LUND UNIVERSITY
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Internationalization and Innovation; A PSM Approach

by

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Abstract. Recent phenomena, as the offshoring of R&D activities, have raised the question of whether intensive internationalization strategies are hampering the abilities of firms to implement innovations. This research wants to study the intensive margin of internationalization in order to understand whether the breakage of the links within the production processes, due to practices such as offshoring and outsourcing, were indeed jeopardizing the innovative capacities of European manufacturing firms in 2008. By implementing a propensity score matching with binary treatment, I find no evidence that internationalization had a negative impact on innovation due to the lost links within the production process, but I do find hints that *intensive* internationalization hurt *intensive* innovation abilities. Lastly, I also find that offshoring and importing intermediate products were better for innovation than outsourcing, on the extensive margin.

Keywords: propensity score matching, offshoring and outsourcing, innovation, internationalization.

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1. Introduction

Since the mid-20th century, firms began relocating part of their production process abroad, a practice that became ever more viable thanks to the combination of low transport costs, the revolution of information and communication technologies (ICT) and the opening of emerging economies with lower costs of production. Firms have started internationalizing in order to profit from the differences in comparative advantages of countries by shifting production where it has been cheaper to undertake and therefore changing the very nature of globalization. Indeed, new forms of internationalization, as outsourcing and FDI, became more popular and contributed to the unpacking of firms and the creation of the so-called Global Value Chains (GVCs). Given the shocks that have played out in the international market, innovation can be considered as a pivotal driver of high-income economies. The latter have higher costs relative to the newcomers and thus, to remain internationally competitive, firms have to ensure permanent innovative changes (Sternberg and Arndt, 2001). Innovation is thus perceived as a key factor for boosting growth in developed countries and the fostering of innovative activities is at the top of policymakers' agenda. Understanding whether intensive internationalization spurs or hampers innovation has therefore implications on trade-promoting policies taken by each member state.

This research wants to study the interaction between these two factors; the internationalization strategies of firms and their ability to retain innovation capabilities. The internationalization practices that are considered are the importing of intermediate products, FDI, and outsourcing, whereas the innovation activities included are product/process innovation, internal R&D and patent application. Most of the literature that studies the offshoring of production has concentrated on the implications that the latter has on the labour markets, both in the host and in the home country, and thus on employment productivity and wages. However, more relevant for this analysis are the scholars that have analysed the impact of internationalization on the innovation capabilities of firms. As argued in Chapter 2, these studies have generally found a positive relationship between the two variables, even though the direction of causality is not as clear and hard to disentangle. Looking at more recent trends on R&D offshoring made me question these previous findings.

Initially, firms contracted out or offshored mainly low value-added activities, however, in recent decades we are also witnessing the relocation of R&D capabilities in order to be closer to their production activities. The shift of R&D may imply that internationalization strategies have hampered the abilities of the company to implement innovations. Kota (2018) claims that strong economies need both manufacturing and R&D activities to maintain a healthy ecosystem and models such as Kline and Rosenberg (1986) show that product and process innovations stem from the learning process that comes from the production stages. Relocating the latter abroad can thus break the links within production and jeopardize the technological learning and innovative capacities of the firm.

The point of departure of my analysis is precisely the idea that intensive internationalization may have hampered the ability of firms to implement innovations by interrupting the links between the different production stages. I argue that the reason for which previous studies have found a positive relationship between the two variables is tied to the methods used in the analyses. In particular, they have mainly focused on the extensive margin of internationalization, thus treating the latter as a binary categorical variable. This research seeks at complementing the literature by implementing a new methodology that allows me to study the intensive margin instead.

The microdata used for the analysis are taken from the Efige dataset of Bruegel institution and comprises information on 14,759 manufacturing firms in Europe (France, Germany, Italy, Spain, Austria and Hungary)

for the year of 2008. The database is useful for my analysis in that it includes internationalization and innovation variables relevant for my research question. Moreover, it ensures comparability across countries and the stratification of the sample to mirror the industrial structure of the economies (Altomonte and Aquilante, 2012).

The method is based on propensity score matching (PSM) with a binary treatment variable. In order to study the different intensities of innovation and internationalization, I follow Altomonte et al. (2013) and construct three binary treatment variables that capture three different intensities of internationalization, based on the number of modes implemented by the firm, and four different binary outcome variables, based on four intensities of innovation, according to the number of innovative activities the firm has carried out. Once the intensities measured are constructed, I proceed with a PSM process by utilizing a kernel matching algorithm as the main outcome. Other strategies, such as near-neighboring matching and radius matching are conducted as robustness checks. This method allows me to solve possible self-selection problems, since the potential outcomes of treatment and control groups are likely to differ, and to study the implications that different intensities of the treatment have had on innovation abilities of firms and on different intensities of innovation. However, it is important to note that the process of propensity score matching is not widely accepted as it presents important drawbacks. For instance, some scholars have criticized the low degree of standardization (see Angrist and Pischke, 2008) and the high sensitivity to changes in e.g. covariates used for the propensity score estimation (see Smith and Todd, 2005). Despite the downsides of using this method, PSM comes in useful when there is no possibility of treatment randomization, as in this case.

The research finds three main outcomes. First of all, it confirms that higher internationalization intensity increases the overall probability of the firm to implement innovative activities. This result contradicts the main hypothesis of the research, i.e. that the innovative capabilities of the firms are jeopardized with intensive internationalization practices. Second, the research finds that the highest intensity of internationalization decreased the probability of implementing the highest intensity of innovation. Indeed, a medium level of internationalization intensity appears to be the optimal one in terms of favouring higher innovation intensities. This second finding is in line with the second hypothesis put forward by the research, i.e. that higher internationalization intensities have a smaller beneficial effect on higher innovation intensities.

One issue with the intensity model I constructed is the fact that I am unable to unpack the single effect of each mode of internationalization. In other words, I am unable to check which strategy, between importing, offshoring and outsourcing, is better for innovation. To remedy for this shortcoming, I construct three different treatments based on the three modes of internationalization and repeat the propensity score matching method. It appears that importing intermediate inputs is better in terms of increasing the overall probability of innovating, but offshoring is more likely to rise the chance of implementing high intensities of innovation. Regarding this third finding, I rely on past literature to outline some potential channels through which importing and offshoring have had an impact on innovation.

The paper is structured as follows. The second chapter revises some key terminology and reviews the literature relevant for the topics studied. The third chapter describes the data and presents some descriptive statistics that give a *prima facie* idea on the relationship between internationalization and innovation and on the kind of manufacturing firms that implemented such activities. The fourth chapter outlines the framework of potential outcomes and the propensity score matching methodology used and discusses the pros and cons of using such method. The fifth chapter reports the main empirical results that provide an answer to the hypotheses formulated in Chapter 2, while the sixth chapter conducts some robustness checks. The last section concludes the analysis.

2. Literature Review

2.1. Defining Internationalization and Innovation

Before proceeding with the review of the literature, it is useful to clarify some terminology by defining the meanings of internationalization and innovation. The literature identifies a variety of channels through which firms can internationalize; via exports, imports of intermediate inputs, direct investments and contracts and agreements. Internationalization through exporting is the most studied by the literature and this research wants to go beyond the common dichotomy exporters versus non exporters by considering the other categories of internationalization.

First of all, one needs to differentiate outsourcing and offshoring. According to Olsen (2006), outsourcing concerns the relocation of activities to a third-party and can be done either domestically, i.e. a firm subcontracts its production activities to an external provider located in the same country, or internationally, when the provider is situated abroad. In the context of this thesis, offshoring concerns the shift of production stages to another unit of the firm situated abroad. Offshoring is sometimes called *vertical Foreign Direct Investment (FDI)* or *intrafirm trade*. In contrast to *horizontal FDI*, which refers to the situation in which a firm invests in a production facility abroad in order to serve foreign customers (Helpman et al., 2004), *vertical FDI* regards the offshoring of part of the company's activities abroad, through the setting up of a new affiliate or controlled firm, or through the acquisition of a local firm (Moran, 2012). Figure I gives a simplified illustration of these concepts.

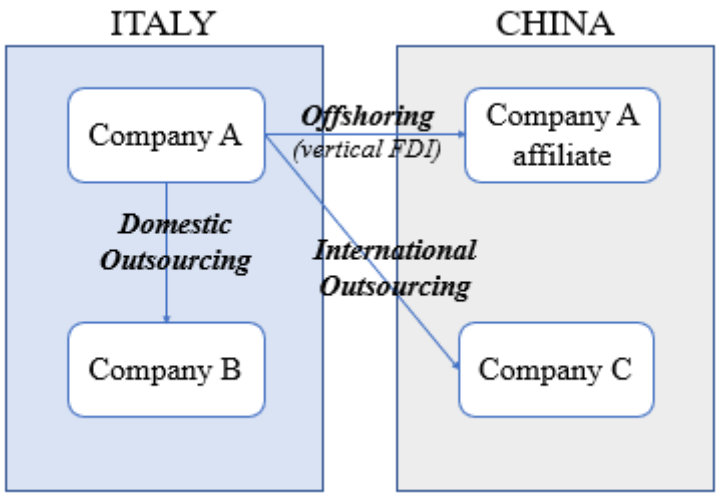

Figure I. An Illustration of Offshoring and Outsourcing
Source: Author's illustration.

This research considers solely international outsourcing and vertical FDI. Both techniques of internationalization can be thought of as attempts by firms to combine the comparative advantages that different locations have, with their own assets and capabilities in order to maximize their competitive advantage. It is precisely the interaction between comparative and competitive advantages that will determine relocation strategies, both in terms of *how* and *where* to relocate (Mudambi and Venzin, 2010).

The third internationalization strategy that is considered is the importing of intermediate goods from abroad. Intermediate inputs are parts and materials that are used to make final products used for national consumption or exported to other countries. As for the other two internationalization strategies described above, the

importing of intermediate inputs has staggeringly increased since the decrease of trade barriers and coordination costs and the progress in information and communication technologies that has happened in the last three decades (Cappariello and Zizza, 2007).

BOX 1. Internationalization variables

The three internationalization variables constructed from the dataset and used for the analysis are:

1. *Importers*: firms that purchased part of their intermediate inputs used for the production of a final good from abroad.
2. *Outsourcers*: firms that outsourced part of their production activities through contracts and agreements to another country. Only international outsourcing is considered in the analysis.
3. *FDI makers*: firms that relocated part of their production activities abroad to foreign affiliates or controlled firms.

Since the mid-20th century, manufacturing firms in Western countries started to outsource their activities, mostly locally (Mudambi and Venzin, 2010). The process of internationalization through direct investments intensified at the end of the 20th century and there are several studies that have documented the sharp integration increase in the international market and the creation of the so-called Global Value Chains (GVCs). The latter can be defined as "the value added of all activities that are directly and indirectly needed to produce [a manufactured final product] […]." (Timmer et al., 2014) and represent the restructuring of firms' operations through the outsourcing and offshoring of resources. Hummels et al. (2001) for instance, documented the growth in vertical specialization, meaning the use of imported inputs in the production of final goods, by using input-output tables for ten OECD countries and four emerging economies. They find that vertical specialization increased approximately by 30% between 1970 and 1990.

The factors that contributed the most to the rise in internationalization are put forward by Baldwin (2006). The author argues that the low cost of transportation and the ICT revolution allowed the unbundling of the production process, thus permitting the *slicing up* of value chains (Krugman, 1995). In other words, it became increasingly more viable for companies to benefit from differences in comparative advantages between countries and relocate production where it is cheaper to undertake. The relocation of production changed the very nature of globalization and had numerous implications on the labour market both in the home and the host countries. For instance, it created an increase in the demand of higher-skilled labour in the home country, as firms typically tend to displace low value-added jobs with lower-skilled workers. As we shall see in the analysis, relocation had also an impact on the innovative capabilities retained in the home country.

In my research I take into consideration the year of 2008, which results to be a delicate year given the outset of the financial crisis. However, research shows that the impact of the crisis was not felt immediately by the international market, rather the shock was delayed to 2009 and 2010. For instance, Timmer et al. (2016) use input-output tables to show the trend in world trade over the period of 2000-2014. Their study reveals that there was a dip in international fragmentation of goods production due to the financial crisis, but this fall became especially evident starting from 2009. Timmer et al. (2013) construct a measure of GVC income to depict the income generated by internationalization activities of firms, and show that the regional share of European countries GVC income in total world GVC income in 2008 was stable at approximately 30%, while between 2009 and 2010 it fell by more than 5 percentage points. Therefore, the year of 2008 can still be used to study the relationship between the two variables since not only was international fragmentation high, but also the effects of the financial crisis had not yet affected the international activities conducted by firms.

Turning the discussion to innovation, there is no common consensus on how to conceptualize the novelty extent of products or processes (Amara and Landry, 2005). Innovation was first described by Schumpeter as the "driving force for development" (Vyas, 2009) and the engine of the process of "creative destruction", that is the mechanism through which old economic structures are destroyed and incessantly replaced by new ones (Schumpeter, 1942). More recent literature has defined it as a complex process linked to the evolution in production functions and processes by which the firm obtains and builds upon their technological abilities (Therrien et al., 2011). Brouwer (1991) categorized innovation as product and process innovations, with the former referring to the introduction of an improved version of the product, e.g. better materials or components, while the latter refers to the implementation of changes in the production processes of the company.

When measuring innovation, one may consider the input side, as R&D investments, or the output side, as patent applications. My analysis takes a holistic view and, rather than considering just one aspect as most of the previous studies have done, I take into account both the input and the output sides. Thus, I examine the amount of internal R&D investments, the implementation of product and/or process changes and whether the firm has filed a patent application.

BOX 2. Innovation variables

The four innovation variables constructed from the dataset and used for the analysis are:

1. *Product Innovation*: if the firm implemented innovative changes to its products, such as the use of new materials, enhancing its quality or performance.
2. *Process Innovation*: if the firm implemented innovative changes to its production processes, such as the use of a new software or equipment.
3. *Internal R&D*: if the firm carried out in-house research and development activities.
4. *Patent Application*: if the firm applied for a patent in 2008.

Despite the lack of a clear definition of innovation, there is instead common consensus on the advantages that firm's innovation brings to the economy. According to Sternberg and Arndt (2001), for instance, innovation is the main source of competitiveness for high-income countries. Given the new trends in the international markets, as the opening of emerging economies, relatively high-cost locations have to develop innovative products and process in order to stay competitive internationally. Moreover, it is widely believed that innovation can be considered as a remedy for stagnant economic growth and unemployment, and therefore the provision of stimuli to spur investments in innovative activities is placed at the top of policy makers' agenda (Kander et al, 2019).

It is interesting to note that, even though many scholars advocate for the key role of innovation, whether the latter will continue to stimulate growth is debatable. Since the industrial revolution, innovation has been considered as the driving force behind the generation of wealth and the growth of the economy, but recent research questions the sustainability of the trend and forecasts an inevitable slowdown. Indeed, there are two conflicting streams of literature concerning the future trends of innovation. The first one optimistically advocates for continuous innovation and a long-term positive impact of the latter on the growth rates of the economy (see e.g. Grossman and Helpman, 1991, 1994), while the second one suggests that over the last 40 years innovations have not spurred economic growth. Gordon (2012, 2016) for instance, emphasizes the low rates of labour productivity in the US despite the innovative activities that have been carried out in recent decades.

2.2. Literature and Hypotheses

2.2.1. Internationalization/Innovation and Firm's Performance

This research is relevant to three streams of literature: i) internationalization and firm performance, ii) innovation and firm performance, and iii) internationalization and innovation. The theoretical literature on the firm's decision when it comes to internationalization strategies dates to Coase (1937), who argued that the choice of producing in-house or outsource depends on transaction costs. More recently, major contributions were given by Antràs and Helpman (2004; 2008) and Antràs (2003). These models predict that firms that are more likely to engage in intrafirm trade, relative to subcontracting, are capital- and skill- intensive and more productive firms. The predictions are mainly based on either the transaction cost theory, i.e. outsourcing is more desirable if transaction costs (such as incompleteness of contracts) is lower than the expected advantage, or principal-agent theory, meaning that opportunism and bounded rationality can result in productivity losses. If transaction costs or the potential conflict of interests are too severe, the firm may opt for direct investment, thus internalizing the decision process and bearing higher fixed set-up costs (Olsen, 2006).

The most studied form of internationalization is exporting. In general, empirical studies have found that firms that export are bigger, more productive and more capital-intensive than firms that do not export. This was shown for Chilean plants by Alvarez and López (2005), for US firms by Bernard and Jensen (1999) and for European firms by Wagner (2007). However, besides exporting, firms can implement other practices to be active in the international market. Wagner (2011) finds that German offshoring firms are larger, more productive and have a higher percentage of exports in total sales, compared to firms that do not offshore. Herzer (2012) confirms the increased productivity in German firms when undertaking FDI and argues about the two-way relationship between FDI and productivity, that is, the rise in productivity is both a cause and a consequence of increased FDI. Tomiura (2007) finds similar evidence as Wagner (2011) for Japanese firms, showing that FDI active companies have higher productivity than both outsourcers and exporters. In line with the latter, Corcos et al. (2013) find that intrafirm trade is more likely to be carried out by firms that are more capital- and skill-intensive and have higher productivity relative to outsourcing firms. Their argument is based on the idea that these types of firms have more at stake and do not want to incur the risk of subcontractors dissipating the value of their assets by sharing their knowledge.

There is a relatively recent strand of literature that studies the effects of importing intermediate inputs on firm's performance. Such studies (see e.g. Halpern et al., 2011; Kasahara and Rodrigue, 2008; Amiti and Konings, 2007) have generally found that the productivity of the firm increases as it imports intermediate inputs from abroad. Many of these papers have captured the benefits of imported inputs by looking at input tariffs reductions. For instance, Amiti and Konings (2007) found that a 10% decrease in the tariff of the imported inputs results in a 12% increase in the productivity of the firm, which is greater than the rise in productivity found when there is a reduction in the tariffs of the output. The channel through which the performance of the firm is affected by the importing of intermediate inputs is the increased technology and/or quality that is embedded in the foreign inputs.

The topic of the relationship between innovation and the performance of firms has attracted management scholars especially since the argument of Schumpeter (1934) who argues that the long-term success of a firm is somehow determined by its innovative capabilities. In line with Schumpeter, current scholars as well continue claiming that continuous innovation activity is an essential factor for the survival of the firm (Kotler, 2000). Cefis and Marsili (2006) for instance, explore the survival probability of Dutch manufacturing firms in 1996 and found that, conditional of the firm's age and size, innovation has a positive and significant effect on the survival probability of the company, and this effect persists in the long-term. Banbury and Mitchell (1995)

and Christensen (1997) argue that innovative capabilities are vital for well-established firms, in that they make the companies more flexible and less vulnerable to the disruptive technologies of the newcomers.

Empirical studies on the relationship between innovation and firm's performance are numerous and reach the general conclusion that the former boosts the latter. For instance, Jiménez-Jiménez and Sanz-Valle (2011) studied the performance of 451 Spanish firms and found a positive impact of innovation on business performance. Geroski et al. (1993) studied British manufacturing firms and found that innovative firms were on average more profitable than non-innovative firms and that innovations had a positive impact on the company's profit margin. Atalay et al. (2013) surveyed Turkish firms operating in the automotive supplier industry and found that product and process innovations had a positive and significant effect on the performance of the companies. Robert (1999) and Artz et al. (2010) found similar results for firms in different industries in the US and Canada.

To give a more complete picture about the relationship, it is also important to mention that there are scholars who put the emphasis on the caveats of innovation. For instance, Simpson et al. (2006) claim that innovation may have negative outcomes on firms' performances such as an increased vulnerability to market risks, greater costs and employee discontent. Lastly, Wright et al. (2005) show that product innovation has an insignificant effect on performance on hostile environments and a positive effect only when considering more benign conditions.

Although the contribution of my research is more relevant to the literature analysed in the next subsection, the theoretical literature and the findings of the empirical studies presented thus far are still important for two reasons. First if all, they provide the reader with an overview of the main concepts and theories behind the topics touched upon this research and with a more complete perspective on the kinds of firms that decide to implement internationalization strategies or innovation activities, which will come in useful when discussing the third finding of the research. Secondly, they enable the assessment on the quality of the Efige dataset. In particular, the coherence between the descriptive statistics presented in Chapter 3 and the findings of the literature analysed in this subsection, are evidence of the validity of the dataset used for the analysis.

2.2.2. Internationalization and Innovation

The streams of literature of international economics and business have identified several channels through which offshoring changes the degree and the nature of economic activity in the home country (Dachs et al., 2014). Firstly, when shifting part of the production abroad, the type of the tasks performed and the types of the inputs used in the home country changes (Grossman and Rossi-Hansberg, 2006). In general, firms tend to offshore low-skills and low-tech jobs, as previously explained, retaining higher value-added activities. Consequently, tasks in the home country become more skill- and innovative- intensive. Secondly, scholars emphasize the reverse transfer of knowledge as a key factor contributing to the increase in innovation in the home country with the offshoring of production (Mihalache et al., 2012; D'Agostino et al., 2013). This means that the firm is able to tap into the skills and capabilities of the host country and thus reverse transfer the knowledge from foreign affiliates to the parent company (see Rabbiosi and Santangelo, 2013).

The relationship between exports and product/process innovations is the most studied by the literature, but the direction of causality is unclear. Studies as Becker and Egger (2013) and Cassiman and Golovko (2011) show that it is innovation that drives exports, but another stream of literature advocates for the *learning by exporting* behaviour of firms. As I mentioned before, exporting firms are usually found to be more productive than non-exporting firms and scholars have argued that this fact supports the evidence that exporting improves firm's productivity. Learning by exporting then means that new information, acquired through foreign customers, improves the manufacturing processes and the product's quality of exporters (Alvarez and López, 2005). Bratti

and Felice (2012), for instance, found that exporting significantly increases the probability of the firms to introduce innovative changes to their products. Similarly, Salomon and Shaver (2005) found that exporters increase the number of patents application and product innovations after they start exporting.

Turning to other forms of internationalization, most of the empirical studies focus on the impact of FDI on productivity, wages and employment, while the evidence on the effects on innovation in the home country is scanter. An influential paper on this matter is Mihalache et al. (2012), who found an inverted U-shaped relation between the degree of internationalization and the degree of innovativeness, which entails that the capability to innovate is highest among the firms that have moderate levels of internationalization. Baum et al. (2018) study Swedish manufacturing firms and show that their participation in global value chains, in terms of offshoring, increased the innovative capacity of firms regardless of their technological intensity. Fritsch and Görg (2013) and Mazzanti et al. (2009) find a positive relationship between outsourcing and technological innovation. Ottaviano and Martincus (2011) found that the probability of Argentinian firms to innovate is increased when outsourcing from abroad. Likewise, Boler et al. (2012) show that companies that are more innovative source more foreign products. Karpaty and Tingvall (2011) instead find a negative effect of offshoring on R&D intensity at home for Swedish multinationals. Lastly, Dachs et al. (2014) found that on average offshoring firms implement more product and process innovations relative to non-offshoring firms.

The relationship between the importing of intermediate inputs and innovation is not so simple to untangle. On the one hand, cheaper inputs enable the firm to purchase them with larger quantities, more varieties and better quality, which decreases the incentives to invest in R&D because production and competitiveness can be reached by importing intermediate inputs. On the other hand, firms may use intermediate inputs to undertake R&D activities and thus, if the cost of the inputs is reduced, the investments in R&D may increase. Most of the empirical literature (see e.g. Fan et al., 2015; Feng et al., 2016) found that innovation increases in response to a more intensive intermediate input importing, even though papers such as Liu and Qiu (2016) found a decrease in patent application of Chinese firms once input tariffs are reduced.

Even though most of these studies have found a positive relation between innovation and internationalization, there are reasons to believe that the outcome is not as straightforward. Models such as Kline and Rosenberg (1986) show that the learning from production activity is key for product and process innovation. Offshoring the production stages can thus imply that technological learning is reduced and with that the innovative capacities of the firms, precisely because of the lessening of these links (Naghavi and Ottaviano, 2009). As Kota et al. (2018) argue, US companies started moving R&D to China in order to be closer to the manufacturers and suppliers. Indeed, they claim that by looking at strong economies around the world we see that a healthy ecosystem needs both R&D and manufacturing activities. The consequences are that US companies have lost the ability to implement the kinds of process improvements that are essential for survival in this ever globalized and competitive world.

As figure II shows, there has been a sharp increase in the outsourcing of R&D of firms located in the Western economies between 2011 (panel A) and 2018 (panel B). For instance, in 2011 the average number of firms in the countries displayed that was sourcing the function internationally was approximately 4% of the total. This number rose by 36 percentage points in 2018, where the average percentage of firms that was outsourcing R&D was approximately 40% of the total number of firms.

The starting point of my research is thus the stylized fact of the rise of offshoring of R&D activities towards countries that were already managing the manufacturing production activities. This phenomenon implies that internationalization could jeopardize the innovative capabilities of the firm, especially when conducted intensively, as Mihalache et al. (2012) suggest. My research precisely analyses this relationship but, in contrast to previous studies, it examines the intensive margin. Most of the literature has looked at internationalization

as a binary variable, i.e. whether or not the firm was conducting activities abroad. Therefore, I ask whether the reason for which scholars have found on average a beneficial effect on innovation capabilities is due to a consideration of a different margin. The negative effect of internationalization on innovation may emerge if one looks at the intensive margin of internationalization instead, i.e. how intensively the firm is active in the international market.

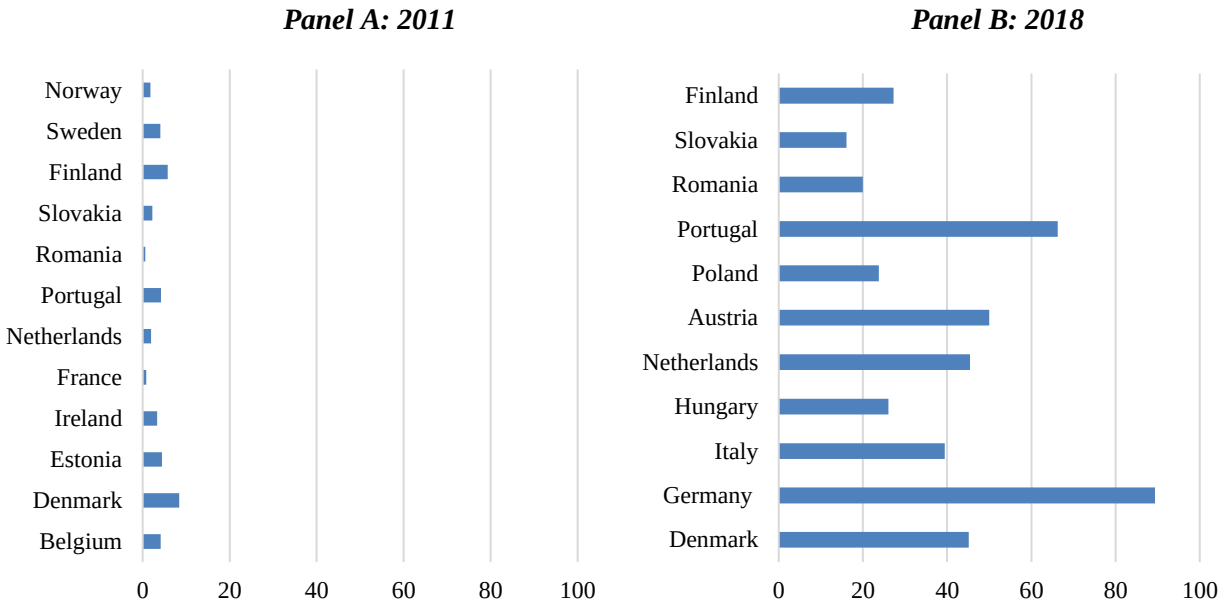

Figure II. Outsourcing of R&D
Source: Eurostat- International Sourcing Statistics surveys 2012, 2018.
Note: Countries in the two panels differ, therefore one should compare only the total average and the general trends between the two panels.

Given the literature analysed and the recent trends mentioned, the research is shaped around two main hypotheses. Firstly, I expect the effect on innovation in 2008 to decrease with the intensity of internationalization, implying that stronger investments on the international market have a diminishing return on innovation.

H1: The positive impact on innovation decreases with an increase in internationalization intensity.

The question then is whether carrying out a higher intensity of internationalization activities may have had a detrimental impact on innovation capabilities. Secondly, I also expect that the higher intensities of internationalization have a lower (or negative) effect on higher intensities of innovation. This stems from the hypothesis that firms that are intensively active abroad may hamper their ability of carrying out numerous innovation activities relative to firms that rely on a more linked production process.

H2: Higher internationalization intensities have a lower positive impact on higher innovation intensities.

To conclude, the research gives a contribution to the literature in examining the intensive margin rather than the extensive one, as it hypothesizes that intensive internationalization may have a diminishing beneficial effect on (intensive) innovation. Moreover, the study gives also a methodological contribution because, in order to look at the intensive margin, I implement a propensity score matching methodology with three binary treatments at the three different intensities of internationalization. The methodology is thoroughly explained in Chapter 4, but the key intuition is that each treatment variable represents a different intensity of internationalization so that I am able to obtain the effect of the increasing intensity of activities abroad on innovation capabilities. Furthermore, as I construct a measure of innovation intensity as well, I am able to unpack the effect on innovation on four different levels of intensity and thus test the second hypothesis of the paper.

3. Data and Descriptive Statistics

The microdata used in this research is taken from the project Efige- *European Firms in a Global Economy: internal policies for external competitiveness*. The database is organized and managed by the European think-tank Bruegel in collaboration with European leading academic institutions, National Central Banks and International institutions, as the OECD. It includes extensive information on internationalization practices undertaken by manufacturing firms in Europe in 2008, with some questions about the period of 2007/2009. More importantly for my study, the dataset allows me to analyze activities other than exporting, such as FDI and outsourcing and, besides the focus on international operations, it also contains a wide range of variables on innovation investments, such as technological innovation and R&D, which make it suitable for answering my research question.

Apart from including the variables of interest for my study, the database has two other important features. First, the comparability across countries. Given that the data is obtained from answers to the same survey, carried out over the same period, the numbers are fully comparable across countries. Thus, Efige represents a better solution relative to the official national statistics that are not harmonized across countries. The second aspect is the stratification of the sample that aims at being as representative as possible of the industrial structure of the countries included in the database, meaning that the latter accurately represents the countries' structures of the manufacturing sector (Altomonte and Aquilante, 2012).

The database includes 14,759 manufacturing firms in Europe and table I shows the distribution across space; around 3,000 are in France, Germany, Italy and Spain, approximately 2,000 in the UK and 500 in Austria and Hungary. The table also displays the percentage for class size. Most of the firms have between 20 and 49 employees and are thus medium size. The focus solely on companies that make use of raw materials, or parts and components in order to produce a final good is justified by the fact that the activities involved in the production processes are particularly vulnerable to fragmentation and entail a high level of international contestability. In other words, manufacturing firms are more prone to internationalization strategies. This implies that the findings of this research apply only to firms operating in the manufacturing sector.

Table I. Distribution of firms

		Percentage of firms in size class			
		[10-19]	*[20-49]*	*[50-249]*	*[250+]*
AUT	443	29.80	37.92	21.90	10.38
FRA	2973	33.67	38.68	20.45	7.20
GER	2935	23.88	38.67	27.02	10.43
HUN	488	30.53	36.07	24.18	9.22
ITA	3021	34.43	46.57	14.20	4.80
SPA	2832	36.58	43.93	14.34	5.16
UK	2067	30.72	38.95	25.11	5.23
Total	***14759***				

Source: Efige database

Table II and III show the distribution of firms and some of their characteristics, i.e. average number of workers and average turnover, for the different categories of internationalization and innovation. From table II it appears that 23% of the sample is composed by firms that are not active abroad and the remaining 77% by firms that are implementing at least one of the different internationalization activities. The table also reveals that firms that are involved in internationalization activities are larger, in terms of number of workers, and more profitable, in terms of average turnover, which is in line with the theories and empirical studies mentioned above.

Table II. Internationalization Statistics

	No. of firms	Share of firms (%)	Average number of workers	Average turnover (million euro)
Non-active abroad	3402	23	42	1-2
Active abroad	11357	77	108	2-10
of which				
Importers	6017	40	138	2-10
Outsourcers	614	4	198	10-15
FDI makers	747	5	462	15-50
Total	*14759*			

Source: Efige database
Note: Modes of internationalization are not mutually exclusive; firms can implement more than one strategy.

Similar results are found when considering the innovative part of firms, as illustrated in table III. Approximately 27% of the firms are not carrying out any innovative activity, whereas the vast majority is involved in at least one of them. In particular, half of the innovative firms in the dataset are involved in internal R&D, product and process innovations, whereas only 10% are carrying out external R&D activities and applied for a patent in 2008. The table also exhibits that most innovative firms are relatively bigger and more profitable relative to firms that are not carrying out any innovative activity. The results presented in tables II and III hint to a possible relation between internationalization modes and innovation capabilities in the sense that it is very likely that larger and more profitable firms are productive enough to be able to implement innovation and internationalization strategies. Moreover, the numbers shown in the two tables are coherent with the findings presented in the literature in the previous chapter, which confirms a positive assessment of the quality of the database used for the analysis.

Table III. Innovation Statistics

	No. of firms	Share of firms (%)	Average number of workers	Average turnover (million euro)
No innovations	3978	27	50	1-2
Innovations	10781	73	108	2-10
of which				
R&D internal	7117	48	128	2-10
Product inn.	7245	49	120	2-10
Process inn.	6493	44	124	2-10
Patents	1953	13	236	10-15
Total	*14759*			

Source: Efige database
Note: Modes of innovation are not mutually exclusive; firms can implement more than one innovation activity.

This relationship between the two variables of interest is partially represented in table IV. In line with Altomonte et al. (2013), I constructed the intensities of internationalization and innovation based on the number of activities undertaken by the firm. For instance, intensity of zero means that the firm is involved in zero out of the four innovative activities presented in table III and zero out of the three internationalization modes presented in table II. In the same vein, an innovation intensity of four and internationalization intensity of three means that the firm is involved in all the innovative and internationalization modes. These measures give a *prima facie* evidence on the relationship between the intensities of the two variables of interest.

Panel A shows the number of firms for each combination of the two intensities. It appears that there are more firms that implement only one internationalization strategy and up to three innovation activities. Panel B

instead depicts the average number of workers and, as hinted before, firms with more employees implement more innovations and internationalization activities. The comparison between the two panels reveals that innovation and internationalization are indeed related; higher intensities are reached by fewer firms and such firms have also a higher number of employees. In particular, comparing the top left corner (when the intensities are zero) with the bottom right corner (when the intensities are at the maximum level) of both panels, it is clear that the average size of the firm sharply increases while the amount of firms falls.

Table IV. Internationalization and Innovation Statistics

PANEL A: number of firms		Innovation Intensity					
		0	*1*	*2*	*3*	*4*	*Total*
Internationalization Intensity	*0*	2919	2103	1813	1192	271	*8298*
	1	1075	1152	1427	1469	508	*5631*
	2	78	118	175	206	166	*743*
	3	6	11	17	33	20	*87*
	Total	*4078*	*3384*	*3432*	*2900*	*965*	*14759*

PANEL B: number of workers		Innovation Intensity					
		0	*1*	*2*	*3*	*4*	*Avg. Empl.*
Internationalization Intensity	*0*	42	50	55	62	93	*302*
	1	70	87	111	130	241	*639*
	2	100	109	229	311	643	*1392*
	3	119	80	260	345	2294	*3094*
	Avg. Empl.	*331*	*326*	*655*	*848*	*3271*	*5431*

Source: Efige database.
Note: Innovation and Internationalization intensities are as in Altomonte et al. (2013). The number of internationalization activities is the sum of these modes: FDI maker, outsourcer, and importer. The number of innovations is the sum of these activities: product innovation, process innovation, internal R&D investments, and patent application.

Lastly, it is interesting to look also at the patterns of offshoring of high value-added activities such as R&D. As I explained in the previous chapter, the internationalization of the production processes may also induce the firm to offshore or outsource its R&D activities in order to restore the link between the innovative capabilities and the production activities. To give a first overview of whether this is the case, table V shows a simple probit regression to check how the probability of outsourcing R&D for the firms in the dataset differs, given their internationalization status. It is clear that firms that are already active in the international market have a higher probability of outsourcing their R&D activities, meaning that the latter follows after the internationalization of production. In particular, firms that are not active on the international market have a negative probability of outsourcing their innovative activities, while the opposite is true for firms that implement one of the three internationalization strategy depicted below.

These statistics give a first evidence on the relation between the variables of internationalization and innovation and the extent to which firms are likely to outsource their innovative capabilities abroad. It would be wrong to draw any conclusion on the data presented so far as these outcomes do not keep into account potential biases, as self-selection. The methodology that is explained and implemented in the next chapters allows me to construct a treatment and control group and then look at the average treatment effect of internationalization intensities on innovation intensities, thus empirically testing the two hypotheses presented above.

Table V. Probability of R&D Outsourcing by Internationalization Status

	(1)	(3)	(4)	(5)
	Dependent variable: probability of R&D outsourcing			
Non Active abroad	-0.523***			
	(0.0392)			
Importers		0.330***		
		(0.0275)		
FDI makers			0.525***	
			(0.0525)	
Outsourcers				0.395***
				(0.0593)
Constant	-1.122***	-1.366***	-1.250***	-1.235***
	(0.0149)	(0.0191)	(0.0142)	(0.0140)
Observations	14,759	14,759	14,759	14,759

Source: Efige database.
Note: Probit regressions. Standard errors in parentheses,
****p<0.01, **p<0.05, *p<0.1.*

4. Framework and Methodology

4.1 Potential outcome framework

Before starting with the estimation method, it is important to review the framework of potential outcomes and highlight the issues that may arise when estimating the effects with a simple OLS. This justifies then my choice for the method that is used in the analysis. Considering a population of *N* firms, where for each firm *i* one can observe an outcome variable Y_i (innovation capabilities) and a treatment variable D_i (equal to 1 if the firm has *actually* implemented internationalization strategies, and 0 otherwise), ideally one would like to observe the difference in innovation outcomes between firm *i* when it internationalized and the same firm *i* when it did not do so, so that the Average Treatment Effect on the Treated (ATET) would be computed as:

$$E[Y_{1i} - Y_{0i} \mid D_i = 1] = E[Y_{1i} \mid D_i = 1] - E[Y_{0i} \mid D_i = 1] \quad (1)$$

Equation (1) gives the difference in *potential* outcomes when firm *i* is *actually* treated and *actually* not treated. However, it is impossible to observe both outcomes for the same firm as the latter can be either treated or not. Therefore, a counterfactual situation is needed, i.e. a firm *j*, similar to firm *i*, that has not been treated. In this way the ATET would simply be the average outcome of those firms that were actually treated and the ones that were not treated, since both outcomes are observables, as:

$$E[Y_{1i} \mid D_i = 1] - E\left[Y_{0j} \mid D_j = 0\right] \quad (2)$$

However, this would require that the potential outcome as a non-treated firm, for the actually treated firm *i*, $E[Y_{0i} \mid D_i = 1]$, is equal to the potential outcome as non-treated for the actually non-treated firm *j*, $E\left[Y_{0j} \mid D_j = 0\right]$. This assumption is very unlikely to hold in a non-experimental setting since treated and non-treated firms are very likely to differ even in the absence of treatment. For instance, a firm *i* that does FDI may be more productive than a firm *j* that is inactive in the international market. This implies that even in the counterfactual case where the firm *i* had not carried on FDI activities, it may still have experienced a larger positive effect on innovation than the non-treated firm *j*. Hence, potential outcomes are not independent of treatment status and firms self-select into treatment participation.

Randomization of the treatment is the key solution to this problem as it would eliminate the self-selection bias, meaning that it would ensure that whether firms internationalize or not depends on a random process and not on observable and/or unobservable characteristics of the firm. In the real world, however, firms' decisions about internationalization do not follow a random process. Therefore, the chosen method has to deal with the bias and make the treatment status independent of potential outcomes, i.e. as good as random.

4.2 Propensity Score Matching

Matching has been widely used in the literature to solve self-selection issues. The key intuition is to find in a large control group (i.e. non-treated firms) those firms that have similar pretreatment observable characteristics *X* to the treated firms. Once the counterfactual group is constructed, the differences in outcomes can be attributed solely to the treatment. One issue with matching strategies is that conditioning on all relevant covariates *X* may incur in the "curse of dimensionality", i.e. it may be hard to find a counterfactual firm for each treated firm that has *exactly* the same values on all covariates (Caliendo and Kopeinig, 2008). Rosenbaum and Rubin (1983) then advocate for the use of balancing scores *p(X)*, meaning that firms are matched based on their probability of implementing internationalization activities. Such matching procedures are known as Propensity Score Matching (PSM).

For PSM to give consistent estimates, two assumptions are needed. The first one is the *conditional independence assumption*, which implies that conditional on the propensity scores, the potential outcomes are independent of treatment assignment as:

$$(Y_{0i}, Y_{1i}) =\perp D_i \mid p(X_i) \quad (3)$$
$$\text{with } p(X_i) = \Pr(D_i = 1 \mid X_i) = E(D_i = 1 \mid X_i)$$

This assumption implies that for each treated firm there exists an untreated counterpart with the same propensity score. Propensity scores are estimated by considering the *observed* characteristics of the firms, and thus it can be thought as a control strategy that only accounts for observables. However, if we assume that the likelihood of having the same values for *unobserved* characteristics increases when observed factors are similar, then the method indirectly accounts for unobservables as well.

The second one is the *common support assumption*, entailing that all treated agents have a counterpart in the non-treated population as:

$$0 < \Pr(D_i = 1 \mid p(X_i)) < 1, \quad (4)$$

This assumption ensures that for each value of the propensity score, $p(X_i)$, there exists both a treated and a non-treated firm, as the probability of the treatment is assumed to be lower than 1 and greater than 0. While the first assumption cannot be tested, it is possible to check whether the overlap assumption is fulfilled by visual inspection, e.g. through histograms or through more formal tests, which is done during the matching estimation process conducted the next chapter. If this assumption does not hold and there are areas of no overlaps than the matching process is not able to identify the treatment effect. In such cases, the estimation is conducted only on the common region.

4.2.1 Econometric Setup

The first step for a propensity score matching process is the estimation of the propensity scores based on the set of covariates chosen. Therefore, the first choice that has to be made concerns the functional form to use. For this analysis I choose a probit model, and as Caliendo and Kopeinig (2008) argue, in the binary treatment case, probit and logit estimation yield very similar results. Equation (6) represents the predicted probability of the treatment, estimated with a probit model.

$$P(Int_i = 1) = \Phi(X_i) \quad (5)$$

The equation indicates the probability of the firms to implement the treatment given the X_i set of firm specific characteristics, such as size of the firm, the legal form of the firm, the sector, the country, whether the firms belongs to a group, the percentage of white/blue/unskilled blue collar workers and the average productivity of the firms between 2001 and 2008[1]. The choice of covariates to add when estimating the propensity scores is important as only variables that influence both the treatment decision and the outcome variables should be included if one wants to avoid bad control biases. In contrast, covariates that are influenced by the treatment (or its anticipation) must be excluded.

Equation (5) thus gives the propensity scores for each firm, that is the probabilities of implementing internationalization strategies given the set of covariates. The second step is the choice of the matching algorithm used to estimate the average treatment effect. PSM estimators differ in many ways; in the definition of the neighborhood for each treatment individual, in how they handle the common support issue and in the way they assign weights to these neighborhoods. The algorithm I choose as the main outcome is the kernel matching method, as, in contrast to other matching algorithms, it uses all the observations from the comparison

[1] The group of covariates included for the estimation of the propensity scores is changed as robustness check in Chapter 6.

group in order to construct the counterfactual outcome[2]. More specifically, it consists in a non-parametric estimator that uses a weighted average of all firms in the control group to construct the counterfactual outcome for the treated firms. As for all matching algorithms, there is a trade-off between variance and bias; this method has a high bias, since there is the possibility that some observations that are used are a bad match, but also a low variance, as more observations are used (Caliendo and Kopeinig, 2008).

Following the framework outlined above, the effects of internationalization is then the difference between innovation outcomes in the treatment *T* and control *C* groups, as:

$$E[Inn_T \mid Int = 1] - E[Inn_C \mid Int = 1] \tag{6}$$

However, the effect of the control group is the counterfactual that cannot be observed on the same set of firms. Therefore, using matching solves this problem as for each firm in the treatment group i.e. that internationalized, propensity score matching finds a non-active abroad firm that is similar in terms of the exogenous set of characteristic *X*. Then the effect of internationalization becomes:

$$E[Inn_T \mid Int = 1, p(X)] - E[Inn_C \mid Int = 0, p(X)] \tag{7}$$

As I mentioned in the first chapter, I believe that part of the reason for which the literature has not found any negative effect of internationalization on innovation is that they have looked mostly at the extensive margin, thus using a dummy variable for internationalization. This research instead wants to overcome the use of a single binary variable for internationalization and thus look at the different intensities. To do so, I repeat the procedure for three dummy variables, *Int_1*, *Int_2* and *Int_3*, that capture whether the firm is implementing one, two or three methods of activity abroad, as shown in equation (8). My expectation is that the ATET that *Int_3* has on innovation outcomes is smaller than *Int_1* and *Int_2*, or negative.

$$\begin{aligned} &E[Inn_T \mid Int\_1 = 1, p(X)] - E[Inn_C \mid Int\_1 = 0, p(X)] \\ &E[Inn_T \mid Int\_2 = 1, p(X)] - E[Inn_C \mid Int\_2 = 0, p(X)] \\ &E[Inn_T \mid Int\_3 = 1, p(X)] - E[Inn_C \mid Int\_3 = 0, p(X)] \end{aligned} \tag{8}$$

The same reasoning is applied to check the effect on the four intensities of innovation. Therefore, the outcome variables in equations (9) were re-specified to include the different *z* intensities of innovation. Equations (8) and (9) provide an empirical test for hypothesis 1 and 2 respectively that are driving this research.

$$\begin{aligned} &E[Inn\_z_T \mid Int\_1 = 1, p(X)] - E[Inn\_z_C \mid Int\_1 = 0, p(X)] \\ &E[Inn\_z_T \mid Int\_2 = 1, p(X)] - E[Inn\_z_C \mid Int\_2 = 0, p(X)] \\ &E[Inn\_z_T \mid Int\_3 = 1, p(X)] - E[Inn\_z_C \mid Int\_3 = 0, p(X)] \end{aligned} \tag{9}$$

4.2.2 Discussion on the Methodology

The pros and cons of the methodology should be discussed under two perspectives; i) the use of PSM as main method for the estimation, and ii) the model of the three treatment variables to reflect the intensive margin. Propensity score matching took a central role in the literature with the seminal papers of Dehejia and Wahba (1999, 2002) who evaluated PSM using the experimental data of LaLonde (1986) as benchmark. They show that the outcomes given by PSM were very similar to the ones obtained when using an experimental setting, which is considered by the literature as the golden standard.

The papers were however criticized by scholars such as Smith and Todd (2005) who argue against the sensitivity of PSM estimation to the choice of a particular subsample of data and to changes in the covariates chosen. Similarly, Angrist and Pischke (2008) do not hold a positive opinion on PSM and stress the lack of standardization in the procedure. Indeed, too many decisions that will influence the final outcome are left at

[2] Other matching algorithms are tested as robustness checks in Chapter 6.

the discretion of the author. Lastly, matching methods are often considered less optimal than other strategies, such as instrumental variables or regression discontinuity design, because they do not allow the direct control of unobserved characteristics. As previously mentioned, unobservables are only accounted for if the assumption that *firms with similar observables have similar unobserved characteristics* is plausible. Having said so, it is also true that PSM is still useful when there is no treatment randomization opportunity. In the case of this research for instance, this method allows me to deal with self-selection issues and thus reveals insightful information on their relationship between internationalization practices and innovation capabilities.

Turning the discussion on the model I have constructed above that looks at the three treatment intensities, there are benefits and important caveats that should be highlighted. One advantage of using this method is that there is no need to control for external shocks or trends. This is because the covariates that are included to estimate the propensity score should not be outcomes of the treatment. For instance, one may be worried of the bias generated by the financial crisis of 2008/2009 if no controls regarding the shock are added. However, how the firms were impacted and responded to the crisis depended on whether they were active or not on the international market and are therefore outcomes of their treatment status, hence controlling for the financial crisis would result in a bad control bias. The covariates that I included are pre-determined characteristics of the firms and I find them to be enough to ensure that the treatment and control groups are similar and can thus be compared. Whether this is indeed the case is more formally discussed in the next chapter.

Where the limitations of the intensity-model are concerned, there are mainly three issues that I want to highlight. Firstly, reverse causality issues are not addressed by this methodology. The literature described above reveals that the direction of causality between internationalization and innovation is not clear and that it could be the latter to drive the former. The model I have outlined however does not deal with this issue and assumes that the direction of causality runs from internationalization to innovation. One way to better address this bias would be to look at several years so that it becomes possible to consider the lags of the variable of interest and run out reverse causality. Unfortunately, the Efige database is only available for one year, but looking at a panel data instead of a cross-sectional database would be optimal for future research.

The second issue with the model is that it does not allow me to look at the whether the location decisions of offshoring or outsourcing production has had an impact on innovation. For instance, it might have been the case that firms that offshored to technologically advanced countries have retained better innovative capabilities thanks to the spillover effects of coming into contact with relatively technologically advanced suppliers. At the same time, it is also true that firms that offshored to lower income and technologically underdeveloped countries may have experienced a sharp reduction in the costs of production and therefore have invested such resources in R&D or other innovative activities. Testing these interesting hypotheses cannot be done with the current model, as it requires the construction of other treatments (such as whether the firm offshored to a high or low income country) and a different PSM procedure.

Third and most importantly, the method does not allow me to unpack what kind of internationalization strategies are most beneficial for innovation and what kind of innovation activities are benefitting the most from internationalization. Ideally, one would also want to identify which methods of internationalization, and also at which intensities, are better for innovation but the model of the three treatments depicted above does not allow me to do so.

To correct for this last point and give some insights on the optimal strategies for being active abroad, I study each internationalization technique, i.e. outsourcing (*OUT*), offshoring (*OFF*) and importing intermediate inputs (*IMP*), as a treatment variable as in the following equations:

$$\begin{matrix} E[Inn_T \mid OFF = 1, p(X)] - E[Inn_C \mid OFF = 0, p(X)] \\ E[Inn_T \mid OUT = 1, p(X)] - E[Inn_C \mid OUT = 0, p(X)] \\ E[Inn_T \mid IMP = 1, p(X)] - E[Inn_C \mid IMP = 0, p(X)] \end{matrix} \quad (10)$$

$$\begin{matrix} E[Inn\_z_T \mid OFF = 1, p(X)] - E[Inn\_z_C \mid OFF = 0, p(X)] \\ E[Inn\_z_T \mid OUT = 1, p(X)] - E[Inn\_z_C \mid OUT = 0, p(X)] \\ E[Inn\_z_T \mid IMP = 1, p(X)] - E[Inn\_z_C \mid IMP = 0, p(X)] \end{matrix} \quad (11)$$

This application allows me to give a further overview about the implications that each mode of internationalization has on innovation on average. In principle, it would have been informative to consider each treatment as a continuous variable, e.g. by looking at the percentage of total turnover that the production activities offshored or outsourced represent, so that it would have been possible to look at the intensities of each internationalization mode as well. In such case, the optimal method that should have been implemented would have been a PSM with continuous treatment. However, such methodology is beyond the scope of this thesis and it requires the individual to take numerous decisions that would have made the standardization problems with PSM even more severe.

5. Empirical Results

Before delving into the propensity score matching procedure, it is important to look at the values of the covariates between the two groups; the treatment and the control group. As previously mentioned, if the characteristics of the firms in the two groups differ, then a simple regression would be biased as it would not consider the differences in potential outcomes of the two groups. To check the similarity of the groups, one can test whether the means of the covariates in the two groups are significantly different with a two-sample t-test.

Table VI precisely shows the p-values on such tests on the covariates. A low p-value implies that it is possible to reject the null hypothesis of equality of the variables between the two groups. From the table it appears that almost all the values of the characteristics used as controls differ between treated and non-treated firms. Only few covariates have similar means in both groups; for instance, the same percentage of firms in the treatment and control groups have a proprietorship legal structure when the treatment is internationalization with intensity three.

Table VI. Two-Sample t-test with Equal Variances (*p-values*)

	Active Abroad	*Internationalization Intensity 1*	*Internationalization Intensity 2*	*Internationalization Intensity 3*
Firmsize1 [10, 19]	0	0	0	0
Firmsize2 [20, 49]	0.03	0.04	0	0
Firmsize3 [50, 249]	0	0	0	0
Firmsize4 [250+]	0	0	0	0
Proprietorship	0	0	0.01	0.45
Partnership	0	0	0	0.01
LL Company	0	0	0	0
Group	0	0	0	0
Workers	0	0	0	0
Country	0.02	0.35	0	0
Sector	0	0.42	0.04	0.16
White collar (%)	0	0	0	0
Blue collar (%)	0	0	0	0
Unsk. Blue collar (%)	0	0	0	0
Avg. product. growth (2001-2007)	0	0	0.59	0.70

Source: Efige database
Note: Null hypothesis of the test: means of the two populations are equal. If the p-value is low it is possible to reject the null hypothesis, thus the two means are unequal.

Despite having determined that the firms composing the treatment and control groups are significantly different for all four treatment status, it is still informative to provide some baseline estimates against which one can compare the results obtained later with the propensity score matching estimation. In order to do so, one can simply run a probit estimation of each outcome variable against the treatments and covariates, as in equation 12. As previously mentioned, running a probit instead of a logit would not give significantly different results (Caliendo and Kopeinig, 2008).

$$P(Inn_i = 1) = \alpha + \beta_1(Int_i) + \beta_2 X_i + \varepsilon$$
$$P\left(Inn_{z_i} = 1\right) = \delta + \beta_3\left(Int_{t_i}\right) + \beta_4 X_i + \in \quad (12)$$

The first probit equation shows the probability of innovation of firms that are active abroad, whereas the second equation depicts the probability of implementing *z* intensities of innovation of firms with *t* intensity of internationalization. *X* is the set of firm-specific characteristics; the size of the firm, the legal form of the firm, the sector, the country, whether the firms belongs to a group, the percentage of white/blue/unskilled blue collar workers and the average productivity of the firms between 2001 and 2008.

Table VII displays these baseline estimates. The first row shows that being active abroad increases the probability of implementing more innovative activities by 60% on average. Moreover, increasing the intensities of internationalization has also a positive impact on the probability of innovating, e.g. having an intensity of internationalization three increases the probability of innovation by 107% on average, while using only one mode of internationalization rises the same probability by 35% on average. This finding runs contrary to the first hypothesis put forwards in this research, specifically that the positive impact on innovation decreases with an increase in internationalization intensity. Moreover, looking at the impacts of the treatment status on the intensities of innovation, one realizes that the second hypothesis is also not confirmed. Indeed, the probability of implementing four innovation activities increases with the internationalization intensities, even though at a decreasing rate, which is discordant with the hypothesis that higher internationalization intensities have a lower positive impact on higher innovation intensities.

These estimates seem to contradict both of the hypotheses put forward in the research, but they do not take into consideration any self-selection issues and, as shown in table VI, the treatment and control groups are very different for all four treatment status. This implies that the potential outcomes of firms are dissimilar as well, thus it is very likely that the outcomes given in table VI are biased.

Table VII. Baseline Estimates (*probit regressions*)

	(1)	(2)	(3)	(4)	(5)
	Innovation	*Innovation Intensity 1*	*Innovation Intensity 2*	*Innovation Intensity 3*	*Innovation Intensity 4*
Active Abroad	0.60***	-0.15**	0.30***	0.53***	1.12***
	(0.060)	(0.062)	(0.067)	(0.078)	(0.237)
Internationalization Intensity 1	0.35***	-0.08	0.08	0.24***	0.37***
	(0.053)	(0.053)	(0.052)	(0.054)	(0.083)
Internationalization Intensity 2	0.63***	-0.10	-0.06	-0.01	1.01***
	(0.150)	(0.132)	(0.126)	(0.129)	(0.144)
Internationalization Intensity 3	1.07**	-0.13	-0.36	0.47	1.02***
	(0.522)	(0.366)	(0.356)	(0.305)	(0.359)
COVARIATES	Yes	Yes	Yes	Yes	Yes

Source: Efige database

*Note: Covariates: firm's size, legal structure (LL Company, Proprietorship, Partnership), whether the firm belongs to a group, number of workers, country, sector, percentages of white/blue/unskilled blue-collar workers, and average productivity growth from 2001 to 2007. Standard errors in parentheses, ***p<0.01, **p<0.05, *p<0.1.*

It is therefore clear that to get a more accurate treatment effect, one has to implement a methodology, such as propensity score matching, that handles the differences between the two groups. To begin the procedure of the estimation, one should firstly check whether the common support assumption, needed to ensure the unbiasedness of the results, is satisfied. Figure III plots the distributions of the densities of the propensity scores, computed by predicting the probability of treatment given the set of covariates as in equation (5), for each treatment variable.

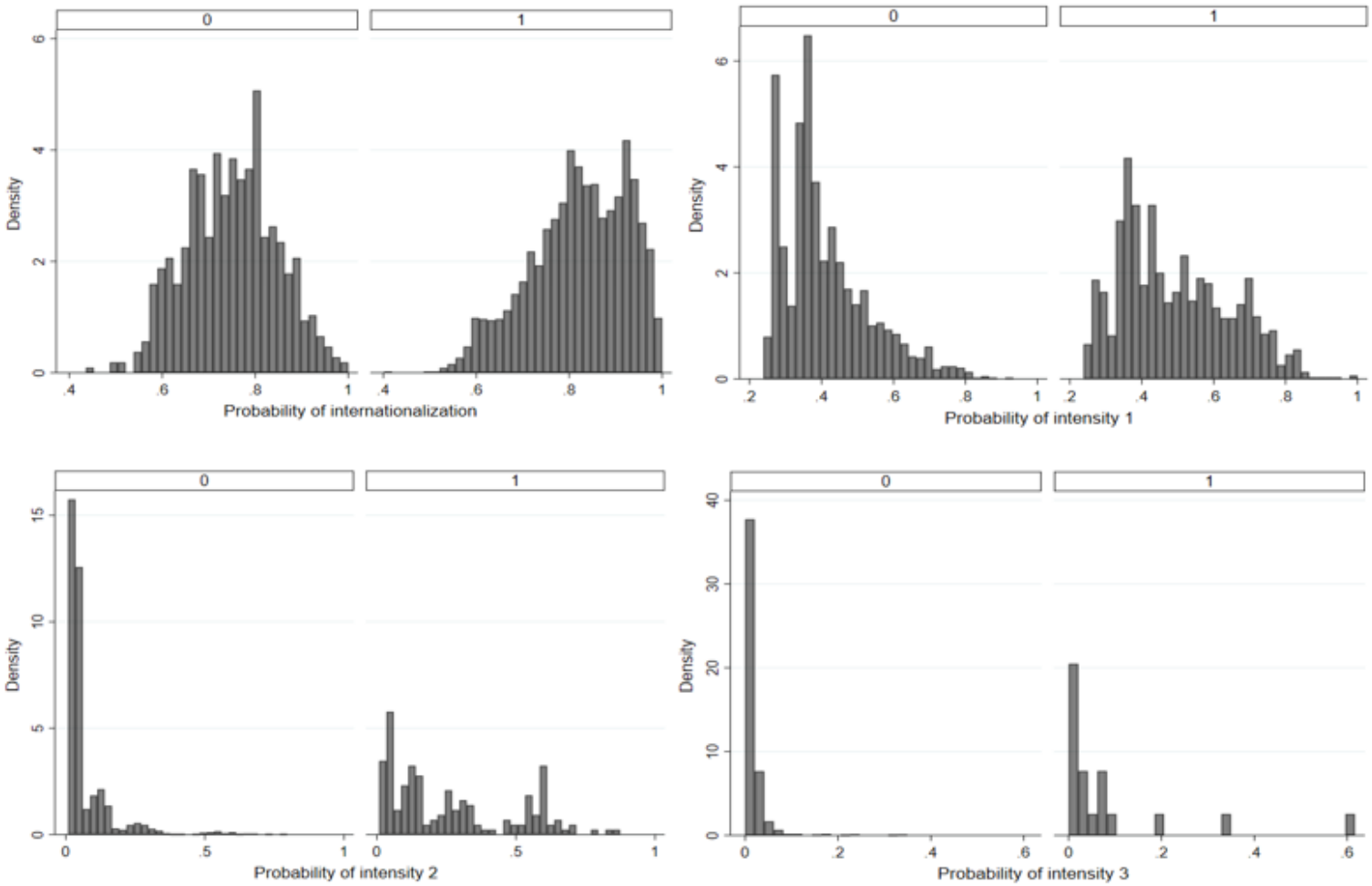

Figure III. Propensity Scores Densities Distributions in Treated and Control Groups (*before matching*)

It appears that in all cases there is no perfect overlap of the propensity score densities between the treatment and control group. Take for instance the first treatment status, being active abroad, where the propensity score density distribution is represented by the first graph in the top-left corner. The control group in the first panel (when treatment is equal to 0) exhibits observations for which there is a very low propensity score, while the treatment group in the second panel of the same graph does not. Furthermore, the treatment group has more observations with high propensity scores relative to the control group. The same reasoning is valid for all four treatment statuses in all four graphs. Some issues will likely arise when estimating intensities two and three of internationalization because finding a good control firm for each treated firm is harder as there are not enough inactive firms that have the same characteristics as the intensive internationalized firms in the treatment groups. Therefore, estimates of the treatment effects when the treatments are internationalization with intensities two and three are less accurate. As there is no perfect overlap, the propensity score matching estimation automatically trims the data to consider only these regions of common support in order to fulfill the second hypothesis.

The next step is to finally estimate the treatment effects with a kernel matching algorithm. From table VIII, it appears that the estimates of the treatment effect are more moderate than the baseline estimates. Despite that, the first hypothesis is still not verified as incrementing the intensity of internationalization increases the likelihood of innovating as well. However, the increase in the probability is smaller in table VIII than the one found in table VII. More specifically, the gap between the probability to innovate when the intensities of internationalization are one and three in the baseline estimates is approximately 70 percentage points, while with PSM estimation is only 15 percentage points. Therefore, even if the first hypothesis is not confirmed empirically, the magnitude of the estimates reveals a lower effect of internationalization on innovation than a simple probit regression.

The second hypothesis is only partly satisfied. Indeed, it appears that moving from one to two modes of internationalization increases the probability of implementing four innovative activities but moving from two to three internationalization strategies decreases it. This implies that the optimal amount of internationalization activities that a firm should have implemented, to avoid jeopardizing its ability of innovating, was two. However, most of the effects of the third level of internationalization are insignificant. This is not surprising as, as it was pointed out before, the number of observations available to estimate this effect is relatively lower than the other intensity treatments.

Table VIII. Propensity Score Matching Estimation (*Kernel*)

	(1)	(2)	(3)	(4)	(5)
	Innovation	*Innovation Intensity 1*	*Innovation Intensity 2*	*Innovation Intensity 3*	*Innovation Intensity 4*
Active Abroad	0.202***	-0.075***	0.073***	0.125***	0.078***
	(0.027)	(0.026)	(0.022)	(0.017)	(0.006)
Internationalization Intensity 1	0.100***	-0.027	0.023	0.061***	0.043***
	(0.017)	(0.017)	(0.017)	(0.016)	(0.009)
Internationalization Intensity 2	0.163***	-0.042	-0.047	0.016	0.248***
	(0.035)	(0.038)	(0.040)	(0.039)	(0.036)
Internationalization Intensity 3	0.241**	-0.045	-0.086	0.188	0.182
	(0.056)	(0.093)	(0.092)	(0.119)	(0.101)

Source: Efige database

*Note: Kernel estimation with "psmatch2" command. Column (1) gives the outcome of equation (8), columns (2) to (5) give the outcomes for equation (9). Standard errors in parentheses, ***p<0.01, **p<0.05, *p<0.1.*

In general, these findings contradict my first hypothesis and confirm the results of the literature, in that higher internationalization seems to have a beneficial impact on innovation of the firm. At the same time however, I do find a hint that internationalization may have had a diminishing effect on high intensity innovation abilities. Firms that were active abroad through three different strategies had a lower probability of implementing intensive innovative abilities than firms that were active through two different strategies. It should be noted, however, that the coefficient is insignificant.

One potential reason for which my results are not in line with the outlined hypotheses may be time. Indeed, by extending this research over time and by looking at more recent years, one could find a more complete picture of the relationship between the variables and uncover an even stronger diminishing effect of intensive internationalization on innovation than the one I find in this research.

5.1 Overlapping and Balancing Tests

The last step in the PSM procedure is to check the overlap assumption more formally and whether the method improved the balance of covariates across groups. For what it concerns the former test, figure IV shows the overlapping areas for each treatment after the matching process was conducted. In general, it appears that for each treated group the matching estimator was able to find a counterpart in the control group. However, the figures also display that there is no perfect overlap especially for the intensities two and three, as the histograms above suggested. Indeed, most of the treatment effect estimation was conducted on firms with relatively low values of propensity scores as it was easier for the algorithm to find a counterfactual in the control group. This issue arises precisely because firms that implement three internationalization modes have very unique features, in that they are highly productive, large and profitable and thus it is harder to find inactive firms with similar values for such characteristics.

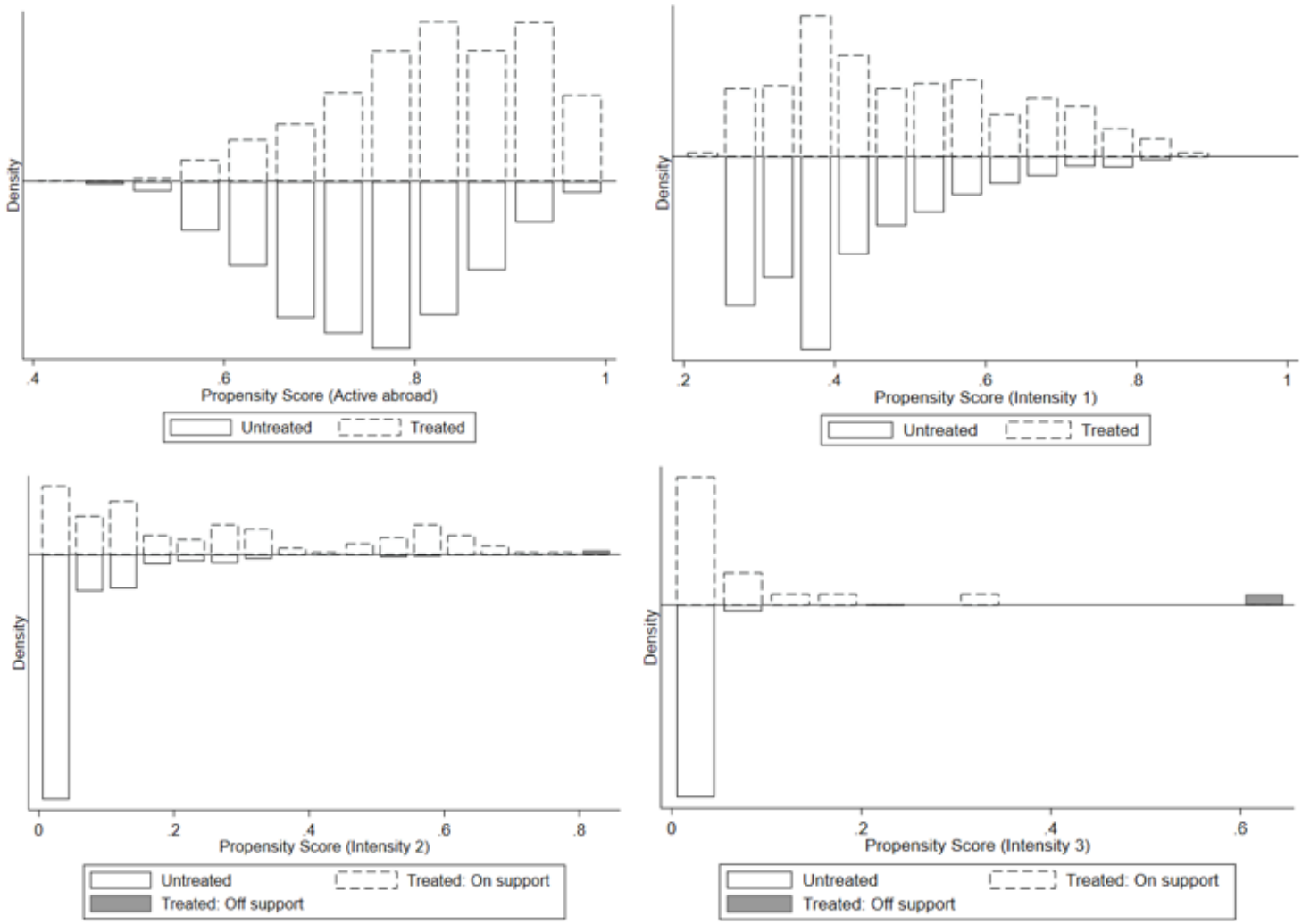

Figure IV. Overlapping (*after matching*)

Figure V shows that the balancing of covariates sharply improved with the PSM process. As I have previously shown in table VI, the treatment and control groups displayed significantly different means for the covariates taken under consideration. The matching process, instead, successfully reduced such imbalance. Indeed, in the figures it is clear that the differences for all treatment variables are closer to be significantly equal to zero in the matched sample relative to the unmatched sample, which suggests that the two groups are comparable and that the effect on innovation is given by the differences in the treatment status.

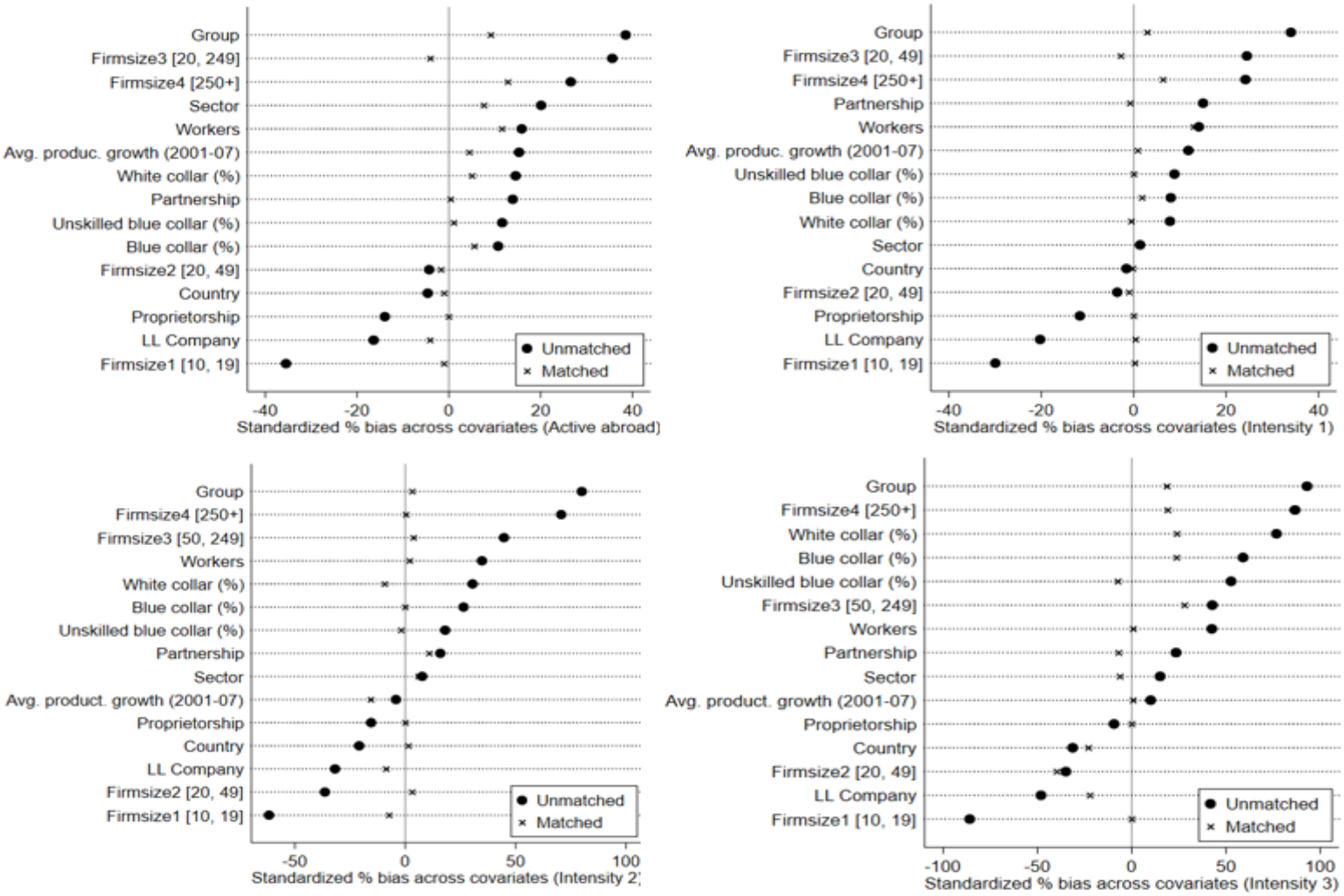

Figure V. Balancing of Covariates

5.2 Unpacking Internationalization Modes

As previously mentioned, it is informative to look at which internationalization modes benefit more the firms in terms of retaining its innovative capacity, but the method that I have used does not allow me to do so. To remedy for this, I still make use of the framework of potential outcomes and the methodology of propensity score matching but I consider as treatments each one of the three internationalization modes (offshoring, outsourcing and importing of intermediate inputs), as described in Section 4.2.2.

The outcomes are presented in table IX[3]. It appears that each internationalization strategy had a positive impact on the overall probability of the firm to innovate. In particular, the best internationalization mode for innovation was importing intermediate inputs, as it increased the probability of innovating by 11%. When looking at the intensities of innovation, the picture is still quite homogeneous. All three strategies decreased the probability of innovating at low intensities whilst increasing it at high intensities. More specifically, offshoring turns out to be the best mode of internationalization for higher intensities of innovation, as it increased the probability of the latter by 18%.

[3] Graphs and tables on the PSM procedure can be found in Appendix.

Table IX. Internationalization Modes on Innovation (*Kernel*)

	(1)	(2)	(3)	(4)	(5)
	Innovation	*Innovation Intensity 1*	*Innovation Intensity 2*	*Innovation Intensity 3*	*Innovation Intensity 4*
Offshoring	0.07***	-0.07**	-0.07**	0.05	0.18***
	(0.028)	(0.030)	(0.035)	(0.039)	(0.034)
Outsourcing	0.09**	-0.02	-0.05	0.03	0.12***
	(0.042)	(0.041)	(0.038)	(0.041)	(0.038)
Importing	0.11***	-0.02	0.03*	0.05***	0.06***
	(0.017)	(0.017)	(0.017)	(0.016)	(0.009)

Source: Efige database

*Note: Kernel estimation with "psmatch2" command. Column (1) gives the outcome of equation (10), columns (2) to (5) give the outcomes for equation (11). Standard errors in parentheses, ***p<0.01, **p<0.05, *p<0.1.*

The interesting question then becomes why it is the case that importing and offshoring are the modes of internationalization with better probability of retaining a firm's capability to innovate. Potential answers to this question can be found in the literature that was described in Chapter 2. Theoretically, if the price of intermediate inputs is reduced, a firm can respond either by increasing investments in R&D (if the firm uses those inputs in R&D activities) or by decreasing investments in R&D. The decrease happens due to the lower incentives to innovate through this channel as competitiveness in the international market is retained since the productivity, or output quality, of the firm increases through the importing of intermediate inputs (Liu and Qiu, 2016). This suggests that importing intermediate inputs raises the firm's innovative capabilities by improving the quality and/or variety of its products and processes. The 11% increase in the probability of innovation may thus be driven by the rise in product and process innovation rather than an increase in R&D investments.

In contrast to importing intermediate inputs, offshoring may be better for intensive innovation because it boosts the abilities of firms to implement all four kinds of innovation investments. As the literature of reverse knowledge transfer has highlighted, through offshoring firms are able to absorb the skills, the knowledge and the capabilities of the host country and reverse the acquired abilities to the parent company, rising the probability of the latter to implement innovative changes to its production process. Moreover, offshoring often reduces the costs of production entailing that more resources become available and can be invested in R&D in order to improve the competitiveness of the company on the international market.

As Antràs and Helpman (2004; 2008) and Antràs (2003) models predict, capital-intensive and more productive firms are more likely to engage in FDI, relative to outsourcing (which is shown also in table II of Chapter 3 of this research). These predictions are empirically confirmed by Corcos et al. (2013) who also argue that offshoring firms have more at stake and avoid sharing their knowledge and yielding the risk of subcontractors dissipating their asset value. This entails that offshoring firms are more likely to retain in-house their innovative abilities rather than outsourcing them to a third party and, unlike outsourcing firms, have enough capital and productivity to be able to implement high intensity innovations.

This discussion could be more accurate and complete if complemented with a study on the location choices of the firms. As mentioned in section 4.2.2, one limitation of the model is that it does not allow me to check whether the decisions of firms to offshore to certain locations has an impact on innovation. However, it would not be surprising to find that offshoring to technologically advanced countries has a greater positive effect on the probability to innovate than offshoring to a lower income and technologically laggard country. If this is indeed the case, the effect of offshoring to tech savvy countries would be greater than 18%, implying that the estimates in table IX could be downward biased.

6. Robustness Tests

To check whether the results in table VIII are sensitive to the choice of the matching algorithm I conduct some robustness tests by changing the latter. In particular, I implement two other matching strategies: i) nearest-neighbor (NN) matching (with and without replacements), and ii) caliper and radius matching. NN matches firms with the closest propensity scores. NN matching *with* replacements means that one untreated firm can be used as a match more than once, while NN matching *without* replacements means that each untreated observation can be matched only once. Matching with replacements implies a trade-off between bias, which will decrease as better-quality matches will be done, and variance, which will increase as the number of units used as counterfactual will fall. Matching with replacements is better if the distribution of propensity score between the treated and control group is dissimilar (Caliendo and Kopeinig, 2008). For instance, in the case of the second intensity as treatment, there are more observations having higher propensities score in the treatment group than in the control. In this case, matching with replacements increases the quality of the matches because it avoids high-score firms to be matched with low-score firms.

Table X reports the results. The general direction and significance of the coefficients seem to be coherent with table VIII, but magnitudes are slightly different and it appears that NN without replacements estimates are more similar to the kernel outcomes of table VIII. This implies that the increase in the variance may have been greater than the decrease in the bias, thus jeopardizing the quality of the results.

Table X. Propensity Score Matching Estimation (*Nearest-Neighbor*)

	(1)	(2)	(3)	(4)	(5)	(6)
	Innovation					
	With replacements	Without replacements	*Innovation Intensity 1*	*Innovation Intensity 2*	*Innovation Intensity 3*	*Innovation Intensity 4*
Active Abroad	0.13***	0.18***	-0.11***	0.05*	0.11***	0.08***
	(0.037)	(0.026)	(0.035)	(0.029)	(0.023)	(0.005)
Internationalization Intensity 1	0.09***	0.11***	-0.02	0.01	0.07***	0.03***
	(0.023)	(0.016)	(0.023)	(0.022)	(0.021)	(0.011)
Internationalization Intensity 2	0.23***	0.15***	-0.04	-0.01	0.054	0.22***
	(0.053)	(0.041)	(0.053)	(0.055)	(0.052)	(0.041)
Internationalization Intensity 3	0.16	0.21*	-0.05	-0.21	0.26*	0.16
	(0.116)	(0.116)	(0.134)	(0.145)	(0.149)	(0.111)

Source: Efige database
*Note: Regressions in columns (3) to (6) are estimated with replacements. NN estimation with "psmatch2" command. Standard errors in parentheses, ***p<0.01, **p<0.05, *p<0.1*

Caliper and radius matching lower the risk of bad matches that can emerge when using NN strategy, as the counterfactual with the closest propensity score can actually be too far away. By imposing a caliper (i.e. a maximum distance between the propensity scores of the treatment and control unit), bad matches can be avoided and the overall quality of the matching increases. As for every matching algorithm, caliper and radius matching involve a trade-off between variance and bias (Caliendo and Kopeinig, 2008). Indeed, the former may be high if fewer matches can be performed and the latter may be low as bad matched are avoided.

Moreover, before the estimation, it is hard to know what a reasonable caliper to impose is (Smith and Todd, 2005).

Table XI shows the results of the estimation with radius matching by decreasing the radius to 0.5 and 0.005. Estimations in the first part of the table (with radius=0.5) are more similar to the ones in table VIII in terms of significance, direction and even magnitude than the estimates presented in the second part of the table (with radius=0.005). This implies that the decrease in the bias obtained when lowering the radius is more than offset by the increase in the variance, resulting in better quality outcomes when the radius is not as low as 0.005.

Table XI. Propensity Score Matching Estimation (*radius/caliper matching*)

	(1)	(2)	(3)	(4)	(5)
radius = 0.5	Innovation	*Innovation Intensity 1*	*Innovation Intensity 2*	*Innovation Intensity 3*	*Innovation Intensity 4*
Active Abroad	0.23***	-0.08***	0.09***	0.15***	0.08***
	(0.021)	(0.020)	(0.017)	(0.014)	(0.006)
Internationalization Intensity 1	0.12***	-0.05***	0.03*	0.09***	0.05***
	(0.016)	(0.016)	(0.016)	(0.015)	(0.008)
Internationalization Intensity 2	0.19***	-0.08***	-0.01	0.04	0.25***
	(0.026)	(0.031)	(0.034)	(0.034)	(0.035)
Internationalization Intensity 3	0.23***	-0.09	-0.08	0.23*	0.18**
	(0.054)	(0.087)	(0.087)	(0.117)	(0.096)
radius = 0.005					
Active Abroad	0.17***	-0.09***	0.07***	0.12***	0.08***
	(0.031)	(0.029)	(0.024)	(0.019)	(0.006)
Internationalization Intensity 1	0.09***	-0.02	0.02	0.06***	0.04***
	(0.018)	(0.017)	(0.017)	(0.016)	(0.009)
Internationalization Intensity 2	0.18***	-0.02	-0.03	0.009	0.22***
	(0.040)	(0.043)	(0.044)	(0.042)	(0.037)
Internationalization Intensity 3	0.19***	-0.02	-0.15	0.14	0.22**
	(0.074)	(0.108)	(0.093)	(0.129)	(0.113)

Source: Efige database
*Note: Caliper/radius estimation with "psmatch2" command. Standard errors in parentheses, ***p<0.01, **p<0.05, *p<0.1*

The last robustness check that I conduct is on covariates. One may be worried that some of the variables I included in the estimation of the propensity scores may cause a control variable bias as they may be outcomes of the treatment. For instance, the average productivity of the firms between 2001 and 2007 may have been partly determined by the internationalization strategies of the firms. Similarly, the percentage of white-collar workers may have increased as more internationalization practices have been implemented, whereas the percentage of blue- and unskilled blue-collar workers may have decreased with internationalization. This is because firms offshore mainly low value-added activities that employ low-skilled workers. These variables are thus outcomes of the treatment and should be excluded from the estimation.

To check whether results change when these covariates are excluded from the estimation of the propensity score, I report the ATET using the kernel matching algorithm and estimating the propensity scores without the above-mentioned variables. Table XII shows that sign and magnitude of the coefficients are similar to the ones reported in table VIII, however, it is interesting to notice that the number of significant results increased. In particular, it appears that the effect of the third level of internationalization on the innovation intensity four is still smaller than the effect of the second level of internationalization, but significant. This gives even stronger evidence of a potential diminishing return that intensive internationalization may have on intensive innovation, further confirming my second hypothesis.

Table XII. Propensity Score Matching Estimation (changing covariates**)**

	(1)	(2)	(3)	(4)	(5)
	Innovation	*Innovation Intensity 1*	*Innovation Intensity 2*	*Innovation Intensity 3*	*Innovation Intensity 4*
Active Abroad	0.240***	-0.048***	0.071***	0.145***	0.072***
	(0.011)	(0.009)	(0.008)	(0.006)	(0.003)
Internationalization Intensity 1	0.131***	-0.044***	0.028***	0.099***	0.048***
	(0.007)	(0.007)	(0.008)	(0.007)	(0.004)
Internationalization Intensity 2	0.171***	-0.082***	-0.005	0.096***	0.162***
	(0.015)	(0.016)	(0.018)	(0.018)	(0.016)
Internationalization Intensity 3	0.249***	-0.115***	-0.022	0.241***	0.151***
	(0.031)	(0.039)	(0.045)	(0.054)	(0.043)

Source: Efige database

*Note: Kernel estimation with "psmatch2" command. The covariates that have been excluded from the estimation of the propensity scores are average productivity of the firm (2001-2007), percentage of white/blue/unskilled blue collars, and total number of workers. Standard errors in parentheses, ***p<0.01, **p<0.05, *p<0.1.*

In general, it appears that the ATET estimates presented in table VIII are slightly sensitive to the matching algorithm used and the set of covariates included when estimating the propensity scores. This confirms that the critiques of scholars such as Angrist and Pischke (2008) and Smith and Todd (2005) against the low standardization of a PSM process, are indeed well-founded. Thus, when implementing propensity matching, it is important to clearly express and justify the reasoning behind the decisions taken. For this thesis, I find that the kernel matching algorithm is the most appropriate to use given the uneven distribution of the propensity scores and the trade-offs between variance and bias as mentioned in chapter 4. Lastly, when excluding the covariates with potential endogeneity issues, I find a significant confirmation of the second hypothesis outlined in the research.

7. Conclusion

The last three decades have been shaped by heterogeneous shocks, such as the ICT revolution and the opening up of emerging economies, that have fundamentally changed the nature of globalization by allowing firms to slice up their production processes. This in turn has had important implications on the ability of firms to retain competitiveness in the international market and made innovation a vital determinant for firms' survival. The relationship between internationalization and innovation has been widely studied in the literature and the general consensus is that the former positively affects the latter, even though the direction of causality is not as clear. However, a relatively recent strand of literature puts the focus on the lost links within the production process that may hamper the capacity of the firm to implement innovations, as the process becomes harder to manage and the overall perspective on production is lost.

The starting point of this paper is precisely this latter literature and the stylized fact that firms are increasingly offshoring their R&D activities to locations that host already their production stages. If this is indeed the case and internationalization lowers investments on innovation, how can one explain the positive relationship between the two variables found by previous scholars? I argue that the reason previous literature has failed to find a hampering effect of internationalization is because it looks at a different margin; the extensive margin. The main contribution of this research is the analysis on the intensive margin of internationalization, so the question is not whether the firm was active abroad or not, but rather at what *intensity* the firm was active abroad. My research question concerns whether high intensity of internationalization was detrimental, or not, for the innovation capabilities of manufacturing firms in Europe in 2008.

The ways a firm can be active abroad are numerous and the most studied one is exporting. Fortunately, the Efige database used for this research allows me to go beyond the usual dichotomy exporters versus non-exporters and to study other modes of internationalization; as outsourcing, offshoring and importing intermediate products. Moreover, the database also enables me to look at innovation from different perspectives. In particular, I consider whether the firm implemented product or process innovation, R&D investments or patent applications. The method outlined is based on the framework of potential outcomes and propensity score matching. More specifically, I construct four different binary treatment effects to look at the intensive margin and five different outcome variables to look at the intensities of innovation as well. One benefit of this methodology is that it solves the issue of selection bias, as treated and non-treated firms have different potential outcomes and cannot be compared. Furthermore, PSM takes care of the biases that may arise due to heterogeneous shocks, such as the financial crisis of 2008, so that no control variable is needed. Although the method is criticized in the literature due to its low level of standardization and high sensitivity to changes in the matching algorithm or in covariates included for the matching, it is also true that PSM is a remedy to the lack of treatment randomization.

Concerns that internationalization may hurt innovation because of the breakage of the links between production and process development are not entirely supported by the empirical evidence of the paper. The findings do not confirm the first hypothesis that higher intensities of internationalization decrease the probability of implementing innovative activities and only partially validate the second hypothesis. In particular, a high-level intensity of internationalization has a lower probability of implementing intensive innovation relative to a medium intensity level of internationalization. According to the empirical investigation, the optimal number of internationalization modes, i.e. the one that increases the chances of intensive innovations, was two rather than three.

One limitation of the model is that it does not allow me to unpack the effect of internationalization, meaning that I am not able to look at which one out of the three strategies considered is more beneficial for innovation. To partially solve this issue, I replace the treatments with the three internationalization modes and conduct the

PSM method once again. I find that importing intermediate inputs was more likely to spur innovation activities but offshoring was better for intensive innovation. This third finding is however incomplete as it considers the extensive margin, e.g. whether the firm has offshored or not part of the production. To look at the intensive margin, a different model, ideally a PSM with a continuous treatment, has to be constructed.

Overall, the findings of the thesis suggest that intensive internationalization practices *may* have had negative implications on the ability of firms to implement intensive innovation, but the positive effects of trade are confirmed. Therefore, policies taken by national governments to promote trade may indirectly have a positive impact on innovation, affecting in turn the economic prosperity of the country. Thus, this research gives not only a methodological contribution by looking at the intensive margin of internationalization, but it also provides a twofold evidence. On the one hand, it confirms the literature and the benefits of trade on innovation. On the other hand, it hints at a possible diminishing return of intensive internationalization to intensive innovation. However, further research on the effects of intensive internationalization is needed to ensure more accurate and more complete estimates. In the remainder of the thesis, I thus suggest four ways in which this analysis can be improved and extended in order to give more precise and extensive results.

Firstly, the methodology used can be improved by looking at more than one year. Unfortunately, the Efige database does not allow me to do so, as the survey was conducted only for the year of 2008. Holding a panel data rather than a cross-sectional database could sharply improve the quality of the estimates and ensure the absence of reverse causality biases, for instance by implementing lag values of the variables. Furthermore, taking a long-term perspective would also accentuate the trends of the relationship over time and give a sense of whether my findings are still valid today, thus increasing the external validity of the research and reveal a stronger and clearer diminishing effect of internationalization on innovation.

Secondly, as I mentioned above, the intensity model I constructed does not allow me to look at which strategy of internationalization is better for innovation. In the paper I try to remedy for it by constructing three other treatment variables representing the three modes of internationalization. However, in this way I lose the effect of the intensive margin, as I consider whether the firm has e.g. offshored or not. The treatment effect at the intensive margin can be retrieved by conducting PSM with continuous treatment variables. Such approach is more complicated to use but it would indeed unpack the effect of internationalization.

Thirdly, one way to extend this research further would be to look at the implications of location choices, that is if offshoring and outsourcing intensities have different impacts on innovation when firms implement it in a tech savvy country compared to a tech underdeveloped country. Unfortunately, the intensity model I constructed does not allow me to do so, as it would require different treatments and a different PSM approach. For instance, one should consider as treatment variable that takes value of 1 if the firm offshored to a high-income and technologically advanced country and 0 otherwise. I believe that such findings would provide key information on the probabilities of firms' survival, which are useful for trade promoting policy decisions.

Lastly, a different way to extend this research would be to look at the ability of the firms to implement *green* innovations. The polluting effects of the production processes and their negative impact on the environment are widely known and the shift towards more environmental-friendly technologies, materials and products is becoming ever more vital, especially given the climate-neutrality target set by the United Nations by 2050. In this light, looking at whether participation in GVCs is jeopardizing or boosting the switch of firms towards a greener production process has not only important policy implications but also a strong contributive power to the betterment of our future and the Earth System.

APPENDIX

Table A-1. Two-sample t-test with Equal Variances (*p-values*)

	Offshoring	Outsourcing	Importing
Firmsize1 [10, 19]	0	0	0
Firmsize2 [20, 49]	0	0.01	0
Firmsize3 [50, 249]	0	0	0
Firmsize4 [250+]	0	0	0
Proprietorship	0.05	0.078	0
Partnership	0	0.52	0
LL Company	0	0.01	0
Group	0	0	0
Workers	0	0	0
Country	0	0	0.03
Sector	0	0.17	0.04
White collar (%)	0	0	0
Blue collar (%)	0	0	0
Unsk. Blue collar (%)	0	0	0
Avg. product. growth (2001-2007)	0.45	0.4	0.02

Source: Efige database

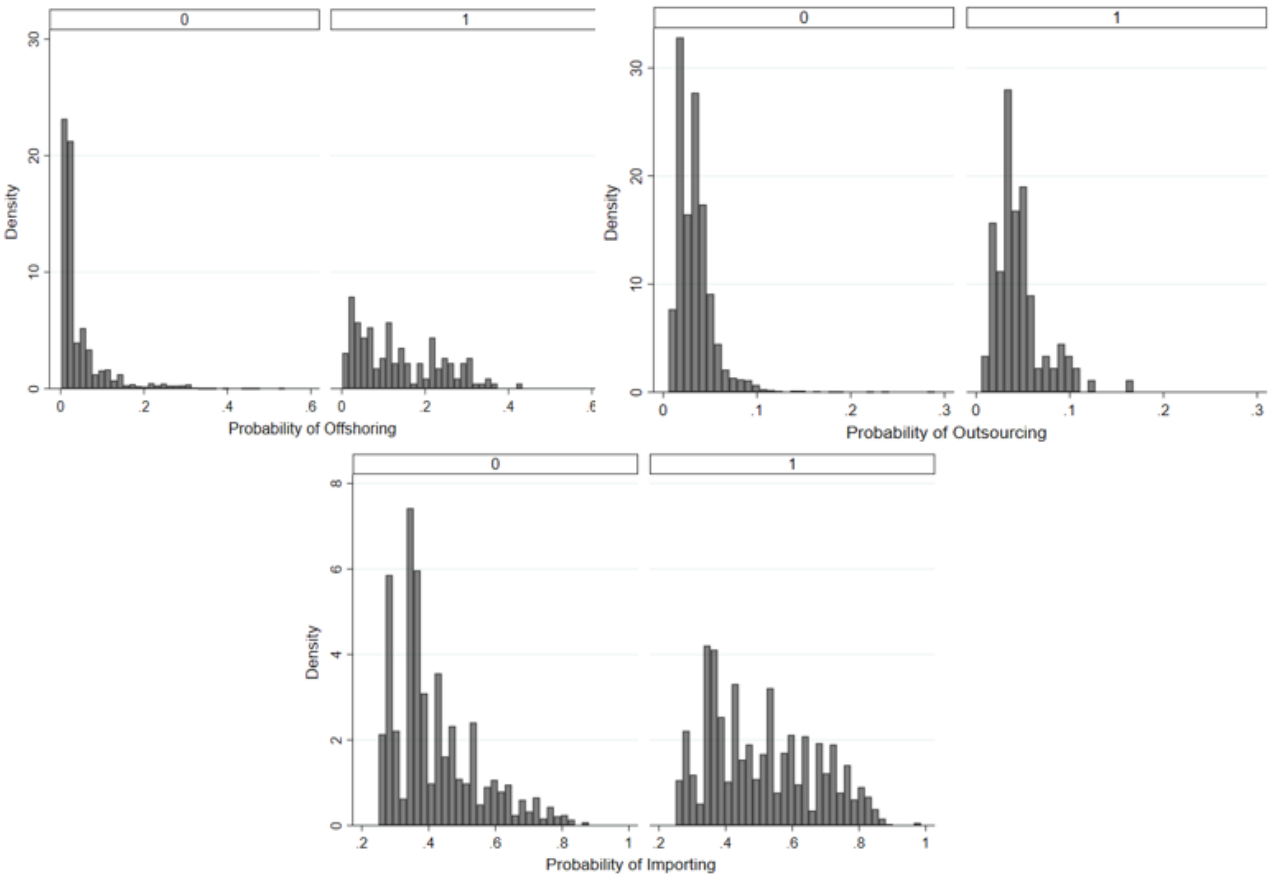

Figure A- 1. Propensity Score Densities Distributions in Treated and Control Groups (*before matching*)

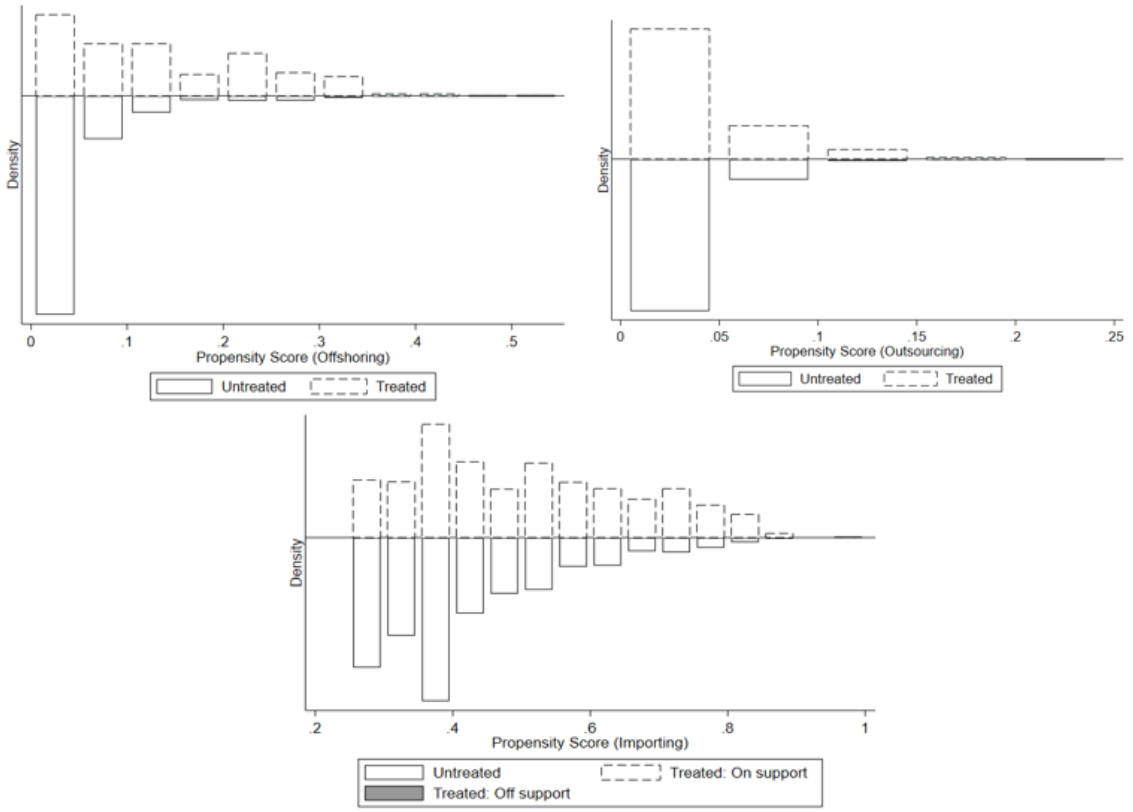

Figure A-2. Overlapping (*after matching*)

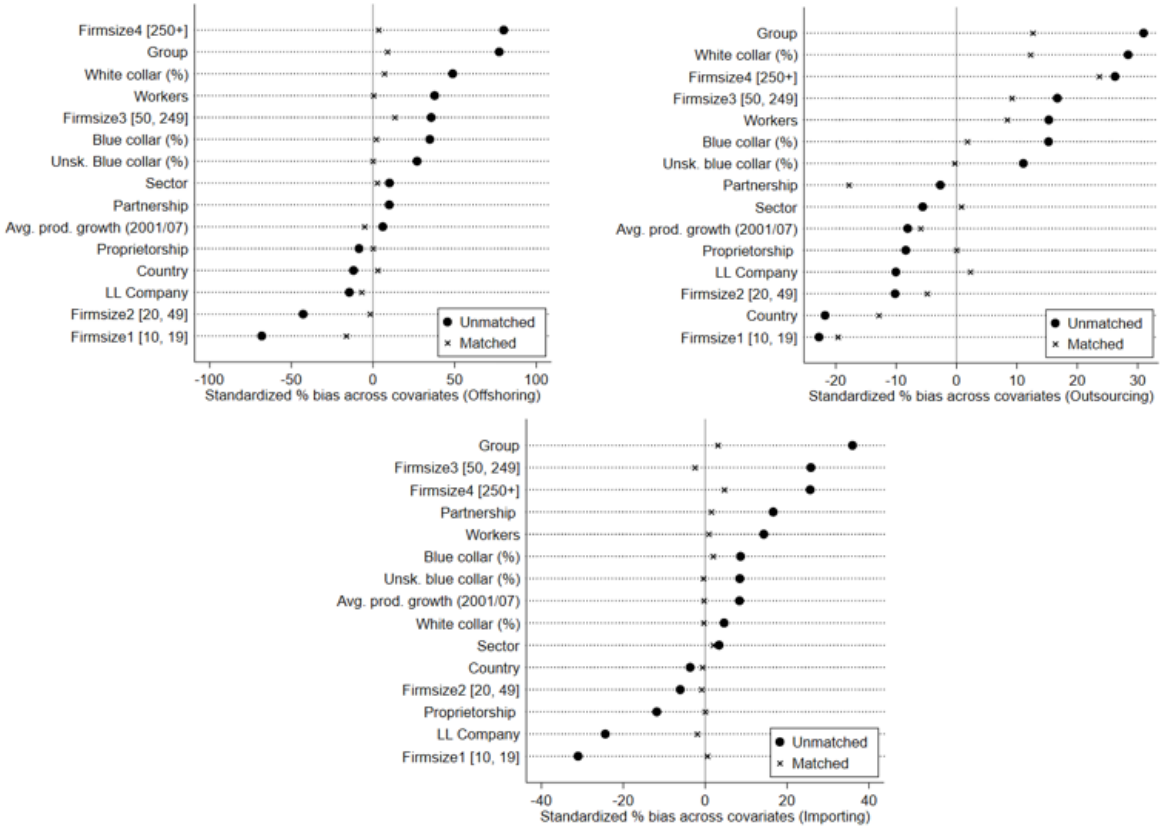

Figure A-3. Balancing of Covariates

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