R&D SUBSIDIES AND FIRM-LEVEL EXPORTS: EVIDENCE FROM FRANCE

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Preliminary version PLEASE DO NOT DIFFUSE

Abstract

This paper investigates an empirical model to provide a new insight into the relationship between public subsidies and exports. The analysis evaluates the export activity of French firms involved in a European program called Eureka. This program provides public R&D subsidies for the formation of research joint ventures. The findings suggest that the Eureka firms register on average gains in exports towards the end of the four-year subsidy period. Interestingly, initial productivity and targeted innovation seem to matter. More precisely, the findings report that the effect tends to be larger for less productive firms and firms targeting product innovation. To control for the potential endogeneity associated with this evaluation, we apply non-parametric matching. We control also for the export history of the firms.

Keywords: R&D subsidies, research joint ventures, exports, proximity-to-the-frontier, product innovation and process innovation.

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1 Introduction

Most politicians consider that exporting can sustain the GDP growth of a country. They also consider good firms the firms competing on foreign markets. Trade economists extensively document to which extent exporters differ from non-exporters. It have been shown that the former firms register, among others, more employees, higher wages and higher productivity.[1] Due to their production efficiency, they can also face more easily the entry barriers on foreign markets, i.e. they can more easily encounter the sunk costs associated with export activity. This contributes to motivate governments to design policies promoting exports.[2]

In this paper, we investigate empirically the role that government intervention can play in encouraging firms to sell more abroad, issue attracting more attention due to the current bad economic outlook. Specifically, we focus on research and development (R&D) subsidies that target productivity gains through two channels: an increase in sales for product innovation and a new cost-reducing technology for process innovation. The subsidies for product innovation are linked to the firm demand-side, i.e. to the preferences of the consumers. This kind of subsidies may indirectly contribute to enlarge the variety of goods, to improve quality and to increase the sales of the firm. On the other hand, the subsidies for process innovation are linked to the firm supply-side, i.e. to the firm cost function. They may indirectly speed up the adoption of a new cost-reducing technology and lower prices.

The study is related to the papers of Bernard and Jensen (2004), Görg *et al.* (2008) and Girma *et al.* (2009). To our knowledge, they are to date the three studies that assess the role of public intervention on exports. First, Bernard and Jensen (2004) investigate among others the role of public export promotion expenditures in the U.S. manufacturing sector. These expenditures aim to reduce informational frictions by providing information on the foreign markets. They find little evidence that export promoting expenditures cause export to increase. On the other hand, they report that only a fraction of firms that were successful in the past can perform well on the export market. Görg *et al.* (2008) argue that the export promotion expenditures might not affect exports since they can hide difference across firms in the ability to produce and export. In particular, this can happen if the targeted firms are not efficient enough to export. Consequently, Görg *et al.* (2008) consider the productivity enhancing subsidies instead of the

[1]See for instance Roberts and Tybout (1997) and Bernard and Jensen (1999).

[2]Belgium, the U.K. and the U.S. for instance implement such public intervention.

public export promotion expenditures. They focus on the subsidies designed mostly to spur the investment in R&D, training and physical capital of Irish manufacturers. Their findings point out that large subsidies can have a positive effect on exports through the intensive margin. It means that large subsidies appear to encourage the exports of the old exporters, i.e. the firms that previously operated on the foreign markets. The findings provide little evidence on the extensive margin of exports. In other words, the subsidies do not seem to encourage the non-exporters to start selling abroad. Next, Girma *et al.* (2009) examine the role of Chinese productivity enhancing subsidies on exports. They document similar results as in Görg *et al.* (2008). Additionally, the findings indicate that the effect of such subsidies tends to be larger for the firms with positive profits, firms within capital intensive sectors and these located in non-coastal areas that have higher trade costs than the firms located by the sea. Therefore, the papers on public intervention and exports provide evidence on the intensive margin rather than on the extensive margin as predicted by Melitz (2003).[3] However, little investigation has been conducted to explain through which channels this outcome on the intensive margin emerges.

The paper contributes in closing the literature gap by deepening the understanding of mechanisms behind the relationship between public intervention and exports. More specifically, our interest is in focusing on R&D subsidies, public support targeting productivity gains. Our interest is also in assessing the differential subsidy effect on more productive and less productive firms as well as on product and process innovation. Specifically, we examine firstly the potential impact of R&D subsidies on exports. Secondly, we test whether this impact varies across more productive and less productive firms as well as across the kind of targeted innovation.

To conduct the empirical analysis, we use an unique dataset of French firms that includes the subsidy status, exports, productivity and targeted innovation and covers 11 years of data (1998-2008). The subsidized firms are these involved in a European program of public R&D subsidies called Eureka. The program, launched in 1985, aims at the formation of research joint ventures (RJVs) of firms and research institutes.[4] A particular feature of Eureka is that the RVJ has to comprise at least two countries. This specific Eureka rule may stimulate the exports of subsidized firms as a successful RJV drives an innovation fitting several markets at once. The international

[3] According to this theoretical approach, it could be expected that productivity enhancing subsidies reduces the sunk cost of exporting and then encourage the non-exporters to enter into exporting.

[4] A research institute is an university or a private research centre.

pattern of the program makes Eureka a suitable framework for our study.

The findings suggest that the R&D subsidies produce average gains in export and in domestic sale of 7.4% and 2.2%, respectively. These outcomes emerge towards the end of a four-year subsidized period. Interestingly, less productive firms and firms targeting product innovation appear to experience larger gains than more productive firms and firms targeting process innovation.

Potential endogeneity issue is inherent to the empirical evaluation of the role of R&D subsidies on exports. It comes from the fact that innovation might be correlated with exports. First, it is possible that an anticipation effect emerges. A firm may bring forward innovation activity because it anticipates an entry into the export market or it anticipates to sell more abroad.[5] Second, the evaluation can suffer from causality issue linked to the persistence in the export activities. For instance, Aw *et al.* (2007) provide evidence that the exporting firms in Taiwan continue to export regardless of their expenditures related to R&D or to worker training. This finding underlines the need to account for the past exporting activity. Lastly, the evaluation can also suffer from simultaneity issue as the inputs required to innovate and to export can be correlated (See for instance Hughes (1986); and Van Beveren and Vandenbussche (2010)).

To correct for potential endogeneity, we apply non-parametric matching technique. Specifically, we perform Kernel propensity score matching that produces control firms similar to the subsidized firms before the subsidies. This technique is selected among others in order to take advantage of the large number of potential control firms in the dataset. In a first step, we reduce the panel into pre-subsidy and post-subsidy periods. Next, we perform Kernel matching to study the gap in exports between the Eureka firms and the control firms on the post-subsidy period.

Kernel matching is likely to provide accurate estimates because it accounts for the anticipation effect as well as simultaneity. In particular, the potential bias linked to the anticipation effect shrinks since the subsidized firms and the control firms have the same characteristics before the subsidies. Moreover, the potential simultaneity bias reduces as the control firms are selected on the pre-subsidy period and the Kernel outcome is computed on the post-subsidy period. Five years lay between the pre- and the post-subsidy periods. The large gap between the two periods also contributes to reduce potential simultaneity. Finally, Kernel matching controls for the export history. The subsidized firms and the matched firms have the same

[5]See for instance Damijan *et al.*, 2010.

past activities, i.e. they have the same export share during the pre-subsidy period.

The remainder of the paper proceeds as follows. The next section surveys existing literature on public intervention, innovation and exports. Section 3 presents the Eureka subsidy program. Sections 4 describes the data and the empirical strategy. In Section 5, we present the results. Finally, we conclude and present the implications of the analysis for policy makers and future research.

2 Related literature

Trade research provides evidence that more productive firms self-select into the export market. In particular, the theoretical Melitz model (2003) documents that only more productive firms encounter the sunk cost associated with exporting. This model assumes exogenous productivity since it comes from a random draw. More recently, trade theoretical models endogenize firm productivity by introducing innovation.[6] More precisely, it is assumed that innovation acts as a driver of productivity jumps.

Empirical models also investigate the role of endogenous innovation on exports using various datasets and methodologies.[7] Specifically, Ebling and Janz (1999) employ a two-step probit and simultaneous probit techniques on the 1997 Manheim innovation panel on services. Lachenmaier and Wöbmann (2006) apply instrumental variables (IV) approach on the 2002 IFO innovation survey concerning manufacturing firms. Becker and Egger (2009) utilize the IFO innovation survey as well as the German Business survey (1994 - 2004) and perform matching. Damijan *et al.* (2010) apply also matching on Slovenian Community innovation survey (CIS) and accounting data (1996 - 2002). Caldera (2010) and Cassiman *et al.* (2010) use GMM estimates and

[6] See Yeaple (2005), Aw *et al.* (2008), Atkeson and Burstein (2010) and Bustos (2011). This literature can be related to the macro models of Romer (1990) and Grossman and Helpman (1991).

[7] Innovation empirical literature provides evidence on the relationship between innovation (R&D inputs and outputs) and exports (See Cassiman and Martinez-Ros (2007) for a literature review). The results on R&D expenditures are mixed if innovation is considered exogenous. When it is considered endogenous, the findings indicate mainly that R&D expenditures cause exports to increase. The papers on R&D outputs treating innovation either as exogenous or endogenous mainly report that product innovation as well as process innovation can affect exports. More interestingly, product innovation seem to induce larger increase in exports than process innovation. Here, we do not review the papers on patents. Since a part of the firm innovation is not patentable, this measure of innovation output is likely to underestimate the R&D impact on exports.

transition probabilities respectively on the same Spanish dataset.[8] Van Beveren and Vandenbussche (2010) apply IV techniques on Belgian CIS data and accounting data (2000 - 2004) to control for the potential endogeneity of innovation. They control also for causality and simultaneity biases.

The main features from the empirical literature on the link between endogenous innovation and exports is that innovation can foster exports and product innovation is more likely to produce an export premium than process innovation. These features are consistent across the papers. In particular, Ebling and Janz (1999) point out that R&D expenditures increase the likelihood of exporting in the German services. On the other hand, little evidence is found on an effect of exports on innovation. Lachenmaier and Wöbmann (2006) report similar results in studying the role of German R&D expenditures on the intensive margin of exports.

Becker and Egger (2009) and Damijan *et al.* (2010) both employ matching to control for potential endogeneity. Becker and Egger (2010) compare the exports of four types of firms: (1) the firms that registered neither product innovation nor process innovation, (2) the firms that only registered product innovation, (3) the firms that only registered process innovation and (4) the firms that registered product and process innovation. The results show a positive effect of innovation on the extensive margin of exports. In addition, product innovation appears to influence more the propensity of firms to export than process innovation. Damijan *et al.* (2010) focus on the Slovenian firms that start exporting. The old exporters are excluded in order to address the causality issue. The results provide little evidence on an effect of product innovation or process innovation on Slovenian exports. However, the results report that exports induce productivity premium. The results report also that exports drive innovation. Exports seem to have a positive effect on the likelihood of starting to register process innovation.

Caldera (2010) and Cassiman *et al.* (2010) use Spanish data on starters as well as on old exporters. Caldera (2010) provides evidence that the firms that introduced product innovation have higher probability to be exporters relative to the ones that introduced process innovation. Cassiman *et al.* (2010) report similar findings. They show that product innovation creates productivity gains and it encourages small firms to start exporting. Furthermore, product innovation appears to prevent exporters stopping to operate on the foreign markets.

The empirical strategy of Van Beveren and Vandenbussche (2010) care-

[8] Caldera (2010) and Cassiman *et al.* (2010) use the ESEE survey running from 1990 to 2002 and from 1990 to 1998, respectively.

fully considers the estimation issues related to the anticipation effect, the causality bias as well as the simultaneity bias. The results show that firms self-select into product and process innovation prior to start exporting. Specifically, it is more the combination of process and product innovation than each type of innovation in isolation that seems to play a role on the extensive margin of exports.

Lately, Lileeva and Trefler (2010) and Aw *et al.* (2011) point out that exports and innovation are complementary. They also point out that combined with each other, exports and innovation induce gains in productivity. Furthermore, Aw *et al.* (2011) document that the sunk and fixed cost of innovation are larger than these of exporting. As a consequence, a larger share of firms decides to perform on the export market than to conduct R&D.[9]

Although various papers examine the role of endogenous innovation on exports, the channel of public intervention has been little studied. To our knowledge the three papers that investigate the role of innovation on exports are the studies of Bernard and Jensen (2004), Görg *et al.* (2008) and Girma *et al.* (2009). Firstly, Bernard and Jensen (2004) assess among others to which extend the export promotion expenditures of U.S. states encourage the exports in the manufacturing industries. Such expenditures aim to reduce trade informational frictions in providing information on the foreign markets. Performing a binary-choice non-structural approach, Bernard and Jensen (2004) find non-significant impact of export promotion expenditures. Hence, Görg *et al.* (2008) consider the subsidies likely to create productivity gains instead of public export promotion expenditures. Such subsidies are designed mostly to increase R&D expenditures, training and physical capital in the Irish manufacturing industries. The choice of the productivity enhancing subsidies is motivated by the fact that the export promotion expenditures can hide heterogeneity in the ability of the firms to produce and export. Such expenditures can then hide firm heterogeneity in productivity. Specifically, it might be that the expenditures do not affect exports because the targeted firms are not productive enough to enter into foreign markets. Applying a non-parametric matching approach on Irish manufacturing firms, Görg *et al.* (2008) show that large subsidies can increase exports through the intensive

[9] Lileeva and Trefler (2010) use IV estimates on Canadian data (1984 - 1996). On the other hand, Aw *et al.* (2011) apply a two-stage approach on Taiwanese data (2000 and 2001-2004) to test their theoretical model. More precisely, in a first stage firm productivity is computed from the estimated parameters of the domestic revenue function and the endogenous productivity evolution. In a second stage, the fixed and sunk costs of exports and R&D are calculated from the dynamic discrete choice estimates of exporting and R&D.

margin. None significant impact is found on the extensive margin. Lastly, Girma *et al.* (2009) examine the role of Chinese productivity enhancing subsidies on exports. Performing IV Tobit model, they report similar results. Additionally, they report that the effect of subsidies is larger for the firms with positive profits, firms within capital intensive sectors and firms located in non-coastal areas that have higher trade costs than the firms located by the sea. This suggests that there is a differential effect of subsidies depending on firm characteristics - issue we examine further in this empirical paper.

3 Eureka, a R&D subsidies program for research joint ventures

The description presented in this section is the only information we were provided with on the Eureka program designed as a tool of European innovation policy. The program was launched in 1985 to promote RJVs for commercial innovation. From 1985 to 2004 there were 8,520 participants from 36 countries forming 1,716 RJVs. Among these participants, 4,698 were European firms, 1,937 were European research institutes. The rest are participants from outside the EU-15 member countries. A Eureka RJV can run between one and eight years. On average, it runs for three and a half years, costs 30,000 Euros a month per partner and comprises five partners, of which three are firms.

Eureka aims to promote the formation of cross-borders RJVs through private and public support. In particular, Eureka promotes RJVs across Europe since it is required that each Eureka RJV draws partners from at least two different countries. Furthermore, the R&D subsidies provided by the national governments, are in the form of interest-free loans or public support.[10] Following the European community treaty, the public support for such cross-border pre-competitive R&D does not exceed 50% of the RJV total expenditures.[11]

The selection of Eureka partners is based on the quality of the research proposal and the well performing firms are more likely to be targeted. In addition, the program supports mainly manufacturing but research in agribusiness and services are also funded as shown in table 1.[12]

[10] The loans need not be repaid if an RJV fails, excepting these from France.

[11] See the European community treaty on the community framework for state aid for R&D and innovation.

[12] Table 1 indicates that Eureka in France covers the half of the 62 NACE two-digit industries. NACE is a classification of economic activities in Europe. The NACE classifi-

[Table 1 about here]

4 Data and empirical strategy

4.1 Data

The database is the merger of the Eureka database and Amadeus. The former database surveys the name, the identification code and the RJV characteristics of the French Eureka firms.[13] Amadeus is a pan-European database (1997-2009)[14] that surveys annual accounts of EU public and private firms.

France provides a suitable framework for assessing the effect of the Eureka subsidies on exports, as the country is one of the main participant to the Eureka program[15] and detailed firm-level information is available. For this country, Amadeus surveys the annual accounts of one million of firms and includes key variables such as employment, export revenue,[16] physical capital and value added. A particular feature concerning the Eureka firms of the sample is that they almost all export during the pre-subsidy period. Therefore, the study investigates mainly the effect of subsidies on export revenue through the intensive margin.[17]

The resulting database registers 207 Eureka firms starting to be subsidized between 1998 and 2003.[18] Value added is deflated by the price index of EU Klems. The physical capital is deflated by the price index of the gross formation of fixed capital from INSEE. The GDP of the French NUTS three regions comes from Eurostat.[19]

cation is available from the EUROSTAT website: http://ec.europa.eu/eurostat/ramon.

[13] The name and the identification code of the Eureka firms were provided by the Eureka secretariat in Brussels. The RJV characteristics are for instance cost, duration, the number of partners and the goal of the research. This information is available on the Eureka website: www.eurekanetwork.org.

[14] To get this time-span (1997-2009), we match Amadeus covering 1997 to 2006 with Amadeus covering 2001 to 2009.

[15] France and Germany are the Eureka main participants.

[16] The export revenue is defined as the quantity exported times the unit price.

[17] Nine Eureka firms do not export before the subsidies, of which five do not export neither after the subsidies.

[18] We use the identification code called SIREN code to merge the two databases. Employment, physical capital and value added are available for 169 Eureka firms on the period $1998-2006$. The matching between Amadeus covering 1997 to 2006 and Amadeus covering 2001 to 2009 reduces the number of Eureka firms. Employment, physical capital and value added are available for 77 Eureka firms on the period $1998-2009$.

[19] France consists of 94 continental NUTS three regions. The Nomenclature of Territorial Units for Statistics (NUTS) in Europe is available on the EUROSTAT website: http://ec.europa.eu/eurostat/ramon/nuts.

Particular geographic and industrial patterns of Eureka come out from the French data. Specifically, firms located in some high-density and backward areas appear to have higher likelihood to be subsidized.[20] The concentration of subsidized firms in backward suggests that the French R&D subsidy policy aims at improving the competitiveness of regions with low density. Firms operating in some specific industries seems also to have a higher probability (table 1). This can be explained by the French industrial policy.

These industrial and geographical patterns motivate our choice to build the control group from firms in close NACE four-digit industries located in the same NUTS three regions as the Eureka firms. Firms in close NACE four-digit industries are firms in the Eureka NACE two-digit industries but the firms in the Eureka NACE four-digit industries. These latter firms were excluded so as not to capture R&D spillovers which might benefit firms selling similar goods or services as the Eureka firms.

In addition, concerning the geographical pattern, the location of subsidized firms seems to be weakly correlated. This is shown in table 2 on concentration indexes. The index in column 1 is the $\hat{\gamma}_{MS}$ firm-based index proposed by Maurel and Sedillot (1999). The index in column 2 is the $\hat{\gamma}_{EG}$ employment-based index by Ellison and Glaeser (1997). Specifically, table 2 reports that the location of any two Eureka firms are positively correlated. Tests on the variance of the concentration indexes show a 95% confidence level (Maurel & Sedillot, 1999). However given the magnitude of the indexes, the correlation is weak. Furthermore, the difference between the estimators is large. The $\hat{\gamma}_{MS}$ firm-based estimator is four times greater than the $\hat{\gamma}_{EG}$ employment-based estimator. Such facts show that the French Eureka firms are heterogeneous in terms of employment (Lafourcade & Mion, 2007).

[Table 2 about here]

We turn next to the summary statistics on the pre-subsidy period (1998−2000) in table 3.[21] Columns 1 and 2 show that the Eureka firms are not representative of the average firms. They are larger firms in terms of employment and sales relative to the other French firms in close NACE four-digit industries located in the same regions. The subsidized firms also are more productive.

[Table 3 about here]

[20] See the map in appendix.

[21] As we will explain more in details in the next section, the interest for a pre-subsidy and post-subsidy periods comes from our matching approach.

In addition, column 2 shows that 48% of the subsidized firms targeting product innovation and 51% are in RJVs gathering more than two countries. Column 4 reports that less productive subsidized firms[22] are larger firms relative to more productive firms. They are also less likely to target product innovation (43%).

4.2 Empirical methodology

4.2.1 Kernel Matching

We apply non-parametric kernel matching[23] to investigate the causal relationship between R&D subsidies and exports. Kernel aims to correct endogeneity as it provides a key missing control group. This control group brings information on the behaviour of the Eureka firms if the they had not been subsidized. Furthermore, the technique is selected among others to take advantage of the large number of potential control firms available.

In a first step, we reduce the panel data into pre-subsidy period ($1998-2000$) and post-subsidy period ($2006-2008$).[24] The observation of one variable on the pre-subsidy period is the mean of the observations in 1998, 1999 and 2000. Similarly, the observation of one variable on the post-subsidy period is the mean of the observations in 2006, 2007 and 2008. Next, we perform Kernel matching to study the gap in exports between the Eureka firms and the control firms on the post-subsidy period. The pre-subsidy period and the post-subsidy period are then the two periods of interest. The period between 2001 and 2005 where firms conduct research is neglected since it is less likely that R&D subsidies affect output during this period.[25]

In the second step, we run a logit model on the firm characteristics that drive the allocation of the subsidies. The model in table 4 is performed on the pre-subsidy period. We control for the department and industry fixed effects to reduce the bias related to the geographical and industrial patterns of the Eureka program in France.

The binary outcome of the dependent variable is 1 if the firm gets the Eureka subsidies afterwards and 0 otherwise. The covariates are the annual

[22] We discuss how less productive and more productive firms are defined more in detail in the following subsection.

[23] We use a Gaussian kernel function.

[24] Collapsing the panel data into pre- and post-subsidy periods contributes to correct for potential autocorrelation (Bertrand *et al.* (2004)).

[25] The firms subsidized in 1998 and 1999 are considered in our core study. We do so because we do not expect R&D subsidies to affect the exports of these firms during the subsidized period that lasts on average three and a half years.

accounts' variables that are likely to bring proper information about firm performance as the selection of the Eureka firm relies on. In particular, the firm characteristics are age, size in terms of employment, total factor productivity (TFP),[26] the growth rate of capital investment, the loans on sales and the export share defined as exports on sales.

The results in table 4 show that size has a positive and significant sign at the five percent level. It suggests that the large firms have a higher likelihood to be subsidized. This can have several meanings. On the one hand, size can be seen as a performance outcome. Large firms are likely to have large R&D expenditures. Then they are more likely to innovate and to submit a good research proposal to Eureka. However, size can also reflect the firm lobbying power. More specifically, large firms can have more bargaining power to get public subsidies. They are hence more likely to be selected.

The results also suggest that that TFP (proxy for the firm technology) and the export share are key firm characteristics to predict the Eureka selection. Both coefficients are positive and significant at the five percent level. Age introduced to account for firm experience, the growth rate of capital investment controlling for the influence of the firm's growth trend on the attribution of subsidies as well as the loans on sales, proxy for credit constraints are not significant.

[Table 4 about here]

In a third step, the firm propensity score, i.e. the estimated probability of being subsidized conditional to the seven firm characteristics in table 4, is derived from the logit estimates. Next, weight is given to each firm in function of its propensity score. This allows to construct the outcome of the artificial control group. Finally, matching compares the outcome of the Eureka firms with the artificial weighted outcome of the control group.

Kernel matching is likely to provide accurate estimates since it address endogeneity issue. The technique accounts for the anticipation effect and simultaneity. Specifically, the potential bias of the anticipation effect reduces because the subsidized firms and the control firms have the same characteristics on the pre-subsidy period. The potential simultaneity bias also lower as the control firms are selected on the pre-subsidy period and the Kernel outcome is computed on the post-subsidy period. The five years laying

[26]We compute TFP following the approach of Levinsohn and Petrin (2003). The semi-parametric approach of Levinsohn and Petrin (2003) corrects the simultaneity bias in the production function estimation linked to input choices (Van Beveren, 2007). We used the value-added TFP version.

between the pre- and the post-subsidy periods also contribute to reduce potential simultaneity. Lastly, Kernel matching controls for the export history. The subsidized firms and the matched firms have the same exports activities during the pre-subsidy period.

We perform several measures to assess the matching quality, i.e. to investigate how well Kernel matching can balance the Eureka firms and the matched firms. The measures in Appendix I suggest that matching performs well. Specifically, the pseudo R^2 of the logit model for the the matched firms is low relative to this on the unmatched firms in table 4. This suggests balancing as there seems to have no difference in explanatory variables between the two sets of firms during the pre-subsidy period. The magnitude of the standardized bias reduction after matching provides additional support for balancing. The measure lies within 0.579 and 0.741. This indicates that matching corrects the average propensity score gap between the subsidized firms and the control firms by 58% to 74%.

4.2.2 More productive and less productive firms

It might be that the impact of R&D subsidies differs across firms in function of their initial productivity. More specifically, it is possible that less productive firms experience a larger export gain since these firms are expected to benefit more from the subsidized RJVs. On the other hand, it might be that the impact of subsidies differs according to targeted innovation as suggested by the literature. This motivates to assess the potential differential effect of R&D subsidies by comparing less productive firms with more productive firms. We also compare firms targeting product innovation with firms targeting process innovation.[27]

To disentangle more productive firms from less productive firms, we build the initial proximity-to-the-frontier-firm index. The index computed on the pre-subsidy period is the TFP of the firm i divided by the TFP of the frontier firm of the NACE four-digit industry j.[28]

$$PROXIMITY_{ij} = \frac{TFP_{ij}}{Max_j TFP_j} \tag{1}$$

[27]The kind of targeted innovation is determined in function of the research description available on the Eureka website. In particular, a RJV is considered targeting a process (product) innovation if the collaborative research is mainly oriented to find a new process (product).

[28]The frontier firm is the firm that registers the highest TFP. TFP_{ij} is the exponential of tfp_{ij} included in the Kernel matching approach.

The normalized index therefore lies within $[0; 1]$. An initial proximity of 1 indicates that the firm i is at the technological frontier of the NACE four-digit industry. The closer to zero the index is, the less efficient the firm is compared to the frontier firm. In this respect, a less (more) productive firm is defined as a firm with an initial proximity-to-the-frontier below (above) 0.37, the median of the proximity index for the Eureka firms. This threshold means that the frontier firm in a Eureka industry is on average three times more efficient than the median subsidized firm.

5 Results from Kernel matching

5.1 Exports and domestic sales

We start with the average results on exports and domestic sales in table 5. We examine next the potential differential effect of R&D subsidies depending on initial proximity-to-the-frontier and targeted innovation (tables 6−8). We report the robustness check in table 9.

The main outcome of interest is the intensive margin of exports.[29] The estimates in column 1 of table 5 indicate a positive average difference in exports after treatment, i.e. the subsidized period, between the subsidized firms and the matched firms. This average difference, also called the average treatment effect on the treated firms (ATT), is significant at the one percent level. This suggests that the R&D subsidies induce export to increase of 7.4%. This corresponds to an average export gain of $687,289$ Euros.

[Table 5 about here]

Turning to the export share, column 2 shows that the subsidized firms become more "export-intensive" than the matched firms. The export share of the former firms appears to be 0.74% higher.[30] The subsidized firms also seem to register 2.2% higher domestic sales (column 3). The positive effect of R&D subsidies on export share and domestic sales is also statistically significant at the one percent level.

The estimates in table 5 suggest that R&D subsidies trigger an increase in exports through the intensive margin. This can be reinforced by the international pattern of Eureka. In particular, it might be expected that the Eureka RJV partners target an innovation fitting several European markets

[29] The impact on the extensive margin cannot be studied since just five subsidized firms of the sample do not export during the data time span $(1998 - 2008)$.

[30] $0.74\% = exp(-3.533) - exp(-3.824)$.

as the RJV must draw partners from at least two countries. The Eureka innovation is then likely to be more "export-oriented" and can provides additional incentives to the subsidized firms to foster the activities on foreign markets.

In order to better understand the channels driving the increase in exports, the following subsection examines the differential effect of R&D subsidies. Specifically, we test whether the impact of R&D subsidies varies across more productive and less productive firms as well as across product and process innovation.

5.2 Differential effect of R&D subsidies

5.2.1 Less productive and more productive firms

We first assess the differential effect of subsidies by performing regressions for less productive and more productive firms (tables 6 and 7). These firms are respectively defined as the firms with an initial proximity-to-the-frontier below and above 0.37, the median proximity of the subsidized firms.[31]

Table 6 on less productive firms shows a positive and significant ATT for exports, export share and domestic sales[32]. We find that less productive firms register 8.5% higher exports, 1.35% higher export share[33] and 1.6% higher domestic sales.

[Table 6 about here]

We find a smaller gain for more productive firms. Table 7 reports that these firms register 6.4% higher exports, 0.5% higher export share[34] and 1% higher domestic sales. Consequently, the estimates in tables 6 and 7 suggest that less productive subsidized firms experience a higher gain in export than more productive fims.

[Table 7 about here]

5.2.2 Product and process innovation

We investigate next the differential effect of subsidies depending on the kind of targeted innovation in table 8. Column 1 on product innovation shows an

[31] Using the mean proximity (0.45) instead of the median produces similar qualitative results.

[32] The ATT is significant at the one percent level across columns.

[33] $1.35\% = exp(-3.152) - exp(-3.531)$.

[34] $0.5\% = exp(-4.130) - exp(-4.538)$.

ATT estimate positive and significant at the one percent level. We find that the R&D subsidies for product innovation can trigger a 11.9% increase of the export intensive margin. Column 2 on process innovation shows similar results but an order of magnitude smaller. We find that the subsidies for process innovation can induce a 2.8% gain in the intensive margin.

[Table 8 about here]

5.2.3 Robustness check

In this section, we test the robustness of the estimates of our Kernel matching. As a first robustness check, we compare radius matching with kernel matching. The first column of table 9 summarizes the results on Kernel matching. Column 2 reports the results on radius matching. These results are qualitatively the same as these driven by Kernel matching for the undifferentiated effect of R&D subsidies and the effect on less productive firms and on product innovation. This provides further confidence to our Kernel model.

5.2.4 Discussion on the differential effect

The results on the differential effect of R&D subsidies document that less productive firms and firms targeting product innovation can experience a larger gain in the intensive margin of exports than more productive firms and firms targeting process innovation. The findings suggest then that the effect may depend on initial productivity as well as on targeted innovation. On the one hand, the effect of the subsidies appear to be stronger for less productive firms. The finding provides support to negative selection as the effect lowers with initial productivity. This is also consistent with Röller *et al.* (2007) and Sissoko (2011) that report a higher profit gain and a higher productivity gain respectively for this kind of firms. Negative selection can emerge because less productive firms self-select by apply for R&D subsidies to encounter high innovation costs. Furthermore, less firms get higher additional incentives to apply to RJVs' program in order to collaborate and share the benefits and the costs of RJV. In so doing, they may also attract R&D spillovers from their partners (Cassiman & Veugelers, 2002).

On the other hand, the effect of subsidies appear to be stronger for product innovation. This suggests that a product innovation is more effective in creating an export premium than new cost-decreasing technology. As the export variable is the firm export revenue, i.e. the quantity sold abroad times the unit price, a price effect and a quantity effect can emerge. Firstly, product innovation taking the form of vertical differentiation may be linked to a price effect. It might be expected that vertical differentiation upgrading the quality of a good raises its unit price. Secondly, product innovation taking the form of horizontal differentiation may be linked to a quantity effect if foreign consumers prefer variety. This differentiation widens the variety of goods produced with the same technology. In the case of preference for variety, the consumers increase the demand of the multi-product firm by buying more differentiated goods.[35] In the study, it might be expected that product innovation combines the two differentiation since France exports mainly into high income countries. It is then likely that vertical differentiation associated with horizontal differentiation[36] creates a larger gain in the export revenue than each kind of differentiation in isolation. The stronger effect for product innovation might be also driven by the import competition from China and other emerging countries. This competition decreasing the sales of old products may give additional incentives to firms to conduct further R&D for new processes and higher quality products. Seen the tougher competition with emerging countries on the domestic and export markets, it is likely that new higher quality products create a stronger effect on firm outcome than new processes.

6 Conclusion

In this empirical paper, we assess the indirect role of public R&D subsidies on exports using an unique dataset of French firms that covers 11 years of data (1998-2008). The dataset comprises the firms involved in a European program of public R&D subsidies called Eureka. These subsidies are for the formation of RJVs. The findings suggest that the subsidized firms experience an average increase in exports towards the end of the four-year subsidy period. Additionally, the findings suggest that initial productivity and kind of targeted innovation matter. Less productive firms seem to experience a larger premium in exports. The premium appears to be also larger for firms targeting product innovation. To control for the potential endogeneity inherent to the analysis, we perform non-parametric Kernel matching and we account for the past export activity of the firms.

[35] This is possible without cannibalization, i.e. the new products of the multi-products firm do not shrink the firm total demand by decreasing the demand for its existing products.

[36] Di Comité *et al.* (2011) present a model combining the effect of horizontal on vertical differentiation.

From a policy prospect, the results have some implications. They suggest that governments can encourage exports by granting subsidies for RJVs mainly to less productive exporters. Specifically, providing R&D subsidies to less productive firms seems to spur them to widen the variety of goods, to upgrade quality as well as to narrow the technology gap in reducing marginal cost. Nevertheless, governments would not neglect more productive firms. Consequently, the design of a proper R&D subsidy policy in Europe can prove to be suitable in many ways. In particular, it can be expected that the gain in exports and the potential quality and technology upgrading support firms to face delocalization and the growing imports from the emerging countries. The extent to which an appropriate subsidy policy can encourage the European firms to be better integrated in the global market and to react to exogenous shocks have been little studied. The paper contributes in deepening the understanding of the channels throughout such a policy can affect international trade. However, this issue deserves to be further investigated.

References

Atkeson, A., & Burstein, A. T. (2010). Innovation, Firm Dynamics, and International Trade. *Journal of Political Economy*, *118*, 433-484.

Aw, B. Y., Roberts, M. J., & Winston, T. (2007). Export Market Participation, Investments in R&D and Worker Training, and the Evolution of Firm Productivity. *The World Economy*, *30*, 83-104.

Aw, B. Y., Roberts, M. J., & Xu, D. Y. (2008). R&D Investments, Exporting, and the Evolution of Firm Productivity. *American Economic Review*, *98*, 451-56.

Aw, B. Y., Roberts, M. J., & Xu, D. Y. (2011). R&D Investment, Exporting, and Productivity Dynamics. *American Economic Review*, *101*, 1312-44.

Becker, S., & Egger, P. (2009). Endogenous Product versus Process Innovation and a Firm's Propensity to Export. *Empirical Economics*, *Advanced online publication 18 November*, doi: 10.1007/s00181-009-0322-6.

Bernard, A. B., & Jensen, B. J. (1999). Exceptional Exporter Performance: Cause, Effect, or Both? *Journal of International Economics*, *47*, 1-25.

Bernard, A. B., & Jensen, J. B. (2004). Why Some Firms Export. *The Review of Economics and Statistics*, *86*, 561-569.

Bertrand, M., Duflo, E., & Mullainathan, S. (2004). How Much Should We

Trust Differences-in-Differences Estimates? *The Quarterly Journal of Economics*, *119*, 249-275.

Bustos, P. (2011). Trade Liberalization, Exports, and Technology Upgrading: Evidence on the Impact of MERCOSUR on Argentinian Firms. *American Economic Review*, *101*, 304-40.

Caldera, A. (2010). Innovation and Exporting: Evidence from Spanish Manufacturing Firms. *Review of World Economics*, *146*, 657-689.

Cassiman, B., Golovko, E., & Martínez-Ros, E. (2010). Innovation, Exports and Productivity. *International Journal of Industrial Organization*, *28*, 372-376.

Cassiman, B., & Martinez-Ros, E. (2007). Product Innovation and Exports: Evidence from Spanish Manufacturing [IESE working paper].

Cassiman, B., & Veugelers, R. (2002). R&D Cooperation and Spillovers: Some Empirical Evidence from Belgium. *American Economic Review*, *92*(4), 1169-1184.

Damijan, J., Kostevc, C., & Polanec, S. (2010). From Innovation to Exporting or Vice Versa? *The World Economy*, *33*, 374-398.

Di Comité, F., Thisse, J.-F., & Vandenbussche, H. (2011). Verti-zontal Differentiation in Monopolistic Competition [Development Working Papers].

Ebling, G., & Janz, N. (1999). Export and Innovation Activities in the German Service Sector: Empirical Evidence at the Firm Level [ZEW Discussion Papers]. (99-53).

Ellison, G., & Glaeser, E. L. (1997). Geographic Concentration in U.S. Manufacturing Industries: a Dartboard Approach. *Journal of Political Economy*, *105*, 889-927.

Girma, S., Gong, Y., Görg, H., & Yu, Z. (2009). Can Production Subsidies Explain China's Export Performance? Evidence from Firm-level Data. *Scandinavian Journal of Economics*, *111*, 863-891.

Görg, H., Henry, M., & Strobl, E. (2008). Grant Support and Exporting Activity. *The Review of Economics and Statistics*, *90*, 168-174.

Grossman, G. M., & Helpman, E. (1991). Quality Ladders in the Theory of Growth. *Review of Economic Studies*, *58*, 43-61.

Hughes, K. (1986). Exports and Innovation. *European Economic Review*, *30*, 383-399.

Lachenmaier, S., & Wöbmann, L. (2006). Does Innovation Cause Exports? Evidence from Exogenous Innovation Impulses and Obstacles Using German Micro Data. *Oxford Economic Papers*, *58*, 317-350.

Lafourcade, M., & Mion, G. (2007). Concentration, Agglomeration and the Size of Plants. *Regional Science and Urban Economics*, *37*, 46-68.

Levinsohn, J., & Petrin, A. (2003). Estimating Production Functions Using Inputs to Control for Unobservables. *Review of Economic Studies*, *70*, 317-341.

Lileeva, A., & Trefler, D. (2010). Improved Access to Foreign Markets Raises Plant-Level Productivity... for Some Plants. *The Quarterly Journal of Economics*, *125*, 1051-1099.

Maurel, F., & Sedillot, B. (1999). A Measure of the Geographic Concentration in French Manufacturing Industries. *Regional Science and Urban Economics*, *29*, 575-604.

Melitz, M. J. (2003). The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity. *Econometrica*, *71*, 1695-1725.

Röller, L.-H., Siebert, R., & Tombak, M. M. (2007). Why Firms Form (or do not Form) RJVS. *Economic Journal*, *117*, 1122-1144.

Roberts, M. J., & Tybout, J. R. (1997). The Decision to Export in Colombia: An Empirical Model of Entry with Sunk Costs. *American Economic Review*, *87*, 545-64.

Romer, P. M. (1990). Endogenous technological change. *Journal of Political Economy*, *98*, 71-102.

Rosenbaum, P. R., & Rubin, D. B. (1985). Constructing a Control Group Using Multivariate Matched Sampling Methods That Incorporate the Propensity Score. *The American Statistician*, *39*, 33-38.

Sissoko, A. (2011). R&D Subsidies And Firm-Level Productivity: Evidence From France [IRES Discussion Papers].

Van Beveren, I. (2007). Total Factor Productivity Estimation: A Practical Review [LICOS Discussion Papers]. (18207).

Van Beveren, I., & Vandenbussche, H. (2010). Product and Process Innovation and Firms' Decision to Export. *Journal of Policy Reform*, *13*, 3-24.

Yeaple, S. R. (2005). A Simple Model of Firm Heterogeneity, International Trade, and Wages. *Journal of International Economics*, *65*, 1-20.

Appendix I - Eureka spatial concentration

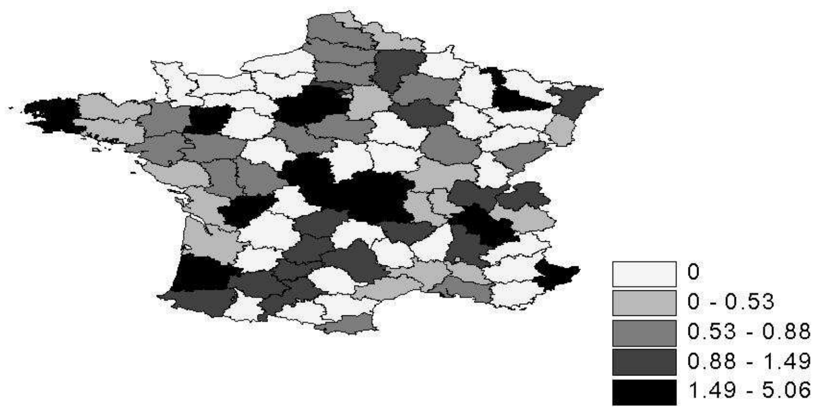
Map and location quotients:

To study the geographic pattern of Eureka, we compute location quotients for the French Eureka NUTS three regions. The location quotient $Q_{e,l}$ is defined as follow:

$$Q_{e,l} = \frac{n_{e,l}/n_e}{n_l/N}$$

where $n_{e,l}$ is the number of Eureka firms located in department l; n_e is the total number of Eureka firms in France; n_l is the number of firms in department l; and N is the total number of French firms.

Figure 1: Concentration of Eureka firms in 2006



The map shows that the Eureka firms are concentrated in heterogeneous NUTS three regions in terms of economic activity.[37] Eureka firms are located

[37] For the regional density, we use the regional GDP per capita, which is available on the Eurostat website:
http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home.

in high-density areas (Ile-de-France and Alpes-Maritimes) and in backward areas (mainly in Indre, Puy-de-Dôme and Landes).[38] This suggests that the location of the Eureka firms and then their selection are not random.[39]

Assessing Matching quality

In order to investigate how well Kernel matching can balance the Eureka firms and the matched firms, we compute the pseudo R^2 after matching and the standardized bias reduction. Specifically, table A first reports in columns 1 and 2 the pseudo R^2 of the logit model on the unmatched firms (before matching) and this on the matched firms (after matching). The latter pseudo R^2 is low relative to the former one for all specifications. This suggests balancing since there seems to have no difference in explanatory variables between the subsidized firms and the matched firms. Second, column 3 shows the standardized bias reduction proposed by Rosenbaum and Rubin (1985). The measure captures the difference in propensity score between the subsidized firms and the (un)matched group. More precisely, the standardized bias SB before matching is defined as:

$$SB_{before \text{ matching}} = \frac{(\bar{P}_1 - \bar{P}_0)}{\sqrt{0.5(V_1(P) - V_0(P))}}$$

where $\bar{P}_1$ is the mean propensity score of the subsidized firms, $\bar{P}_0$ is the mean propensity score of the unmatched firms. $V_1(P)$ and $V_0(P)$ are the respective variances.

The SB after matching is defined as:

$$SB_{after \text{ matching}} = \frac{(\bar{P}_1 - \bar{P}_0)}{\sqrt{0.5(V_1(P) - V_0(P))}}$$

where $\bar{P}_0$ and $V_0(P)$ is the mean and the variance of the matched firms' propensity score.

The magnitude of the standardized reduction across specifications provides additional support for balancing. The measure lies within 0.579 and 0.741 meaning that matching corrects the difference between the subsidized firms and the control firms by 58% to 74%.

[38] The Eureka firms are mainly founded in Puy-de-Dôme, Hauts-de-Seine, Yvelines, Charente and Creuse. The location quotient for each of these departments is over 3.

[39] The assumption that the location of Eureka firms is random (as far as the location of firms can be random (see Ellison and Glaeser (1997)) is rejected.

Table A: Kernel matching balancing quality:

Matching	Pseudo R^2 before	Pseudo R^2 after	SB red.	Eur. firms	Match. firms
All firms and targeted innovation	0.441	0.064	0.694	62	10,853
Less productive firms	0.421	0.061	0.741	32	5,700
More productive firms	0.406	0.066	0.704	28	4,047
Product innovation	0.371	0.099	0.579	31	8,305
Process innovation	0.503	0.073	0.691	28	2,319

‡ The Pseudo R^2 before kernel matching is the pseudo R^2 of a logit model performed on the unmatched firms. The Pseudo R^2 after matching is the pseudo R^2 of a logit model performed on the matched firms. The standardised bias (SB) reduction measures the difference in SB before and after matching.

Appendix II - Tables

Table 1: NACE two digit Eureka industries

NACE	industry	Number of firms
01	Agriculture	3
05	Fishing	1
15	Food Products and Beverages	13
17	Textiles	3
18	Wearing Apparel	1
20	Manufacture of Wood	3
21	Manufacture of Paper Products	1
22	Publishing and Printing	2
24	Chemicals	12
25	Rubber and Plastic Products	5
26	Other Non-metallic Mineral Products	1
27	Basic Metals	4
28	Fabricated Metal Products except Machinery and Equipment	7
29	Machinery and Equipment	17
30	Office Machinery and Computers	2
31	Electric Machinery and Apparatus	4
32	Radio, Television and Communication Equipment	14
33	Medical Instruments, Watches and Clocks	18
34	Motor Vehicles, Trailers and Semi-Trailers	3
35	Other Transport Equipment	10
36	Furniture	1
40	Electricity, Gas, Steam and Hot Water Supply	1
45	Construction	4
50	Sale and Repair of Motor Vehicles and Motorcycles	2
51	Wholesale Trade and Commission Trade	4
52	Retail Trade except of Motor Vehicles and Motorcycles	2
63	Supporting and Auxiliary Transport Activities	1
64	Post and Telecommunications	1
67	Activities Auxiliary to Financial Intermediation	1
72	Computer and Related Activities	25
73	Research and Development	17
74	Other Business Activities	26

Table 2: Concentration indexes of Eureka firms‡

	2006	
	$\hat{\gamma}_{MS}$	$\hat{\gamma}_{EG}$
Value	0.0227	0.0044
Standard Deviation	0.0007	0.0009
Number of firms	522,592	522,592
Number of industries	2	2
Number of spatial units	94	94

‡ $\hat{\gamma}_{MS}$ is the firm-based index and $\hat{\gamma}_{EG}$ is the employment-based index. The spatial unit is the NUTS 3 region.

Table 3: Summary statistics of key variables on the pre-treatment period (1998 – 2000)‡

	Unmatched firms	Eureka firms	More product. Eur. firms	Less product. Eur. firms
Employment	45	1,074	796	1,346
	(242)	(3388)	(1487)	(4544)
Total sales	1,092,075	21,900,000	16,900,000	26,800,000
	(8,343,710)	(6e+07)	(4e+07)	(7e+07)
Exports	160,190	9,287,815	7,145,206	11,400,000
	(2,177,215)	(3e+07)	(4e+07)	(3e+07)
Domestic sales	932,060	12,600,000	9,804,233	15,400,000
	(7307558)	(4e+07)	(4e+08)	(1e+07)
TFP	4	4.5	4.7	4.2
	(0.7)	(2)	(1)	(2)
Product innovation		0.48	0.57	0.43
RJVs with more than 2 countries		0.51	0.53	0.49
Number of firms		77	38	39

‡ The unmatched firms are the firms in close NACE four digit industries located in the Eureka NUTS three regions. An observation on the pre-treatment period is the mean of the observations in 1998, 1999 and 2000. More (less) productive firms have a proximity-to-the-frontier above (lower) than 0.37, the median proximity of the subsidized firms. RJV is research joint venture. Std Dev. is the standard deviation.

Table 4: Characteristics of firms getting R&D subsidies: Eureka firms versus firms in the same NUTS 3 regions and in close NACE four-digit industries‡

	I
Age	0.001
	(0.002)
ln(Employment)	0.245***
	(0.034)
ln(TFP)	0.224***
	(0.078)
Δ *ln(TFP*	-0.078
	(0.074)
ln(Exports/Sales)	0.995***
	(0.283)
ln(Loans/Sales)	-0.212
	(4.877)
Δ Capital	0.001
	(0.001)
Department FE	YES
Industry FE	YES
Intercept	2.917***
	(0.869)
R^2	0.441
Number of observations	17,723

‡ Table reports the regressions results of the Logit model where the control group comprises the firms in the Eureka departments operating in the 4 digit NACE industries close to the Eureka ones. FE stands for fixed effects. Standard Errors reported between brackets. Significance level: *** p-value<0.01, ** p-value<0.05 and *p-value<0.10.

Table 5: Results for exports and domestic sales $(2006 - 2008)$‡

	ln(Exports)	*ln(Export share)*	*ln(Domestic sales)*
ATT	0.763***	0.291**	0.305***
	(0.864)	(0.711)	(0.309)
Outcome average of the Eureka firms	11.071	-3.533	14.033
Outcome average of the matched firms	10.308	-3.824	13.728
Outcome difference	7.4 %	0.74 %	2.2 %
Number of Eureka firms	62	62	62
Number of matched firms	10,853	10,853	10,853

‡ The table reports the Gaussian kernel matching results. ATT is the average treatment effect on the treated firms. The 0.74% outcome difference $= exp(-3.533) - exp(-3.824)$. The bootstrapped standard errors are in parentheses (1000 replications). Significance level: *** p-value<0.01, ** p-value<0.05 and *p-value<0.10.

Table 6: Results for less productive firms (2006 − 2008)‡

	ln(Exports)	*ln(Export share)*	*ln(Domestic sales)*
ATT	0.890**	0.379***	0.211**
	(0.959)	(0.740)	(0.439)
Outcome average of the Eureka firms	11.376	-3.152	13.779
Outcome average of the matched firms	10.487	-3.531	13.567
Outcome difference	8.5%	1.35%	1.6 %
Number of Eureka firms	32	32	32
Number of matched firms	5,700	5,700	5,700

‡ The table reports the Gaussian kernel matching results for the less productive firms. These firms have a proximity-to-the-frontier lower than 0.37, the median proximity of the subsidized firms. ATT is the average treatment effect on the treated firms. The 1.35% outcome difference $= exp(-3.152) - exp(-3.531)$. The bootstrapped standard errors are in parentheses (1000 replications). Significance level: *** p-value<0.01, ** p-value<0.05 and *p-value<0.10.

Table 7: Results for more productive firms (2006 − 2008)‡

	ln(Exports)	*ln(Export share)*	*ln(Domestic sales)*
ATT	0.629***	0.409***	0.142***
	(1.396)	(1.131)	(0.425)
Outcome average of the Eureka firms	10.528	-4.130	14.264
Outcome average of the matched firms	9.900	-4.538	14.122
Outcome difference	6.4%	0.5%	1.0 %
Number of Eureka firms	28	28	28
Number of matched firms	4,047	4,047	4,047

‡ The table reports the Gaussian kernel matching results on more productive firms. These firms have an initial proximity-to-the-frontier higher than 0.37, the median proximity of the subsidized firms. ATT is the average treatment effect on the treated firms. The 0.5% outcome difference $= exp(-4.130) - exp(-4.538)$. The bootstrapped standard errors are in parentheses (1000 replications). Significance level: *** p-value<0.01, ** p-value<0.05 and *p-value<0.10.

Table 8: Results for product and process innovation (2006 − 2008)‡

ln(Exports)	Product innovation	Process innovation
ATT	1.067***	0.316***
	(1.158)	(1.104)
Outcome average of the Eureka firms	10.059	11.710
Outcome average of the matched firms	8.992	11.395
Outcome difference	11.9%	2.8%
Number of Eureka firms	31	28
Number of matched firms	8,305	2,319

‡ The table reports the Gaussian kernel matching results on the subsidized firms targeting product innovation or process innovation. A firm is is considered targeting a product (process) innovation if its RJV focuses mainly on a new product (process). ATT is the average treatment effect on the treated firms. The bootstrapped standard errors are in parentheses (1000 replications). Significance level: *** p-value<0.01, ** p-value<0.05 and *p-value<0.10.

Table 9: Robustness check: Radius matching‡

ln(Exports)	ATT Kernel	ATT Radius	Pseudo R^2 after	SB red.	Eur. firms	Match. firms
All firms and targeted innovation	0.763***	1.141**	0.082	0.616	62	10,853
	(0.864)	(0.571)				
Less productive firms	0.890**	1.466*	0.086	0.638	32	5,698
	(0.959)	(0.870)				
More productive firms	0.629***	1.222	0.064	0.367	28	4,042
	(1.396)	(0.968)				
Product innovation	1.067***	1.771**	0.144	0.393	31	8,303
	(1.158)	(0.887)				
Process innovation	0.316***	0.824	0.067	0.645	27	2,315
	(1.104)	(0.936)				

‡ The table reports the radius matching results with the radius = 0.03. ATT is the average treatment effect on the treated firms. The Pseudo R^2 after radius matching is the pseudo R^2 of logit model performed on the matched firms. The standardized bias (SB) reduction measures the difference in SB before and after radius matching. More (less) productive firms have a proximity-to-the-frontier above (lower) than 0.37, the median proximity of the subsidized firms. A firm is is considered targeting a product (process) innovation if its RJV focuses mainly on a new product (process). The bootstrapped standard errors are in parentheses (1000 replications). Significance level: *** p-value<0.01, ** p-value<0.05 and *p-value<0.10.