys R&D services from other firms, public administrations, universities or organizations abroad. Both independent variables are included in the analyses with a two-period lag. Finally, we include *Innovation,* which is a dichotomous variable that takes the value 1 whether it develops product or process innovation. It is included in the analyses with a one-period lag, being incorporated here in one model as the dependent variable and in another one as an independent variable to analyze its mediating role by studying the indirect relationship offshoring has on productivity.

Control variables. Following on from previous work, we include variables to capture other firm-specific characteristics that may be related to productivity (Guthrie 2001; Konrad and Mangel 2000; Görg et al. 2008). First, we control for size, using the logarithm of the number of employees as a proxy for firm size (*Size*). Second, we control for whether the company is a new firm using a dichotomous variable that takes the value 1 if the firm has been incorporated in the last 2 years (*New firm*). Third, we control for international activity, using a dichotomous variable that indicates the international presence of the firm. This variable takes the value 1 if the firm has sold its products or services abroad (*International activity*). Fourth, we control for foreign ownership with a dichotomous variable that takes the value 1 if at least 50 % of the firm's capital is in non-domestic hands (*Foreign ownership*). Fifth, we control for industry. Our database contains 55 sector classifications that are grouped in accordance with the Spanish Stock Exchange's January 2005 sector classification (with several modifications, such as identifying certain services as knowledge intensive). The activities are grouped into five categories: *Oil and energy*; *Basic materials*, *industry and construction*; *Consumer goods*; *Consumer services and KIBs*. The exclusion of one of the sectors from the models is necessary to avoid problems of perfect multicollinearity. Thus, the models do not include *Consumer goods*, which is used as a baseline category. Lastly, we control for year with bivariate indicators for each year of analysis.

10.3.3 Methodology

With a view to verifying hypothesis 1, and given that *Productivity* is a continuous variable, we estimate a regression model that analyzes the direct impact of the governance modes of R&D offshoring—captive and outsourcing—on productivity (Model 1). More formally, the empirical model presents the following econometric specification:

$$\begin{aligned}(\text{Productivity})_{it-1} = {} & \alpha_p + \beta_1(\text{Captive offshoring R\&D})_{it-2} + \beta_2(\text{Offshore R\&D outsourcing})_{it-2} \\ & + \beta_3(\text{Size})_{it} + \beta_4(\text{New firm})_{it} + \beta_5(\text{International Activity})_{it} + \beta_6(\text{Foreign Ownership})_{it} \\ & + \beta_7\left(\sum \text{Sector}_n\right)_{it} + \beta_8\left(\sum \text{Year}_t\right)_{it} + \varepsilon_i\end{aligned}$$

where α is the constant, β is the vector of coefficients and ε is the error term.

In order to verify hypothesis 2, which analyzes the indirect effect of both modes of R&D offshoring on productivity, through innovation, we need to test the mediating role of innovation in that relationship. To analyze the mediating role of innovation, we have followed the methodology described by Baron and Kenny (1986). This methodology has been used to analyze the presence of mediator variables in many studies (Boxall et al. 2011; Dou et al. 2010; Reuber and Fischer 1997, among many others).

According to this methodology, there are four steps to determine whether a variable mediates the relationship between an independent variable and a dependent variable:

1. The first step is to analyze the direct relationship (already described in hypothesis 1); that is, confirm there is a significant relationship between the independent variables (*Captive offshoring* and *Offshore outsourcing*) and the dependent variable (*Productivity*)—see Fig. 10.1.
2. The second step is to show that the independent variables (*Captive offshoring* and *Offshore outsourcing*) are related to the mediator variable (*Innovation*).
3. The third step is to show that the mediator variable (*Innovation*) is related to the dependent variable (*Productivity*).
4. The fourth and final step is to check that correlation between the independent variables (*Captive offshoring* and *Offshore outsourcing*) and the dependent variable (*Productivity*) is significantly reduced when the mediator variable (*Innovation*) is included in the model.

If the four steps are fulfilled, we can affirm there is an indirect relationship between the governance modes of offshoring and productivity through innovation. In this case, empirical support would be provided for hypothesis 2. "Perfect mediation" holds if the independent variable has no effect when the mediator is controlled, which would indicate that there is only an indirect relationship between the two variables.

To test for mediation, Baron and Kenny (1986) recommend estimating three regression equations:

1. Regression of the independent variable (X) on the dependent variable (Y); model 1.
2. Regression of the independent variable (X) on the mediator variable (M); model 2.
3. Regression including the independent variable (X) and the mediator (M) on the dependent variable (Y); model 3.

Depending on the dependent variable, two types of econometric models were used as follows: (1) the regression model where the dependent variable is *Productivity*—model 1 (see the specification model described earlier for hypothesis 1) and model 3 (the same specification as model 1 including *Innovation* as independent variable); and (2) the probit model where the dependent variable is *Innovation*—model 2. Formally, this model has the following econometric specification:

$$\begin{aligned}\text{Prob (Innovation)}_{it-1} = {} & \alpha_p + \beta_1(\text{Captive offshoring R\&D})_{it-2} + \beta_2(\text{Offshore R\&D outsourcing})_{it-2} \\ & \beta_3(\text{Size})_{it} + \beta_4(\text{New firm})_{it} + \beta_5(\text{International Activity})_{it} + \beta_6(\text{Foreign Ownership})_{it} \\ & \beta_7\left(\sum \text{Sector}_n\right)_{it} + \beta_8\left(\sum \text{Year}_t\right)_{it} + \varepsilon_i\end{aligned}$$

where α is the constant, β is the vector of coefficients and ε is the error term.

All our models were also analyzed for potential multicollinearity problems by conducting an analysis of the variance inflation factor (VIF). Individual VIF values higher than ten, combined with average VIF values higher than six, indicate a multicollinearity problem (Neter et al. 1989). The values set out in Table 10.1 show there are no problems of multicollinearity in any of the models. All the models include the remaining firm-specific controls and sector and yearly dummies.

10.4 Results

10.4.1 Descriptive Statistics

Figure 10.2 provides a graphic description of the proportion of firms in the sample that undertake captive offshoring and offshore outsourcing R&D, depending on their size and on their business sector. Interesting differences are related to governance models of offshoring and the size of firms. Captive offshoring R&D is preferred mainly by large firms, while offshore R&D outsourcing is chosen by firms regardless of size. This may be because offshore R&D outsourcing is a favored option when resources to invest in captive operations are not available or when dealing with smaller-scale projects. Regarding the sectorial distribution, the highest proportions of firms pursuing offshoring activities are to be found in the sectors of basic materials, industry and construction and consumer goods.

10.4.2 Direct Relationship Between R&D Offshoring and Productivity

The first column in Table 10.2 gathers the results for model 1, which tests hypothesis 1. The coefficients of the variables *Captive offshoring R&D* and *Offshore R&D outsourcing* are positive and significant, with the coefficient for offshore outsourcing being higher. These findings provide empirical support for hypothesis 1. Regarding the control variables, the size variable has a negative coefficient, but it is not significant. Being a newly incorporated firm is negatively and significantly related to productivity. For their part, international activity and foreign ownership have a positive and significant impact on productivity. Finally, the coefficients related to the sectorial categories *Oil and energy* and *Basic materials* are positive and significant, suggesting that belonging to these sectors is associated with greater productivity than when pertaining to *Consumer goods* (which is the category excluded from the analyses). The opposite happens in the case of firms belonging to the sectors of *Consumer services* and *KIBs*, whose coefficients are negative and significant.

Table 10.1 Descriptive statistics, correlations and collinearity diagnostics of the independent and control variables

	Mean	St. Dev.	1	2	3	4	5	6	7	VIF[1]	VIF[2]
1. Captive offshoring $R\&D_{t-2}$	0.01	0.10	1.000							1.06	1.06
2. Offshore R&D outsourcing$_{t-2}$	0.03	0.16	0.096***	1.000						1.02	1.02
3. Innovation$_{t-1}$	0.59	0.49	0.058***	0.086***	1.000					−1.08	1.08
4. Size$_t$	4.19	1.67	0.088***	0.0049***	−0.022***	1.000					1.09
5. New firm$_t$	0.02	0.13	−0.009	−0.008	−0.039***	−0.151***	1.000			1.01	1.01
6. International activity$_t$	0.05	0.50	0.076***	0.094***	0.270***	0.081***	−0.077***	1.000		1.04	1.10
7. Foreign ownership$_t$	0.09	0.29	0.203***	0.031***	0.039***	0.257***	−0.033***	0.201***	1.000	1.13	1.13
							Media VIF			1.06	1.07

***$p < 0.01$, **$p < 0.05$, *$p < 0.10$. $N = 45{,}205$

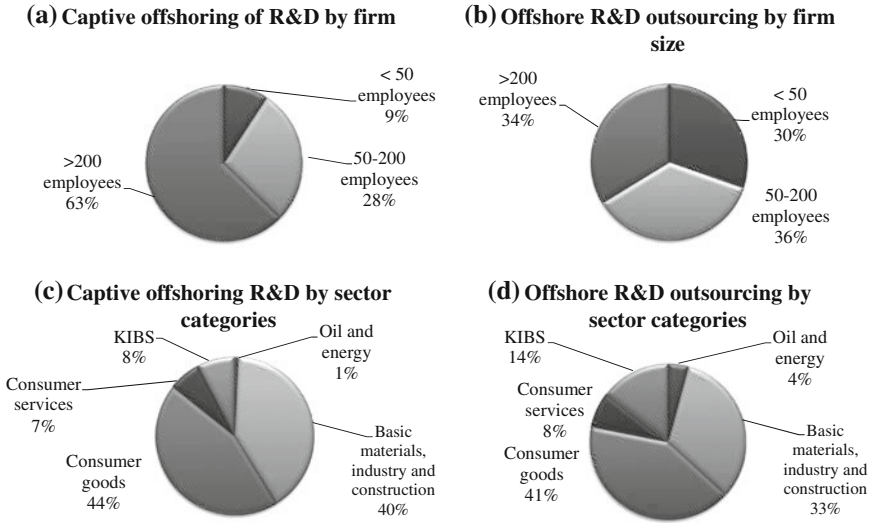

Fig. 10.2 Captive offshoring R&D and offshore R&D outsourcing by size and sector categories

10.4.3 Indirect Relationship Between R&D Offshoring and Productivity

To test hypothesis 2, which postulates the positive and indirect effect of R&D offshoring on productivity, through innovation, it is necessary to analyze the mediating role of *Innovation* in this relationship. This requires verifying that the four conditions mentioned above are met. Condition 1 has already been satisfied, as it has been shown there is a positive and direct effect of captive offshoring R&D and offshore R&D outsourcing on productivity (model 1). Condition 2 involves corroborating the relationship between both modes of R&D offshoring and *Innovation*. To analyze this relationship, we consider the probit model, whose results are presented in the second column of Table 10.2—model 2. The estimated coefficients for both modes of offshoring are positive and significant, indicating that the explanatory variables (*Captive offshoring* and *Offshore outsourcing*) are related to the mediator (*Innovation*), thus satisfying Condition 2. The next step is to include the mediator variable (*Innovation*) in the original regression, together with the independent variables. It can be seen (in column 3 of Table 10.2—model 3) that the coefficient of the mediator variable is positive and significant for the relationship with *Productivity*, and so Condition 3 is also satisfied. Finally, Condition 4 is satisfied, given that the relationship between the independent variables and the dependent variable *Productivity* is significantly reduced when *Innovation* is included in the model. In the case of offshore R&D outsourcing, the mediating relationship is partial, which indicates that the effect of these activities on the firm's productivity is both direct and indirect, through innovation. The significance of *Captive offshoring R&D* is reduced to zero in model 3, indicating perfect

Table 10.2 Offshoring of R&D and firm productivity

	Model 1 productivity_t	Model 2 innovation_{t-1}	Model 3 productivity_t
Captive offshoring of $\text{R\&D}_{t-2}$	0.129** (2.18)	0.913*** (7.11)	0.091 (1.54)
Offshore R&D outsourcing_{t-2}	0.215*** (5.83)	0.679*** (9.71)	0.184*** (4.99)
Innovation_{t-1}	–	–	0.203*** (14.46)
Size_t	−0.003 (−0.86)	−0.043*** (−7.86)	−0.001 (−0.03)
New firm_t	−0.511*** (−6.44)	0.921*** (3.40)	−0.559*** (−7.07)
$\text{International activity}_t$	0.474*** (34.24)	0.540*** (27.97)	0.437*** (31.13)
$\text{Foreign ownership}_t$	0.470*** (21.60)	−0.129*** (−4.17)	0.478*** (22.04)
Oil and energy	0.579*** (10.24)	0.007 (0.09)	0.577*** (10.25)
Basic materials, industry and construction	0.087*** (5.28)	−0.003 (−0.15)	0.088*** (5.35)
Consumer services	0.031* (1.68)	−0.441*** (−16.41)	0.065*** (3.35)
Knowledge-intensive services	−0.816*** (−42.88)	−0.128*** (−4.73)	−0.806*** (−42.56)
Constant	11.549*** (57.80)	0.517*** (16.29)	11.407*** (46.46)
Test of goodness of fit	621.66***	2075.41***	592.51***
R^2	0.227		0.234
Log. Likelihood	–	−13,322.04	–

***$p < 0.01$, **$p < 0.05$, *$p < 0.10$

mediation; that is, the positive effect of captive offshoring on productivity is an indirect effect through innovation (perfect mediation holds). It can thus be contended that captive offshoring R&D makes a positive contribution to firm productivity insofar as the firm innovates.

These results, therefore, offer empirical support for hypothesis 2, given that an indirect relationship has been confirmed between R&D offshoring and firm productivity.

10.5 Discussion and Conclusions

In recent years, and on an ever expanding basis, firms have turned to offshoring no longer for reasons of cost-cutting but in search of creativity and innovation (Contractor et al. 2010b). Offshoring high-value-added activities such as R&D is increasingly gaining in importance (Ambos and Ambos 2011; Contractor et al. 2010a). In spite of the significance of these strategies, the analysis of their implications in terms of business productivity has not received the attention it deserves in scholarly literature. This paper takes a step forward in this direction by analyzing the implications the governance modes of R&D offshoring have for productivity. First, an analysis is made of the potential direct impact on productivity of captive offshoring R&D and offshore R&D outsourcing. Second, an investigation is conducted into the indirect effect that, through innovation, these two modes of offshoring governance may have on productivity.

Regarding the first relationship, the results forthcoming enable us to conclude that offshoring activities have a positive and direct impact on productivity. This positive relationship is consistent with that found in other research conducted for material and services offshoring (Amiti and Wei 2009; Görg et al. 2008). Most previous research focused solely on the analysis of outsourcing modes. This work has gone further, conscious that the development abroad of R&D activities through affiliates or independent third parties has different implications and, therefore, constitutes a highly strategic decision for a firm. Along these lines, the results show us that both modes of governance of offshoring have a positive and direct impact on productivity. It is thus revealed that both captive and outsourcing formulas are relevant for boosting productivity. These results may be explained by different location, disintegration and externationalization advantages associated to each modes of governance of R&D offshoring.

As regards the second relationship, offshoring has a positive and indirect impact on productivity through innovation. In other words, a firm's productivity increases thanks to the improvement in processes or the supply of new products—innovation—which in turn is impacted positively by engaging in the offshoring of R&D activities. This indirect effect is greater in the case of captive offshoring than in that of offshore outsourcing. In line with prior research, the impact captive offshoring has on innovation performance outperforms that of offshore outsourcing (Nieto and Rodríguez 2011). The incorporation of new products and enhanced

processes has a positive bearing on business productivity, as shown by other authors (Hall et al. 2009; Musolesi and Huiban 2010). This greater positive impact on innovation will lead to a better performance in terms of productivity. By analyzing the indirect relationship of offshoring on productivity, it is also found that the mediating effect of innovation is perfect in the case of captive offshoring and partial in the case of offshore outsourcing. The existence of a partial effect means that both the direct and indirect effects of offshore outsourcing on productivity are present. Both when the firm manages to record innovative results and when it does not, offshore outsourcing operations have a positive impact on productivity. As noted earlier, this effect may be due to the various advantages—location, disintegration and externalization—which this mode of offshoring may provide for the company. The perfect mediation effect of captive offshoring indicates that the positive impact on productivity of the offshoring activities undertaken by the firm's own facilities abroad occurs solely insofar as the firm manages to innovate in its processes or products. The advantages related to location-specific resources and the disintegration of firm value chain have potential for improving productivity through innovation.

All things considered, this research reaches interesting conclusions regarding the implications of R&D offshoring for productivity. The identification in the analysis of two modes of governance—captive and outsourcing—enriches the study made by providing further knowledge on the implications for a firm of sourcing R&D overseas. The evidence gathered highlights how important it is for a firm to choose the most suitable mode of governance according to the strategic goals it is pursuing. The empirical results are obtained from an extensive sample of Spanish firms of different sizes belonging to different business sectors (both manufacturing and services). The representativeness of the sample, together with Spain's status—occupying a mid-table position in the technological league of countries—means that the study's findings can be generalizable to different sectors and countries.

This research has certain limitations, which are in part due to the data available. It would therefore be of considerable interest to distinguish between destination countries according to their degree of technological development and analyze whether the impacts on productivity are different depending on that level of development. Another important issue to be considered is the geographic diversity or heterogeneity of the countries in which a firm conducts its R&D operations. In turn, the existence of inter-organizational linkages between R&D units—both when they are the firm's own facilities and when they belong to third parties—increases both the breadth and depth of knowledge in different ways and allows exerting a more reliable control over such activities. The establishment of these linkages may be crucial in terms of the direct and indirect impacts R&D offshoring operations have on productivity. Future research would do well to analyze these and numerous other aspects of the relationship between R&D offshoring and its implications for firms.

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