# *Multinationality, R&D and productivity: evidence from the top R&D investors worldwide*

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# Multinationality, R&D and productivity: Evidence from the top R&D investors worldwide ☆

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A B S T R A C T

This paper investigates the effects of multinationality on firm productivity, and contributes to the literature in two respects. First, we argue that multinationality affects productivity both directly and indirectly through higher incentives to invest in R&D. Second, we maintain that the multinational depth and breadth have different direct effects on productivity and R&D. Using data from the top R&D investors in the world, we propose an econometric model with an R&D and a productivity equation that both depend on multinationality. We find: i) multinational depth has a positive effect on productivity, while the effect of multinational breadth is negative; ii) multinationality (along both dimensions) has a positive effect on R&D intensity, translating into an indirect positive effect on productivity; iii) the positive indirect effect is however not large enough to compensate the negative direct effect of multinational breadth.

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## 1. Introduction

A large number of recent studies in international economics have shown that initiating production abroad has a positive causal effect on firm productivity.[1] These studies compare the productivity of multinational firms with domestic ones. Yet, they rarely address the degree of multinationality, that is, the extent at which firms operate on a multinational scale. This important aspect is instead widely investigated in the international business literature, which shows that the degree of multinationality can have different effects on firm performance depending on its *depth*, accounted by the share of the multinational activities, and its *breadth*, understood as the geographical dispersion of the multinational activities (Contractor, Kumar, Kundu, & Pedersen, 2010; Hsu, Lien, & Chen, 2015; Sullivan, 1994). International business scholars have mainly analyzed the role of breadth and depth of multinationality with respect to the firm economic and financial performance measured in terms of accounting-based profitability indicators or market-based indicators of the firm value (Bausch & Krist, 2007; Yang & Driffield, 2012). Unlike the international economics literature, international business studies rarely analyse how multinationality affects productivity.[2] Thus there is a gap in the literature, which we intend filling by combining the international economists' focus on productivity with the more elaborated understanding of multinational depth and breadth developed in international business.

Furthermore, both the international economics and business literature have stressed that the effects of multinationality depend

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☆ The views expressed are purely those of the author and may not in any circumstances be regarded as stating an official position of the European Commission.
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   [1] A positive effect of this kind has been found, for example, by Barba Navaretti & Castellani (2004) and Borin & Mancini (2016) for Italy; Barba Navaretti, Castellani, & Disdier (2010) and Hijzen, Jean, & Mayer (2011) for France; Wagner (2011) for Germany; Hayakawa, Matsuura, & Motohashi (2016) for Japan; Cozza, Rabellotti, & Sanfilippo (2015) for China.

[2] A notable exception can be found in Kafouros et al. (2008, 2012) who use measures of multinationality to explain MNEs productivity. Another exception is Driffield, Love, & Yang (2016), who instead use multinationality as a moderator of the relationship between the productivity of the affiliates and of the parent companies.

on contextual factors, and have singled out the key role of R&D (Fleming & de Oliveira Cabral, 2016; Kirca et al., 2011). In this perspective, R&D is usually incorporated in the analysis as a moderating factor, possibly magnifying the effect of multinationality on firm performance (Añón Higón, Manjón Antolín, & Mañez, 2011; Garcia Pires, 2015; Morck & Yeung, 1991). Using R&D as a moderating factor treats it implicitly as exogenous, although it is obviously a strategic choice of the firm. To overcome this view, authors in international business have highlighted that some of the effects of multinationality may be mediated through the effect it has on other firm-specific factors and strategies, including choices about R&D (Hult 2011; Verbeke & Brugman, 2009). In this paper we follow this perspective and submit that multinationality increases the incentives to invest in R&D.

In sum, drawing on international business and applied international economics perspectives, this paper provides a novel conceptualization of the relationship between multinationality and productivity by investigating the potentially differential effects of breadth and depth of multinationality on firm productivity, and by investigating the mediating (instead of the moderating) role of R&D.

In our empirical application we use an econometric strategy that allows estimating two separate (though interlinked) productivity and R&D regressions using Seemingly Unrelated Regression (SUR). The resulting model is tested with respect to a sample of more than 2000 of the top R&D investors worldwide.

Our results show that multinational depth has a direct positive effect on productivity, while an increase in multinational breadth is associated with lower productivity. In contrast, both multinational breadth and depth are positively correlated with investments in R&D, but the relationship is stronger for multinational breadth. As R&D intensity positively affects productivity, we uncover a positive indirect effect of both multinational breadth and depth. However, this indirect effect is not large enough to compensate for the negative direct effect of the multinational breadth on productivity.

The rest of the paper is organized as follows. Section 2 articulates our hypotheses. Section 3 presents the empirical analysis by illustrating data and empirical method. The results of the empirical analysis are discussed in Section 4. Section 5 concludes.

## 2. Hypothesis development

Our hypotheses are developed as follows. First, in Section 2.1 we deal with the role of multinational depth and breadth as determinants of productivity. Then, in Section 2.2 we consider the effect of multinationality on R&D and of the latter on productivity. Addressing this aspect allows us to distinguish between the direct and indirect productivity effects of multinationality. This distinction requires a conceptual clarification. Hult (2011) argues that multinationality affects firm performance only after being converted in some form of behaviour or action. In this perspective, the effects of multinationality are assumed to be only *indirect*, that is operating through the incentives to adopt other strategies. We contend that this view highlights a key issue, which we investigate with reference to R&D investments as a strategic choice. However, it overlooks that, as maintained in a long tradition of studies in international business and economics, multinationality has also positive and negative effects on productivity, even without considering the changes in the incentives to adopt other strategies. In the following Section 2.1 we discuss a variety of these effects which we consider, in this understanding, as *direct*.

### 2.1. The direct effects of multinationality on productivity

The effects of multinationality on productivity[3] can be both positive and negative and depend on which facets of multinationality are considered. We highlight three different channels through which multinationality can affect firm productivity. First, multinationality may allow firms to achieve a more (a) *efficient organization of production*, mainly through cheaper sourcing of intermediate inputs and better exploitation of economies of scale. Second, multinationality offers to firms (b) *learning opportunities* that can foster innovation in their processes, products and organization. Third, multinationality can impose on firms (c) *costs of organizational complexity*, which can hamper their productivity.

In the following we will discuss the three channels and we will argue that the effects of multinationality are likely to be different depending on whether we consider depth or breadth.

#### 2.1.1. More efficient organization of production

Multinationality allows firms to organize production more efficiently by rationalizing the location of production tasks along the value chain. In particular, firms can exploit gains from the international division of labour and by sourcing cheaper inputs. Firms which organize their multinational structure in order to realize lower costs are said to engage in "efficiency-seeking" foreign direct investments (FDI) (Cuervo-Cazurra & Narula, 2015; Dunning, 1993) and have been labelled vertical multinational enterprises (MNEs) (Barba Navaretti & Venables, 2004). Such vertical MNEs achieve efficiency gains along the value-chain by maintaining a high level of multinational breadth rather than of multinational depth, as the major advantages stem from the ability to exploit lower sourcing costs in a wide variety of locations. However, efficiency gains can also accrue to firms choosing multinational depth over breadth by concentrating production in fewer locations. Concentration of production can lead to higher economies of scale at plant-level, which can boost the firms' efficiency.

#### 2.1.2. Learning opportunities and access to knowledge

Establishing affiliates in many different countries (multinational breadth) or having deeper presence in fewer countries (multinational depth), entail opportunities to access novel sources of knowledge and engaging in new learning processes. Accessing novel sources of knowledge and new learning opportunities however lead to costs and benefits, which may differ between multinational depth and breadth.

In particular, multinational breadth may offer firms the opportunity to add new and different elements to their knowledge set, increasing the likelihood of discovering new valuable combinations of ideas (Kafouros, Buckley, & Clegg, 2012), and integrating them from diverse markets and contexts (Cantwell & Mudambi, 2005; Hitt, Hoskisson, & Kim, 1997). By tapping into different scientific and technological contexts and confronting different consumer preferences or supplier requests, MNEs acquire context-specific knowledge which can be transferred within their organisation and applied in different contexts to obtain a positive productivity impact. The transfer to different contexts can actually increase the innovation activities of the MNE (Zanfei, 2000). The potential to access a variety of (especially tacit) knowledge sources and technological opportunities, which can be leveraged for the

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[3] Productivity can be defined as a measure of output obtained from a given set of inputs. A more productive firm is one that with the same quantity of inputs (usually intended as the quantity of labour, physical capital and materials) produces more than another firm. See Syverson (2011) for a synthetic but comprehensive coverage of definitions and determinants of productivity at the firm-level.

introduction of new (or improved) products, process, and organisational innovations, in turn can boost MNEs productivity. Though, in order to effectively exploit such potential learning opportunities, the local units of the MNE need to be embedded both in the external network of the host country – to tap into local knowledge – and in the internal network of their MNE – to exchange knowledge with other units of the MNE (Castellani & Zanfei, 2006; Meyer, Mudambi, & Narula, 2011). As Narula (2014) puts it, MNEs need to have wide pathways of knowledge exchange both with external parties and within the MNE.[4]

On the side of costs, a higher multinational breadth clashes with the cognitive limits to knowledge coordination and to its integration capacity. Thus, maintaining such wide pathways of knowledge exchanges becomes more expensive (both financially, and in terms of human resources), implying that there are decreasing returns to multinational breadth (Narula, 2014). This is confirmed by the greater resort to flexible and reversible forms of international governance (e.g. strategic alliances) found at higher levels of multinational breadth (Castellani & Zanfei, 2004). In other words, higher multinational breadth may increase the potential sources of learning, but the costs of keeping high pathways of knowledge transfer could become large as well; accordingly, MNEs may not be actually able to benefit from all potential sources of learning. On the contrary, on very high levels reducing the multinational breadth can increase the embeddedness of foreign subsidiaries in both their external and internal MNE networks.

The picture of learning gains and costs can differ substantially when we consider multinational depth. On the one hand, higher multinational depth will imply lower additional variety in the accessible knowledge sources as compared to a higher breadth, because the number of simultaneously accessed markets is lower. On the other hand, increasing the depth of multinationality enlarges the opportunities of developing long lasting relations with international partners. Indeed, subsidiaries with more stable relationships will be less likely to act opportunistically and may be more willing to commit resources and capabilities to their local partners. In line with this argument, Ahlbrecht and Eckert (2013) show that firms start with low intensity market entry modes and then increase their commitment over time.[5] The hypothesis of higher commitment is also consistent with other empirical evidence showing that higher multinational depth increases the probability of resorting to ownership-based international relationships (e.g. mergers and acquisitions) rather than to more flexible and collaborative modes of governance (e.g. joint ventures and strategic alliances) (Castellani & Zanfei, 2004). Both of these aspects suggest that a deeper multinational presence could be associated with greater engagement in irreversible and relatively specific investments and thus with higher productivity.

### 2.1.3. Organizational complexity

Creating affiliates in foreign markets leads to organizational change implying costs of at least three kinds: (i) agency-related costs as coordination or monitoring becomes less effective with more geographically dispersed units; (ii) social/cultural/ institutional costs in terms of adaptation to a larger number of cultures; (iii) organisational costs attributable to the need of creating 'interfaces' for organizing MNEs' operational interdependencies across different countries (Baier, Rammer, & Schubert, 2015; Bartlett & Ghoshal, 1998; Ethiraj & Levinthal, 2004). As highlighted by a long-standing tradition of management studies (Richard, Devinney, Yip, & Johnson, 2009), and recently embraced by scholars in organisational economics (Bloom, Sadun, & Van Reenen, 2010), productivity reflects also organisational effectiveness. To the extent that multinationality increases the complexity of organizing a firm, it stands to reason that the associated organizational costs should *ceteris paribus* negatively affect its productivity. Most likely, the larger the variety of foreign operations, the higher the organizational complexity is. We therefore expect that multinational breadth should be more negatively related to productivity. On the contrary, we expect multinational depth to cause lower organizational costs than multinational breadth, and thus to be less negatively associated with productivity.

The combination of the three channels discussed above suggests that multinational depth entails the potential for higher commitment and embeddedness in foreign operations, which should allow for a high level of learning (sub b), moderate organizational costs (sub c) and intermediate opportunities of gains from more efficient production organization (sub a).

All in all, the previous arguments lead us to put forward our first research hypothesis with respect to the direct productivity effect of multinationality:

**Hp1a.** Multinational depth has a positive effect on productivity.

Like multinational depth, multinational breadth is associated with a number of positive opportunities to improve productivity, such as the potential of accessing larger markets and diverse sources of knowledge (sub b), and organizing production more efficiently (sub a). However, it also entails significantly higher organizational complexity (sub c) because the costs of managing international activities typically increase with geographical distance and dispersion. This is widely shown in the literature. Contractor et al. (2010), for example, hint at the increasing costs of efficient communication associated with geographical dispersion. Santos and Eisenhardt (2005) and Grimpe and Kaiser (2010) point to the deterioration entailed by geographical dispersion on the firm's integrative capabilities and to the dilution of their core resources. In the same respect, Ceci and Prencipe (2013) refer to a decrease in the effectiveness of mechanisms reducing opportunistic behaviour inside firms, such as monitoring. Finally, Baier et al. (2015) provide evidence that a higher degree of geographical dispersion significantly reduces the firms' organizational adaptability.

In addition to higher complexity costs, extending activities to a larger number of markets may force MNEs to narrow their pathways of knowledge transfer to and from international markets. Narrower pathways however limit the potential of benefiting from localized learning opportunities (sub b). While it is not possible to derive a clear expectation with respect to the overall balance between cost and gains of multinational breadth in terms of productivity, the higher costs of multinational breadth may imply that its net effects on productivity are smaller than those of multinational depth, leading to the following hypothesis:

**Hp1b.** The direct effects of multinational breadth on productivity are smaller than those of multinational depth.

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[4] To describe this situation, Narula (2014) introduces the concept of high bandwidth connections, which imply "regular, efficient and intensive two-way knowledge flows, for instance through systematic face-to-face engagement between scientists, engineers and managers in different units" (p.12).

[5] It is worth mentioning that recent contributions have highlighted that such commitment does not need to increase in a deterministic way, as MNEs may reduce their commitment when performance and prospects are not sufficiently promising (Johanson & Vahlne, 2009; Santangelo & Meyer, 2011). In the context of this paper, we contend that higher multinational intensity is consistent with a long history of internationalisation and thus with a sequence of positive learning effects from foreign markets.

## 2.2. The indirect effects of multinationality on productivity: the mediating role of R&D

An important part of the effect that multinationality exerts on firm productivity passes through the deliberated creation of new knowledge. Besides the previously discussed direct effects, multinationality can create higher incentives to increase R&D investments. The higher learning potentials stemming from multinationality discussed in the previous section (in particular, sub b), are likely to increase the pay-offs associated with R&D. Since we expect that a higher R&D intensity will increase firm productivity, we claim that there is an indirect effect of multi-nationality on productivity, which is mediated through higher investments in R&D.

Before moving to developing our specific hypotheses in this last respect, a word of caution is necessary. This paper highlights the role of R&D as a mediating factor in the relationship between multinationality and productivity. However, it needs to be noted that R&D is not the only mediating factor in the multinationality-productivity relationship. Our framework may thus still confound some indirect effects, which are mediated by other firm strategic choices, such as, for example, organizational change and advertising. Still, some of these strategies are difficult to observe in available data, and we believe that R&D is a good place to start, considering that the literature has set a strong case for a positive relation between both multinationality and R&D, and between R&D and productivity. All in all, we submit that the approach proposed in this paper adds a significant contribution to our understanding of the relationship between multinationality and productivity, although more research is needed on other possible mediating factors.

To start with, let us note that the mediating effect played by R&D in the relationship between multinationality and productivity has been largely neglected in the literature, in favor of a view where R&D increases the returns of multinationality (Añón Higón & Manjón Antolín, 2012; Kafouros, Buckley, & Sharp, 2008; Morck & Yeung, 1991). In other words, R&D is usually treated as a moderating, rather than mediating, factor of the relationship between multinationality and productivity. This approach, how-ever, neglects that the level of R&D investment is a strategic choice of the firm, and cannot be treated as exogenous with respect to multinationality. Indeed, the literature has highlighted at least two main reasons why multinationality could increase the incentives to invest in R&D. On the one hand, both wider and deeper multinationality increase the size of the market that can be served by a MNE. Since the degree of duplication of R&D within a MNE is very limited,[6] a higher turnover associated with larger markets amplifies the incentive to invest in R&D. Indeed, the larger the firm turnover, the more R&D fixed costs are spread over larger sales, and the higher the intensity of R&D investments to exploit economies of scale within the MNE (Barba Navaretti & Venables, 2004; Markusen, 2004; Petit & Sanna-Randaccio, 1998). On the other hand, multinationality creates an incentive to invest in R&D in order to leverage the broader sources of learning. Multi-nationality enables firms to establish a spatially (and sectorally) diffuse system for the absorption and creation of new competencies (Cantwell & Mudambi, 2005; Cantwell & Piscitello, 2005; Cantwell & Santangelo, 1999; Patel & Vega, 1999; Zander, 1999), and thus contributes to increasing a firm's ability to explore new

sources of knowledge (Cantwell, 1995; Castellani & Zanfei, 2002). However, being able to explore new sources of knowledge does not necessarily mean that the MNE will also be able to access it and benefit from it (Kafouros et al., 2012). In order to be able to do it, an MNE need to possess the necessary ability to decode and absorb external knowledge. Thus, the higher the exploration potential, the higher the incentives for MNEs to invest in R&D to increase their absorptive capacity (Cohen & Levinthal, 1990), which can assist them in exploiting external know-how (Escribano et al., 2009; Tsai, 2001). The argument that multinational breadth increases incentives to invest in R&D is particularly straightforward, because these incentives are directly related to a greater variety of knowledge sources. On the other hand, though to a lesser extent, a higher multinational depth is also expected to positively correlate with R&D.

**Hp2a.** Multinationality (both in depth and in breadth) has a positive effect on R&D intensity.

**Hp2b.** The effect of multinational breadth on R&D intensity is expected to be higher than that of multinational depth.

Finally, it is quite uncontroversial that R&D and productivity are positively related because R&D can contribute to introducing new products and/or processes, which in turn allow the firm to achieve higher productivity.[7] In fact, the argument that R&D increases productivity has been increasingly supported since the seminal paper by Griliches (1979), as is documented in various reviews (Doraszelski & Jaumandreu 2013; Hall & Mairesse 1995; Mohnen & Hall, 2013). Typically, the literature finds a positive effect of R&D on productivity at the firm-level, with an elasticity ranging from 0.05 to 0.25. This leads us to our last hypothesis:

**Hp3.** R&D intensity has a positive effect on firm productivity.

On the basis of the previous hypotheses, that is by combining Hp3 and Hp2a/Hp2b, we thus expect an indirect positive effect of multinationality on productivity, mediated by higher investments in R&D. Furthermore, we expect this effect to be stronger for MNEs with higher multinational breadth.

A summary of the hypotheses displaying the basic structure of our conceptual model is shown in Fig. 1.

## 3. Empirical analysis

### 3.1. Data

Our empirical analysis is based on a sample of 2858 of the top R&D investing firms worldwide. The information underlying our analysis comes from two sources. We retrieved R&D investments and other economic and financial data from the EU Industrial R&D Investment (IRI) Scoreboard (http://iri.jrc.ec.europa.eu/), which the Institute of Prospective Technological Studies (IPTS, Joint Research Centre – JRC, European Commission) conducts annually since 2004 (European Commission, 2013). In particular, the data used in this analysis refer the top R&D investors in 2012. The initial sample included 2858 firms, which accounted for more than 90% of worldwide Business Enterprise Expenditure on R&D (BERD). The focus on the top R&D investors allows us to deal with companies that are in general all MNEs (Montresor & Vezzani, 2015b) and thus

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[6] In the traditional model of MNEs, R&D is concentrated in the headquarters, and its output is used throughout the MNE network. While this model has been called into question by the increasing internationalization of R&D (Dunning & Lundan, 2009; Narula & Zanfei, 2005), still most of the R&D is kept close to the headquarters (Belderbos, Leten, & Suzuki, 2013).

[7] It should be noted that the literature suggests that more complex and radical product innovations generally rely more on formal R&D, while process innovations are much more related to embodied technical change, achieved by investments in new machinery and equipment (Crépon, Duguet, & Mairesse, 1998; Conte & Vivarelli 2014; Montresor & Vezzani, 2015a; Castellani, Piva, Schubert, & Vivarelli, 2016).
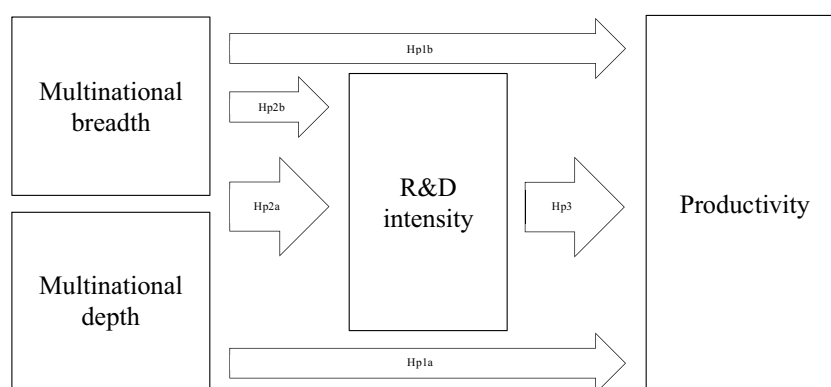
**Fig. 1.** Graphical summary of the structural model.

to investigate the effect of the degree of multinationality on productivity, rather than of the choice of going multinational. Moreover, as this paper aims to investigate the effect of multinationality on R&D, and of R&D on productivity, it seems opportune that our sample include firms for which R&D is an integral part of their strategy, and that account for a large share of the world's R&D investments.

The previous data on R&D have been combined with a second source of information on the subsidiaries controlled by these companies worldwide provided by Bureau Van Dijks' ORBIS. Out of the 2858 available firms, we were able to match 2746 firms as the global ultimate owner of at least one subsidiary in ORBIS.[8] This allows us to identify all the firms in ORBIS that are subsidiaries of these global ultimate owners. With this information, by counting the number of subsidiaries outside the home country, and the number of foreign countries where these subsidiaries are located, we are able to compute our focal measures of multinationality. Owing to missing values in some of the variables, the final number of usable observations was reduced to 2124.

Most of the companies in our sample are headquartered in a European country (32%) or in the USA (31%), while 19% are headquartered in Japan and the others in the Rest of the World (Table 1). In terms of sectors, the sample is mainly composed of companies operating in Industrial Goods & Services (27%), Information and Communications Technologies (24.5%) and Pharmaceuticals and Health Care (13%),[9] which are normally recognized as high or medium-high technological sectors (Table A1). It should be noted that, by construction, our sample does not need to be representative of the population of firms across countries and sectors, as it is explicitly compiled to represent the top R&D investors in the world, and is thus naturally more concentrated in some countries and sectors. Given our focus on R&D in investigating the interrelation between productivity and multinationality, we regard this selection as a desirable feature of our sample.

The companies in our sample control a total of 588540 subsidiaries, which are, in turn, mainly industrial companies (37%) and branches (57%). However, the higher number of branches hides an extremely skewed distribution across companies, providing unreliable figures for the affiliate structure of some companies. Moreover, there are large country differences in the

**Table 1**
Distribution of companies across world regions (estimation sample).

| Region | # of companies | Freq (%) |
|---|---|---|
| EU | 679 | 32.0 |
| (DE | *142* | *6.7)* |
| (GB | *135* | *6.4)* |
| (FR | *106* | *5.0)* |
| | | |
| USA | 655 | 30.8 |
| | | |
| Japan | 414 | 19.5 |
| | | |
| RoW | 376 | 17.7 |
| (CN | *129* | *6.1)* |
| (TW | *94* | *4.4)* |
| | | |
| Total | 2124 | 100 |

share of branches, ranging from 18 % in the 'Rest of the World'[10] to 64% among Japanese companies. For these reasons, we decided to drop branches from the analysis.

Finally, it should be noted that data on the companies' subsidiary structure were available only for the last year of our reference period, that is, 2012. For this reason, although we have an unbalanced panel dataset with respect to economic and financial information, we are able to exploit only the cross-sectional nature of our data when estimating the effect of our different measures of multinationality.

### 3.2. Variables

The focal variable of the empirical analysis is represented by labour productivity, which we compute by dividing the company's total turnover by the number of its employees. While the firm's value added is a more consistent measure of output to obtain labour productivity, data on value added are missing for many non-EU firms due to different accounting practices. Accordingly, in order to have a greater coverage, we have followed the choice made

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[10] The 'Rest of the World' region includes all countries outside the EU, USA and Japan. This country group represents about 17% of the companies in the sample.

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[8] The remaining 112 companies are not matched to any subsidiary in ORBIS. This is probably because these companies may be in an intermediate position within a group (such as when holding companies control the actual industrial company).

[9] Information and Communications Technologies include Software & Computer Services and Technology Hardware & Equipment, whereas the Pharmaceuticals and Health Care sector includes Health Care Equipment & Services, and Pharmaceuticals & Biotechnology.

**Table 2**
Descriptive statistics, by region of origin (2012).

|  | Stats | EU | Japan | RoW | USA | All regions |
|---|---|---|---|---|---|---|
| Multinational depth | *Average* | 33% (59%) | 46% | 53% | 62% | *47%* |
| (Share international subsidiaries) | *Std. dev.* | 0.22 (030) | 0.28 | 0.38 | 0.25 | *0.30* |
|  | *Median* | 33% (67%) | 49% | 60% | 68% | *49%* |
| | | | | | | |
| Multinational spread | *Average* | 12 (21) | 11 | 9 | 17 | *12* |
| (# of countries where a firm has subsidiaries) | *Std. dev.* | 15 (21) | 12 | 14 | 17 | *15* |
|  | *Median* | 6 (14) | 7 | 3 | 12 | *7* |
| | | | | | | |
| R&D intensity | *Average* | 2.23 | 2.26 | 1.83 | 3.22 | *2.46* |
| (log of R&D per employee) | *Std. dev.* | 1.58 | 0.99 | 1.25 | 1.54 | *1.52* |
|  | *Median* | 2.20 | 2.19 | 1.75 | 3.26 | *2.34* |
| | | | | | | |
| Labour Productivity | *Average* | 5.35 | 5.79 | 5.07 | 5.45 | *5.40* |
| (log of sales per employee) | *Std. dev.* | 0.93 | 0.75 | 0.90 | 0.91 | *0.92* |
|  | *Median* | 5.36 | 5.72 | 5.06 | 5.47 | *5.41* |
| | | | | | | |
| Capital Intensity | *Average* | 4.67 | 4.74 | 4.03 | 4.80 | 4.60 |
| (log of fixed assets per employee) | *Std. dev.* | 1.21 | 0.92 | 1.21 | 1.03 | 1.14 |
|  | *Median* | 4.57 | 4.67 | 3.95 | 4.87 | 4.57 |
| | | | | | | |
| Size | *Average* | 8.21 | 8.90 | 9.00 | 7.93 | 8.38 |
| (log of number of employees) | *Std. dev.* | 2.09 | 1.38 | 1.51 | 1.98 | 1.91 |
|  | *Median* | 8.27 | 8.76 | 8.98 | 8.02 | 8.51 |

For EU firms, we report the indicators of multinational depth and breadth both excluding the subsidiaries located in other EU countries, and including them (in brackets).

by a number of previous studies and used turnover as an output proxy (see, for example, Gaur, Delios, Singh, 2007; Girma, Gorg, & Strobl, 2004; Park, Li, & Tse, 2006; Zatzick & Iverson, 2006).[11]

As far as the explanatory variables are concerned, we measure R&D by its intensity, defined as the company's corporate R&D investments divided by the number of employees.[12] In order to measure the different aspects of multinationality described in the theoretical background, we calculate two different indicators. The depth of multinationality is proxied by the share of international subsidiaries of each company, which we calculate as the number of international subsidiaries divided by the total number of subsidiaries.[13] As a robustness check, this measure has been calculated also by considering only subsidiaries located in non-EU-28 countries for the European companies. In doing so, we consider the EU as a homogeneous socio-economic area (like the USA). Inter-alia, this second measure allows us to focus on multinational activities towards markets that are geographically and institutionally more distant. The breadth of multinationality is proxied by a second indicator that, following a consolidated tradition,[14] counts

the number of foreign countries in which a firm has its subsidiaries. Also in this case, we compute the indicator either using or excluding intra EU-28 subsidiaries.

As further control variables, in the econometric analysis we also introduce the capital/labour ratio, computed as the depreciated book value of fixed assets as a share of the total number of employees, and a measure of firm size.

Looking at the descriptive statistics (Table 2), the degree of multinationality of our companies is relatively high. On average, 47% of the subsidiaries are located abroad. This is not a surprisingly result, given that in our sample firms are relatively large. However, interesting differences arise across macro-regions. For example, US companies display the higher degree of multinationality, whereas European ones stand at the opposite extreme.

In interpreting the position of European companies, it should be noted that the low degree of their multinational depth largely results from the exclusion of intra-European linkages in the computation of the relative indicator. When calculating multinational depth on the basis of actual national borders, EU firms turn out to be more internationalised, although the share of international subsidiaries is still lower than for the US (59% vs. 62%). This interpretation is confirmed when we consider the multinational breadth of European companies. Even so, US companies keep the widest geographical diversification (17 countries), whereas European ones are very similar to Japanese (12 and 11).

It is worth noting that the average and median of the multinational depth indicator are relatively close, suggesting a low degree of skewness in the distribution. On the other hand, the indicator measuring multinational breadth is right skewed, with the median always lower than the average. Compared to the multinationality variables, labour productivity and R&D intensity shows a lower degree of skewness (averages and medians are very close). The average values of labour productivity do not vary widely across regions. Companies headquartered in Japan have the highest values of labour productivity, those from the Rest of the World the lowest, while European and US companies have very similar intermediate values. R&D intensity shows a higher degree of variation across regions. US companies are, on average, the most R&D intensive (3.22), while Japanese and European ones still have similar average values (2.26 and 2.23, respectively). Companies headquartered in the Rest of the World are, on average, the less

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[11] It should be noticed that, for the firms of our sample that report both turnover and value added, the correlation between the two variables is pretty high, spanning from 0.793, considering the 2004–2012 period, to 0.755, considering only 2012. In the light of that, we are confident that our results would get largely confirmed by defining productivity as the standard ratio between value added and employees. This is also expected, looking at the results of previous papers that have worked explicitly with both the measurements of labour productivity at stake (see, in particular, Girma et al., 2004).

[12] More precisely, R&D is defined as the cash investment funded by the companies themselves and excluding R&D undertaken under contract for customers, such as governments or other companies.

[13] Most studies use the share of foreign sales to total sales, or the share of foreign employees (assets) in total employees (assets). Admittedly, these would be better measures of multinational depth, since they would capture the actual size of foreign operations. To the extent that foreign subsidiaries operate at a smaller scale than domestic ones, the share of foreign subsidiaries may yield an upward biased measure of multinational intensity. Unfortunately, in our dataset no information is available on the size of foreign and domestic operations.

[14] Although this measure has been criticized since it does not consider neither the size of the activities in the different countries (Hennart, 2011), nor the diversity of host countries (Hsu et al., 2015), it is still a good proxy of the geographical depth of multinational presence, and have been used for example, in Morck & Yeung (1991), Ietto-Gillies (1998), Castellani & Zanfei (2004), Thomas & Eden (2004), UNCTAD (2004) and Kafouros et al. (2008, 2012).

R&D intensive (1.83). It should be noted that part of these differences is accounted by the different distribution of companies across sectors. In fact, while European and Japanese top R&D investors are more concentrated in medium–high R&D-intensive sectors, US ones are more frequent in high technological sectors (European Commission, 2013). Accordingly, specificities across sectors of activity and countries of origin should be taken into account in the estimates.

## 3.3. Econometric strategy

In order to analyse the direct and indirect effects of multi-nationality on productivity we use a system of equations approach. The model we use expresses both labour productivity and R&D intensity as functions of multinationality. Beyond that, we propose a step-wise model structure by assuming that R&D intensity is an explanatory variable in the labour productivity regression. Using a log–log specification, and thus allowing the coefficients to be interpreted as elasticities, the model structure looks as follows:

$$\log(R) = \delta_1 \log(M) + x'\beta_1 + u_1 \tag{1a}$$

$$\log(P) = \delta_2 \log(M) + \gamma \log(R) + x'\beta_2 + u_2 \tag{1b}$$

where $P$, $R$ and $M$ denote productivity, R&D intensity and the vector of measures of multinational depth and breadth, respectively. $x'$ is a vector of control variables, which includes (the log of) the capital/labour ratio, the number of employees (both in log linear and quadratic form), a set of NACE 2-digits industries and country of headquarter location fixed effect. Due to the limited numbers of observations, smaller countries were aggregated into country groups.[15] It is worth noting that by regressing labour productivity on capital intensity, we are implicitly assessing the correlation of the other independent variables with a measure of total factor productivity. Furthermore, this also allows us for a more flexible interpretation of the correlations between multinationality, R&D investments and productivity. Namely, we are not forced to impose a functional form and we can interpret R&D and multinationality both as shifters of the labour productivity and as inputs into it. Finally, similarly to Banker, Hsihui, and Kemerer (1994), we also allow for a potential non-linear effect of company size on both productivity and R&D intensity, in order to control for the presence of economies (and diseconomies) of scale.

The two equations of the model (1a and 1b) can be easily estimated using ordinary least squares (OLS) for each regression separately. This holds true despite the fact that the R&D intensity appears as an explanatory variable in the labour productivity regression, which might at first sight raise issues of simultaneity. However, the structure of the model is purely triangular, since R&D is conceptualised as an input for the efforts to improve productivity, and it seems sensible not to include labour productivity as an explanatory variable in the R&D regression. Additional to this conceptual reasoning, we have also implemented the two Eqs. (1a) and (1b) in a structural equation model, and tested whether the model was consistent with the triangularity property. Applying a model restriction that prevents saturation, a test on the null hypothesis of triangularity yields a Chi-square statistic of 2.41, which was not significant at the 10% level. Thus, we can safely regard the triangular structure as an adequate representation of the model.[16] In conclusion, triangularity allows

us to estimate Eqs. (1a) and (1b) separately by OLS without having to take simultaneity into account.

By differentiating Eq. (1a) with respect to multinationality we obtain:

$$\frac{\partial \log(R)}{\partial \log(M)} = \underbrace{\delta_1}_{tot.effect=dir.effect} \tag{2a}$$

Instead, when differentiating Eq. (1b) with respect to multi-nationality we obtain:

$$\frac{\partial \log(P)}{\partial \log(M)} = \underbrace{\delta_2}_{dir.effect} + \underbrace{\gamma\delta_1}_{ind.effect} \tag{2b}$$

While Eq. (2a) is straightforward, Eq. (2b) reveals the direct effect of multinationality on productivity, denoted by $\delta_2$, and the indirect (mediating) effect $\gamma\delta_1$.

Once we have consistent estimators for the individual coefficients and the relative covariance matrix, it is easy to calculate also the direct and indirect effects, their associated standard errors, and test for their statistical significance. To obtain our estimates, we implement the seemingly unrelated regressions (SUR) estimation procedure proposed by Zellner (1962, 1963) and Zellner and Huang (1962), assuming an unrestricted covariance matrix for the error terms. This allows for a possible correlation in the error terms of Eqs. (1a) and (1b), and yields the covariance matrix needed to compute the standard error of $\gamma\delta_1$.

## 4. Results

Table 3 shows the results of the SUR estimates of Eqs. (1a) and (1b). Each set of estimates is presented in two columns. The first shows results for Eq. (1a), where the dependent variable is R&D intensity, while the second column presents results for Eq. (1b), where the dependent variable is productivity.

In Table 3 we present three sets of estimates referring to different ways of including multinationality measures in the regression equations. In columns (1) and (2) we include only multinational depth. In columns (3) and (4) we include only multinational breadth, while in the last set of estimates, (5) and (6), we include both measures of multinationality jointly. This approach allows us showing that it is important to control for both depth and breadth of multinationality, and that failing to do so may lead to biased estimates. Indeed, the two facets of multinationality are positively correlated ($\rho = 0.446$), but they also clearly identify two different strategies of internationalisation, because multinational depth can go with both high and low multinational breadth.

In Table 3 multinational depth and breadth are computed including all foreign subsidiaries. For EU firms this means that subsidiaries outside national boundaries but within-EU28 countries are considered as foreign. In Table 4 we instead present the same set of estimates, but we compute multinationality of EU firms by considering all intra-EU28 subsidiaries as if they were within national borders.

In column (2) of Table 3, multinational depth does not significant affect productivity, seemingly contradicting Hp1a. However, as we are about to show, this is due to a specification error deriving from the fact that we do not account for the breadth of multinationality.

Confirming our Hp2a, in column (1) the depth of multi-nationality has a significant and positive effect on R&D, which is largely expected and consistent with the argument that multi-nationality increases incentives for R&D.

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[15] In particular, in the empirical estimation we include the following country/region fixed effects: France, Germany, Great Britain, and rest of Europe, USA, Japan, China and Taiwan, rest of the world.

[16] Results are available from the authors upon request.

**Table 3**
Effect of multinationality (including within-EU28 countries) on labour productivity and R&D intensity – Seemingly unrelated regressions.

| | R&D Intensity (1) | Labour Productivity (2) | R&D Intensity (3) | Labour Productivity (4) | R&D Intensity (5) | Labour Productivity (6) |
|---|---|---|---|---|---|---|
| Multinational depth | 0.125*** (0.020) | 0.015 (0.014) | | | 0.054 (0.043) | 0.114*** (0.027) |
| Multinational breadth | | | 0.321*** (0.028) | −0.123*** (0.018) | 0.295*** (0.035) | −0.179*** (0.022) |
| R&D Intensity | | 0.141*** (0.015) | | 0.159*** (0.014) | | 0.157*** (0.014) |
| Capital Intensity | 0.264*** (0.019) | 0.377*** (0.013) | 0.332*** (0.020) | 0.348*** (0.013) | 0.332*** (0.020) | 0.347*** (0.013) |
| Size | −1.672*** (0.081) | 0.477*** (0.060) | −1.608*** (0.088) | 0.328*** (0.059) | −1.609*** (0.088) | 0.323*** (0.059) |
| Size square | 0.069*** (0.005) | −0.025*** (0.003) | 0.072*** (0.005) | −0.019*** (0.003) | 0.072*** (0.005) | −0.020*** (0.003) |
| Sector fixed effects | Included | Included | Included | Included | Included | Included |
| Country group fixed effects | Included | Included | Included | Included | Included | Included |
| Constant | 8.811*** (0.391) | 1.884*** (0.291) | 8.696*** (0.420) | 2.666*** (0.289) | 8.477*** (0.456) | 2.217*** (0.307) |
| Observations | 2124 | 2124 | 2124 | 2124 | 2124 | 2124 |
| R-squared | 0.581 | 0.462 | 0.576 | 0.497 | 0.576 | 0.502 |
| RMSE | 0.904 | 0.605 | 0.897 | 0.559 | 0.897 | 0.557 |
| Indirect Effect | | | | | | |
| Multinational depth | | 1.8%*** | | | | 0.8%** |
| Multinational breadth | | | | 5.1%*** | | 4.6%*** |
| Total Effect | | | | | | |
| Multinational depth | | 3.2%** | | | | 12.2%*** |
| Multinational breadth | | | | −7.2%*** | | −13.2%*** |

Standard errors in parentheses – *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Sector fixed effects: NACE 2-digits. Country group fixed effects: France, Germany, Great Britain, and rest of Europe, USA, Japan, China and Taiwan, rest of the world.

Whatever the specification, in Table 3, we confirm Hp3. The effect of the R&D intensity variable on productivity is positive and significant, and is of about 0.15: well in the range of effects found in the literature (Doraszelski & Jaumandreu 2013; Hall & Mairesse 1995; Mohnen & Hall, 2013). Putting this result in connection with that on Hp2a, it emerges that multinational depth actually exerts also a positive indirect effect on productivity channelled by the increase in R&D intensity. Increasing multinational depth by 100% leads an indirect 1.8 % increase in labour productivity (see Table 3).

If we control only for the multinational breadth, columns (3) and (4) of Table 3, we obtain different insights. On the one hand, in the productivity equation, the coefficient attached to multinational breadth is negative and significant, suggesting that the costs of organisational complexity induced by higher breadth may outweigh the positive benefits derived from operating in different markets. On the other hand, the incentives to invest in R&D increase with multinational breadth (supporting Hp2a). Comparing coefficients in column (3) and (1) we gather that multinational breadth may provide stronger incentives to invest in R&D than multinational depth, as predicted by Hp2b. By connecting this result with that for Hp3, a stronger indirect effect on labour productivity than that obtained when considering multinational depth also emerges (+5.1 %). However, this positive indirect effect is not strong enough to compensate for the negative direct one (−12.3%), and the overall relationship between multinational breadth and labour productivity remains negative.

In the last two columns of Table 3, we finally consider the effects of both dimensions of multinationality jointly. In fact, while breadth and depth may be correlated, our theory suggests that they capture distinctive strategies of MNE expansion and may have different relations with productivity and R&D. Indeed, considering the depth and breadth dimensions of multinationality jointly provides interesting results. On the one hand, when we control for the breadth of multinationality, the coefficient associated with multinational depth in the productivity equation increases in magnitude (from 0.015 to 0.114) and becomes statistically significant. This suggests that, for a given multinational breadth, a deeper multinational activity is associated with higher productivity. Conversely, for a given multinational depth, a higher multinational breadth is associated with lower productivity. Not surprisingly, because depth is positively correlated with breadth, failing to control for the negative effects of multinational breadth on productivity would bias the effect of multinational depth downward. The joint consideration of both facets of multinationality also allows providing empirical support for Hp1b: while multinational depth increases the firm productivity, a greater multinational breadth is associated with a lower effect on productivity. On balance, our results suggest that the organisational costs and difficulties in extracting value from the many locations where the MNE has a presence, may lead to a decrease in productivity as multinational breath increases.

As far as the effect of multinationality on R&D is concerned, column (3) suggests that multinational breadth is strongly correlated with higher investments in R&D, while the effect of multinational depth is much smaller and imprecisely estimated. This confirms Hp2b and suggests that the incentives to invest in R&D are strongly associated with greater multinational breadth. This could be so both because MNEs can distribute the costs of R&D

**Table 4**
Effect of multinationality (excluding within-EU28 countries) on labour productivity and R&D intensity – Seemingly unrelated regressions.

| | R&D Intensity (1) | Labour Productivity (2) | R&D Intensity (3) | Labour Productivity (4) | R&D Intensity (5) | Labour Productivity (6) |
|---|---|---|---|---|---|---|
| Multinational depth | 0.141*** (0.019) | 0.004 (0.013) | | | 0.047** (0.022) | 0.065*** (0.015) |
| Multinational breadth | | | 0.271*** (0.025) | −0.118*** (0.017) | 0.241*** (0.029) | −0.162*** (0.020) |
| R&D Intensity | | 0.142*** (0.015) | | 0.167*** (0.015) | | 0.164*** (0.015) |
| Capital Intensity | 0.266*** (0.019) | 0.376*** (0.013) | 0.310*** (0.019) | 0.344*** (0.014) | 0.307*** (0.019) | 0.342*** (0.014) |
| Size | −1.673*** (0.081) | 0.483*** (0.060) | −1.574*** (0.080) | 0.501*** (0.058) | −1.597*** (0.080) | 0.468*** (0.059) |
| Size square | 0.069*** (0.005) | −0.026*** (0.003) | 0.069*** (0.005) | −0.028*** (0.003) | 0.070*** (0.005) | −0.028*** (0.003) |
| Sector fixed effects | *Included* | *Included* | *Included* | *Included* | *Included* | *Included* |
| Country group fixed effects | *Included* | *Included* | *Included* | *Included* | *Included* | *Included* |
| Constant | 8.862*** (0.387) | 1.904*** (0.291) | 8.817*** (0.380) | 1.839*** (0.287) | 8.771*** (0.381) | 1.774*** (0.286) |
| Observations | 2124 | 2124 | 2124 | 2124 | 2124 | 2124 |
| R-squared | 0.584 | 0.462 | 0.597 | 0.474 | 0.597 | 0.479 |
| RMSE | 0.900 | 0.605 | 0.886 | 0.598 | 0.886 | 0.596 |
| Indirect Effect | | | | | | |
| Multinational depth | | 2% *** | | | | 0.8%** |
| Multinational breadth | | | | 4.5% *** | | 3.9%*** |
| Total Effect | | | | | | |
| Multinational depth | | 2.4%* | | | | 7.2%*** |
| Multinational breadth | | | | −7.3%*** | | −12.2%*** |

Standard errors in parentheses – *** p < 0.01, ** p < 0.05, * p < 0.1. Sector fixed effects: NACE 2-digits. Country group fixed effects: France, Germany, Great Britain, and rest of Europe, USA, Japan, China and Taiwan, rest of the world.

over larger sales achieved by operating in a larger number of markets, but also because this is associated with the access to more external knowledge sources, which increase the value of investing in R&D.

When we do not consider intra-EU subsidiaries in our measures of multinationality, results do not change much. Three things are however worth noting in Table 4.

First, in column (6) the direct effect of multinational intensity on labour productivity is much smaller than when we measure multinationality including intra EU-28 subsidiaries (Table 3). This is consistent with the idea that multinational expansion within the EU has a larger effect on productivity, probably because of lower coordination costs due to the lower geographical and institutional distance of the host markets.[17] Second, the effect of multinational depth on R&D turns out now statistically significant, while it was not in the companion estimates in Table 3. This could be related to the fact that within the EU, countries are already highly integrated, so that the motives of tapping new knowledge sources might be less pertinent within the EU. This may imply a more imprecisely estimated effect of multinational breadth on the incentives to invest in R&D. This argument may indeed be more important for knowledge sources that are geographically distant. Third, the

indirect effect of multinationality on labour productivity appears to be slightly lower than in the previous regressions, with estimated elasticities of 0.8% and 4.6% for the depth and breadth dimensions of multinationality, respectively. Once more, we find that the indirect effect of multinational breadth on productivity is not large enough to counterbalance the negative direct one. Overall, the elasticity of productivity with respect to the geographical breadth of the subsidiary structure turns out to be significantly negative (−13.2%), in contrast to the positive effect derived from deeper engagement in international markets (+12.2%).

## 5. Discussion and conclusions

Multinationality, that is the extent to which firms extend their networks of activities across borders, can create opportunities to enhance firm productivity. This can occur both directly and indirectly, by increasing incentives to invest in R&D activities, which in turn could raise productivity. But multinationality can also increase costs and amplify managerial complexity, which offset the potential productivity gains. The mutual relationship between multinationality, R&D and productivity is the core of this paper, and we tackle it by bringing together international economics and international business insights into a novel econometric approach. This approach distinguishes itself from past approaches by simultaneously allowing for direct and indirect (R&D-transmitted) effects of multinationality on productivity, and by differentiating these effects according to the breadth and depth of multinationality.

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[17] Similar results have been found by Rugman & Oh (2010) and Contractor (2012). The former used a measure of regional sales, which in their terminology mean sales outside the home country, but within the home geo-economic region (e.g. within-EU28), as opposed to overall foreign sales. The latter study finds that performance is higher in firms that have internationalised in regions proximate to their home country.

Using data on the top R&D investors worldwide, we are able to confirm a long-standing finding in economics and innovation studies that R&D has a positive effect on productivity. In addition, we uncover several interesting effects of multinationality on productivity and R&D. First, we find that multinational depth is positively associated with MNE productivity, while multinational breadth is negatively associated with productivity. These results are consistent with the idea that a more focused multinational activity allows to achieve higher embeddedness and maintain a wide pathways of knowledge transfer both between the subsidiary and the local contexts, and within the MNE (Castellani & Zanfei, 2004; Narula, 2014). By the same token, while a more geographically dispersed structure of MNE activities can offer more opportunities to access larger markets, achieve efficiency gains and explore more sources of knowledge, there are also negative effects. In particular, multinational breadth may entail organizational costs that hamper productivity (Baier et al., 2015) and force MNEs to maintain narrow channels of communication that do not enable them to fully exploit the knowledge exploration potential (Narula, 2014).

Second, we find that multinationality increases the incentives to invest in R&D. This may have two explanations. On the one hand, it can be accounted by increasing returns to scale in R&D, as R&D entails sunk fixed costs that can be distributed over a larger sales base (Cohen & Klepper, 1996; Petit & Sanna-Randaccio, 1998). On the other hand, it can be explained by the motive of building absorptive capacity to leverage new knowledge sources through multinationality (Cantwell & Mudambi, 2005; Narula & Zanfei, 2005). Gaining access to more knowledge sources creates additional incentives to further invest in R&D and leverage the externally acquired knowledge. Consistently with this interpretation, we find that a higher multinational breadth, which is associated with a larger access to a variety of different knowledge sources and to a larger market, provides stronger incentives to invest in R&D than multinational depth.

Combining the fact that multinationality has a positive effect on R&D, and that R&D has an effect on productivity, we provide evidence of a positive indirect effect of multinationality on productivity, which is stronger for multinational breadth. However, the positive indirect effect of multinational breadth is more than compensated by the negative direct effect on productivity. As we suggested earlier, a word of caution is necessary when we consider that R&D is not the only strategic action that may be affected by multinationality. In other words, our framework may still confound some indirect effects that are mediated by other firm strategic choices, such as organizational change and advertising. Filling this gap, by addressing the effect of multinationality on different strategic choice, and the consequent effect of such actions on productivity and performance, is certainly an interesting direction for future research.

Our findings have important theoretical and managerial implications. Starting with implications for theory, this paper contributes both to the international economics and the international business literature. On the one hand, we fertilize the tradition of economic analysis of the determinants of productivity, which has highlighted inter alia the role of R&D, with the international business focus on the role of the degree of multinationality and its different facets. On the other hand, we enrich the literature on the relationship between multinationality and performance, suggesting that some of the confusion that has arisen around this relationship in the past may have been due to a somewhat broad-brush operationalization. In this paper we align with some recent contributions (Hult, 2011; Verbeke & Brugman, 2009), which have proposed a more structural characterisation, by treating R&D as a mediating rather than as a moderating factor. We believe that this more structural approach allows considering the multinationality and performance relationship in a more accurate and analytical way.

Concerning the managerial implications, we find strong support for the view that multinationality increases the incentives to invest in R&D. This supports the argument that multinationality is also about gaining access to knowledge. To the extent that these positive indirect effects may be overcompensated when considering productivity, this highlights the fact that multinationality should be more rewarding for more R&D-intensive firms (Bausch & Krist, 2007). It also shows, however, that there are considerable costs associated with multinationality, which come in the form of organizational and transactional complexity. This reinforces the claims made by Baier et al. (2015) and Medcof (2001), both emphasizing the repercussions of multinationality on the organizational structure. Whether or not a firm should become more multinational, also depends on how intensive of R&D it is, or how able it is to manage the increased level of complexity.

## Appendix A. Descriptive statistics and alternative specification

See Table A1.

**Table A1**
Distribution of companies across industries (estimation sample).

| ICB Sector | # of companies | Freq (%) |
|---|---|---|
| Oil & Gas | 43 | 2.02 |
| Chemicals | 128 | 6.03 |
| Basic Resources | 62 | 2.92 |
| Construction & Materials | 65 | 3.06 |
| Industrial Goods & Services | 576 | 27.12 |
| Automobiles & Parts | 125 | 5.89 |
| Food & Beverage | 69 | 3.25 |
| Personal & Household Goods | 119 | 5.6 |
| Pharmaceuticals and Health Care | 278 | 13.09 |
| Retail | 22 | 1.04 |
| Media | 20 | 0.94 |
| Travel & Leisure | 23 | 1.08 |
| Telecommunications | 26 | 1.22 |
| Utilities | 33 | 1.55 |
| Financial Services | 14 | 0.66 |
| Information and Communications Technologies | 521 | 24.53 |
| Total | 2124 | |

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