A Counterfactual Impact Evaluation of EU State Aid in Greece

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Abstract: EU state aid adopted from Member States is increasing at a fast pace due to the Covid-19 pandemic and energy crisis. Given its impact on the European economy, securing a maximum value added is a challenge for both policy makers and public administration. State aid impact depends not only on available resources but also on spending decisions that must be in line with state aid rules. It is believed that new policies would benefit if they were based on assessed evidence of existing policies during periods with similar characteristics. Our contribution analyses the characteristics of Greek development law based on a unique dataset extracted from the management information system of the Ministry of Economy. We hypothesize that there will be a change in firm productivity in the first years since program closure. Using counterfactual impact evaluation and propensity score matching, we find that there is a minor negative impact of development law on productivity. This might be an indication that firms receiving state aid do not perform as expected and perhaps better planning during policy modeling is needed.

Key-Words: counterfactual impact evaluation, propensity score matching, state aid

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1 Introduction

"One of the great mistakes is to judge policies and programs by their intentions rather than their results", [1]. Indeed, governments are increasingly using policies to support firms, all the more so due to the covid-19 outbreak, [2] and the energy market disruption caused by Russia's invasion of Ukraine, [3]. As state resources are limited and these programs are ultimately financed by taxpayers, it is expected that they have an overall beneficial impact. Thus, the challenge is to design programs for meeting well-defined objectives. Designing a program to improve a current market status is quite like designing a medical treatment for a patient. You need to know what works, what does not, whether the observed results are attributable to the intervention, and whether the results are worth the expense.

More than 200 million EU people (48% of the EU-28 population) are eligible for regional state aid during the period 2022-2027, [4]. The European Commission already uses a method called Counterfactual Impact Evaluation (CIE) to diagnose inefficiencies on existing policies and support policy makers on a range of decisions i.e. to scale up existing policies, to adjust budget allocations, or even to stop policies that do not seem to work. It expects to receive over 2,000 evaluations by 2023, [5]. The need for ex post evaluation of the effective implementation of adopted state aid cases is also highlighted during competition policy discussions in the European Parliament, [6]. CIE answers a particular type of question, i.e., what is the causal effect of an intervention on an outcome of interest? To estimate the causal effect, CIE is based on an analysis of what happened to participants compared to a scenario of what would have happened to them in the absence of the intervention. The methodological challenge is to build a group of non-participants with similar characteristics with the group of participants, i.e. the counterfactual group. The difference between the observed outcome and the outcome of the counterfactual is seen as the causal impact.

In February 2011, the government of Greece issued the national development law 3908 (DL2011 henceforth). Development laws are in general the longest-standing state aid national policy for investment incentives in Greece. DL2011 was open for applications until 2014 and eligibility criteria were based on General Block Exemption Regulation 800/2008, [7]. The program appeared potentially promising before implementation, since it was targeted to improve a large number of areas such as entrepreneurship, technological development, competitiveness, regional cohesion, green economy, efficient utilization of existing infrastructures, and deployment of the country's human resources, [8]. This argument is even stronger if we consider that between 1998 and 2014 development laws funded

investment plans of a total budget of more than €32bn with a government contribution of €6.2bn, [9]. This amount is one third of the investment gap[1] in Greece, [10]. Therefore, an investment incentives tool that might contribute to closing the investment gap can be considered as an important tool to support Greek firms. But, despite the alleged potential benefits of development laws, there is already some evidence that they fail to generate the expected impacts. An assessment of the Ministry of Economy, [11] revealed that out of 11,735 approvals for aid during the period 2004-2014, only 5,364 firms have eventually managed to carry out the planned investments.

Throughout the years, CIE is used to assess policies similar to DL2011; results have been contradictory. There is evidence that competition for incentives can offer more projects to poor areas [12]; can be effective for the economy, [13]; reduces initial cost of investment and lowers the risk of a new investment, [14]; provides externalities to local market, [15]; increases value added, [16]; and helps firms to survive, [17]. On the other side, Blomström et al., [18]) find that it is very difficult to make projections about the benefit of investments; Charlton, [19] suggests a targeted allocation of EU funds to more important areas like education or infrastructure; Michalek, [20] reports that the same investments would have been performed without aid; and Santos, [21] finds that subsidized firms have a lower contribution to growth. For an overview of the research on positive and negative effects of investment incentives, see Cedidlova [22].

Our intention is to contribute to this discussion, by assessing the impact of DL2011 on the performance of firms which received state aid. As a measure of performance, we use productivity, i.e. how well resources are used to produce output. In an input-constrained environment producing the same output with less resources is important in terms of natural resources and available working units, [23].

To do this we need to compare two groups of firms (funded and non-funded). Comparing groups with dissimilar characteristics (other than funding) would be problematic, therefore we use propensity score matching to find a reliable counterfactual for our CIE. Propensity score matching calculates the probability of receiving financial support on the basis of a set of observable characteristics and matches treated firms to non-treated ones with similar probability scores. We use data extracted from the management information system (MIS) of the Ministry of Economy and compare the productivity levels of treated and non-treated manufacturing firms two years after the ending of DL2011.

We evaluate DL2011 mainly for two reasons. The first reason is data availability; i.e. the existence of a MIS. As reported on the explanatory memorandum of DL2011, [24] the MIS was designed to collect and organize applicant firm data and support granting authorities to make correct decisions. Although the creation of this MIS was an uncharted field for the granting authorities, it contributed to the rationalization of the existing procedures, facilitating information exchange between granting authorities and the firms. This common information flow was expected to create a positive climate of trust, thus improving transparency on the selection criteria of the firms. The second reason is the duration of the measure. The DL2011 was active (i.e. open for submissions) for less than four years. This can be considered a short duration if we consider that previous laws (development law 1262 of 1982, development law 1892 of 1990) were active for at least eight years. This short duration means that it is more likely that all firms of DL2011 implement their planned investments under the same economic, political, socio-cultural, and technological conditions.

There are four areas of discussion that we usually encounter in a state aid policy evaluation, i.e. number of applicants, number of approvals, implementations actually made, and impact of the program. The first area is the most communicated one, since policy makers pursue to publish the number of applicants and the total budget of the investments. For example, a three-month open call for investments in tourism managed to attract 562 applications with an estimated budget of €1.6bn, [25]. The second area is about the approval decisions. Many applications are usually rejected due to budget limitations. In our example the available state aid budget is 150 m€ per year, [26]. The third area includes the finalized investment plans that received the financial aid. There is evidence that many firms never finalize their investments, [11]. The fourth area is the analysis of policy impact. Much of the research emphasis to date has been on monitoring the collected data in terms of capital formation, creation of new firms, and creation of new jobs at both the regional and sectoral perspective, [27]. But state aid policy might appear potentially attractive yet fail to generate the expected results. In our example, can we tell if a new aided investment operates better than non-funded ones in terms of productivity?

[1] This is defined as missing investments in Greece to reach European average competitiveness level.

Counterfactual impact evaluation could answer this question since it estimates the change that would have occurred without the state aid policy. The European Commission and member states already use this method to evaluate state aid policies, [28]. To our knowledge, there are no evaluations of this kind in Greece yet, although there is one study under preparation, [29]. Our aim is to bring some evidence in the area of counterfactual impact evaluation and contribute to the creation of an evidence-based state aid policy in Greece, especially nowadays that the available state aid budget for the period 2021-2027 has been more than doubled compared to last period due to the Recovery and Resilience Fund.

The rest of the paper is organized as follows: Section 2 describes the policy framework. Section 3 reviews the literature. Section 4 discusses the theoretical hypotheses of our research. Section 5 introduces propensity score matching analysis and section 6 presents the data. Section 7 provides the methodology steps and the corresponding assumptions and the findings. Section 8 discusses the policy implications of the findings and provides recommendations to policy makers. We conclude with a summary and suggestions for future research.

2 The Policy under Examination

DL2011 is a state aid measure that provides financial support to firms wishing to implement new investments in Greece. This type of public support may confer advantages to firms over competitors. Therefore, state aid measures must follow specific rules to ensure that distortion of competition is avoided at both the national and European levels. In our case, DL2011 is a national law that follows European Commission (EC henceforth) regulations applicable for all state members. It complies with the conditions of General Block Exemption Regulation for regional aid (GBER henceforth). It is a simplified regulation that declares certain categories of aid compatible with the internal market. The main advantage of GBER is that the member state assesses the measure based on predefined criteria and then it simply notifies the results to the EC. It is so popular that since 2015, more than 96% of new state aid measures in the European Union comply with GBER, [30].

Based on the state aid case registry, [31] more than 1,405 measures with similar characteristics to the DL2011 have been created in the European Union since 2011. Therefore, the evaluation of DL2011 provides insights potentially useful to other EU countries as well.

DL2011 offers financial grants and tax reliefs to private firms for the implementation of investment projects. The investments must be related to the building of new establishments or to the upgrading of existing establishments, [8]. Eligible costs include both tangible and intangible assets i.e. buildings, mechanical engineering equipment for the production line, transportation and installation of equipment, special facilities, transportation vehicles, know-how, landscaping the surrounding area, infrastructure projects, and expenditures for consulting studies, [32]. Creation of new jobs is also related to the above investments.

Maximum aid intensities are applicable to the above eligible costs taking into consideration the location of the investment. The aid intensity (i.e. the percent of the investment budget that is provided as aid) is not higher than 40% of the total eligible cost in NUTS 2 regions whose GDP per capita is below 55% of the EU average and is not higher than 15% in NUTS 2 regions whose GDP per capita is below 65% of the EU average. The maximum aid intensities are increased by 10% for medium-sized enterprises and by 20% for small enterprises. The beneficiary has to cover the remaining part of the investment providing a financial contribution of at least 25% of the eligible costs of the project [7]. Upon each call for proposals, any Greek private legal entity can submit an application for aid, including all necessary documents and data [33]. To be successful and receive financial support, applicants must fulfil a set of eligibility criteria and must pass a minimum threshold of a point system based on a set of criteria [34]. The former represents on/off criteria based on the typical requirements and the objectives of DL2011. The latter represents the criteria used to score the applications and rank the eligible applications. The firm can only initiate its intended project activities after the application for the aid. This indicates that the new investment is due to the incentives provided through DL2011 (incentive effect). If otherwise, the project is rejected, [8].

The minimum budget of an investment plan can be €100k and the maximum amount of aid per firm can be €15m, [8]. The responsible body for monitoring high budget investments i.e. more than €3m is the Ministry of Economy. Regional authorities are responsible for the monitoring of investments with lower budgets. The appraisal of the investments is performed from the members of the National Register of Evaluators, [35]. The approval decision contains all terms and conditions that the beneficiary should fulfil during the implementation of the project. The relevant

summary of the Ministerial decision is published in the Official Gazette and the state aid enters into force, [36].

3 Literature Review

We have identified thirty-seven European studies that measure the impact of EC state aid on firms' labor productivity using propensity score matching, one of the methods of CIE. The studies come from thirteen countries: Croatia, [37]–[42], Czech Republic, [16], [43]–[50], Denmark, [51], Finland [52], [53], France, [54], Germany, [55]–[57], Hungary, [58]–[60], Italy, [61]–[66], Latvia [67], Lithuania, [68], Portugal, [69], [70], Spain, [71], and Sweden, [72].

Twenty (54%) studies showed negative or no results. The remaining seventeen (46%) showed positive results. As the results of this literature about the impact of the incentives are mixed, we examined results based on regional characteristics of the programs. Of the 37 studies, twenty-eight (76%) studies were performed at the national level. In sixteen (57%) of them the impact of the incentives was negative. Nine cases (24%) were performed at the regional level; the cases of positive impact were higher (56%) than those with the negative impact. Even national incentives policies seem to provide contradictory results as some policies provide positive results and some others negative results. For example, in the Czech Republic, 5 (56%) studies showed positive results. In Italy and Croatia four (67%) studies showed negative results. Motivated by the above contradictions we run a parallel study to examine the characteristics affecting the outcome of the above policy interventions [73]. In this study, we found a lack of consistent reporting of the propensity score matching method and we propose guidelines to allow comparison across studies and to facilitate interpretation across academia and policy makers.

4 Theoretical Hypotheses

As in the above studies, in this paper we examine the impact of an incentive policy on firms' labor productivity. We examine the impact of DL2011 on manufacturing firms that applied for state aid to implement new investments. Their applications include business plans for the establishments of new production units or for the upgrade of their existing production units.

DL2011 offers non-repayable financial support to firms that manage to pass the selection criteria. This could mean that successful applicants face a relief on their financial obligations over non-successful applicants. Therefore, DL2011 minimizes implementation risk and firms can dedicate their efforts to improve performance.

On the other hand, successful applicants may start implementing business plans that perhaps they are not yet ready to successfully implement and hence their submitted business plans are not carried out to the end. As mentioned in the introduction, nearly half of the approved projects have not managed to successfully implement their investments.

Therefore, an interesting question to ask would be: what happens, in terms of performance, to those firms which receive state aid. Therefore, we work with three hypotheses. The first hypothesis is that DL2011 has a negative impact on successful firms; the second hypothesis is that DL2011 has a positive impact; and the third hypothesis is that there is no impact.

5 Method

Policy interventions are typically aimed at remedying an existing situation. They can be seen as analogous to treatments given in medicine. In this light, DL2011 is the treatment, which is implemented on the expectation of improving the status of firms that will receive state aid. The aim of our analysis is to measure the effect of DL2011 on labor productivity that is our outcome of interest. Of course, changes in the outcome may be only partly due to the intervention, and sometimes not at all. Thus, a fundamental problem is how to establish attribution, i.e. how to determine that the outcome is the effect of the intervention and not of other factors.

Since we cannot observe the same firm at a certain point of time, being in both statuses, the challenge is to define a group consisting of firms that have not received state aid but have similar characteristics with the firms that are treated (we call this the non-treated group). This group consists of firms that applied for aid but did not get funding (while the treatment group consists of firms that did get funding). This can be done using counterfactual impact evaluation. Counterfactual model analysis was first started from Neyman-Rubin, [74]. Khandker et al., [75], provide a review.

The causal impact of DL2011 can thus be seen as the difference between the outcome of treated firms and the outcome without the treatment, [74], [76].

The impact of the intervention using the outcomes of two groups can be calculated only if

the two groups have similar characteristics. Random assignment is considered to be a reliable form of research design since all eligible firms have the same probability of receiving the treatment, [77]. If all firms have the same probability of getting treated, then it is considered that the output will represent the eligible population and that the impact is due to the intervention.

In our case, we cannot randomly assign firms in the two groups (treated and non-treated) since DL2011 uses an evaluation procedure that selects the firms that will be funded.

A positive evaluation leads to treatment (financial support) while a negative evaluation leads to non-treatment. Therefore, the two groups cannot be built randomly. Instead the groups can be built based on the selection criteria of the evaluation procedure of DL2011, [34]. Rosenbaum & Rubin, [76], first showed that a method called propensity score matching can mimic random assignment under the condition that the study is performed based on a set of observable firm characteristics. Therefore, the groups can be defined based on a series of selection criteria. Propensity is defined as a firm's probability of being treated. That means that two firms with the same characteristics have the same probability of receiving the aid. If a firm from the control group has the same propensity score with a firm of the treated group, then it is considered as the most comparable counterpart and the allocation can be considered as random. A review of the propensity score matching method can be found in a series of most cited studies, [78]–[82], [76], [83]. Gertler et al., [84], and Khandker et al., [75], provide an overview.

The propensity score is used to convert the multidimensional vector of observable characteristics to a single composite variable. In our case, if we assume that the age of the firm is a selection criterion in DL2011, and theory and empirical findings also suggest that it affects productivity, a simple method would be to compare all firms with similar age in both treated and non-treated firms. But, as mentioned earlier, there is a series of criteria that affect the selection of a firm while economic theory and empirical literature report a series of productivity determinants. Therefore, it seems more plausible to create a multidimensional vector of variables that affect selection of firms and the outcome of the treatment. Propensity scores convert this dimensionality issue into a single score, and then based on this score firms from the two groups can be matched.

In other words, two firms with the same propensity scores have about the same observed characteristics except the exposure to treatment. Therefore, the effect of the treatment (DL2011) can be measured by comparing the output (i.e. labor productivity) of a matched pair of firms.

6 Data

Our dataset consists of 1,910 firms that applied for state aid under DL2011. All applications were submitted between September 2011 and March 2014. Following the assessment of the applications by the granting authorities, 1,261 investment applications were successful (deemed eligible to receive aid) and 649 applications were rejected.

Table *1* shows the number of approved investments and their main characteristics. We highlight that state aid to industry is €1.24bn in total of €1.95bn for all sectors, which shows that the main part (63%) of the financial support of the DL2011 is channeled to industry.

Table 1. DL2011 investments.

Type	Number of investments	Total budget of investments (€bn)	State aid (€bn)	New Average Working Units
Applications (all sectors)	1,910	7.95	2.75	9,774
Approved (all sectors)	1,261	5.68	1.95	6,140
Applications (industry)	1,114	5.08	1.73	3,791
Approved (industry)	742	3.64	1.24	2,375

Source: Own calculations, data retrieved from Greek Ministry of Economy.

The call was open for economic activities in the primary, secondary, and tourism sectors, [8]. Our scope is limited to firms which submitted business plans to operate only in the secondary sector because (a) we want to compare firms with similar characteristics and (b) the secondary sector offers the largest sample. Therefore, we consider applications with economic activities belonging to the statistical classification NACE 10-39 (Table 2); thus, our sample includes 1,114 firms. We made some exclusions, as follows. As discussed, our aim is to find firms with similar characteristics. Thus, we exclude 495 cases of wind and hydropower generation plants (NACE 35) and our sample now consists of 619 industrial firms. We exclude these firms because they seem to have different characteristics from other industrial firms. For example, wind power plants find abundant sources of raw material, and they have very few permanent employees.

Then, we exclude firms with two applications and firms that relate to other applicant firms. We find this information on the declaration forms signed by the firms. The reason for this exclusion is that the outcome of one project should be independent from the assignment of treatment on other projects, thus fulfilling Stable Unit Treatment Value Assumption [76], [85]. Thus, we keep 544 firms that were already operating at the time of the application. We exclude firms that do not operate at the time of the application because they may never operate upon failing to receive state aid. Thus, these firms could not be included in the control group. We then exclude cases with missing values, which occur mainly among limited liability companies. These are mostly very small enterprises with low sales figures and low average working units. Therefore, we have a working dataset of 135 industrial enterprises.

Table 2. NACE codes used in the analysis

NACE	Description
10,11,12	Manufacture of food products, beverages, and tobacco products
13, 14, 15	Manufacture of textiles, wearing apparel, leather, and related products
16	Manufacture of wood and of products of wood and cork, except furniture
17	Manufacture of paper and paper products
18	Printing and reproduction of recorded media
19	Manufacture of coke and refined petroleum products
20	Manufacture of chemicals and chemical products
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
22	Manufacture of rubber and plastic products
23	Manufacture of other non-metallic mineral products
24	Manufacture of basic metals
25	Manufacture of fabricated metal products, except machinery and equipment
26	Manufacture of computer, electronic and optical products
27	Manufacture of electrical equipment
28	Manufacture of machinery and equipment
29	Manufacture of motor vehicles, trailers, and semi-trailers
31-32	Manufacture of furniture; other manufacturing
33	Repair and installation of machinery and equipment
36	Water collection, treatment, and supply
37, 38, 39	Sewerage, waste collection, treatment, and disposal activities; materials recovery, remediation activities and other waste management services

Source: Own elaboration, data retrieved from Greek Ministry of Economy.

All of them include a business plan for the establishment of new production units. Among them, the firms whose investment plans were rejected are 66. One of the characteristics of DL2011 was that rules and selection criteria are published in advance and a firm entering in the MIS knows (a) if it is eligible and (b) the assessment points it receives. Therefore, it is most likely that firms knowing that they cannot achieve a high ranking do not proceed with an application for state aid. This is an important characteristic of the management information system that reduces the work needed from the agencies to evaluate the applications. Regarding our research, while this characteristic reduces the effort to build a large control group, it provides a control group which is more similar to the "treatment" group, because firms included in our control group are those applying for aid but failed to provide the documentation to justify their application. This is a condition of DL2011: applications that are not accompanied by all supporting documentation in original form are rejected, [36].

We now need to evaluate whether our sample is large enough for our statistical analysis. The discussion on the proper sample size is based on two criteria. The total sample size and the size of the control group compared to the size of the treatment group. Many studies, [74], [76], [86], [87] report that the size of the control group is a crucial parameter for the quality of the results. Intuitively, a high control-to-treatment ratio provides a better probability to find two reliable matched groups. However as Rubin, [88], reported in his study, the improvements in bias reduction from control-to-treatment ratio 2:1 to 9:1 were modest. Thus, we found no clear guidelines in the extant literature about the sampling characteristics. In our case, only one applicant out of five is not approved. This fact does not provide us the opportunity to use a high control-to-treatment ratio.

Data was drawn from the MIS of the Ministry of Economy under official permission. To complete our dataset with financial data, we also used publicly available sources, [89]–[91]. Table 3 lists the source we used to collect data.

Table 3. Sources of data for observable variables and indicators.

Source	Observable Variable (Indicator used in the study)
Ministry of Economy	Status of firm- to observe treated and non-treated firms
	Human Capital (experience of shareholders, experience of management team, specialization of management team, education)
	FDI (financial contribution of foreign investors)
	Innovation (use of innovative techniques)
	Physical capital (eco-friendly production process)
	Firm age (years of operation)
	Exports (exporting revenues)
	Average Working units of firms, used for the calculation of labour productivity
General Electronic Commercial Registry	Balance sheet information used for the calculation of labour productivity
National Printing House of Greece	
National Transparency Portal	
Websites	

Source: Own elaboration.

7 Propensity Score Matching: Use and Results

The steps of the propensity score matching method were outlined by a number of studies, [92], [93], [77], [94], [95]. Our study includes five steps: (1) variable selection, (2) calculation of propensity scores, (3) matching estimation, (4) diagnosis of matching quality, and (5) calculation of average treatment on treated effect[2].

7.1 Variable Selection

A basic assumption of propensity score matching is conditional independence (Rosenbaum & Rubin, 1983). This means that all variables that affect both participation and outcome of the intervention are included in the analysis, [77], [88], [94], [98]–[100]. This holds true in our case, since each variable we selected represents a selection criterion of DL2011 (conceptual relevance) and is also a determinant of productivity (theoretical relevance), [101]. Variables affected by the treatment are not to be included in propensity score matching, [93]. Under this assumption, assignment to the intervention can be considered as random and each firm has the same probability of being treated.

Based on our literature review of 35 studies that analyze the impact of state aid on firm productivity using propensity score matching we use the eleven variables listed below, [28]. The variables *Shareholders*, *Management*, *Specialization*, *Age*, *Education*, *Innovation*, *Eco-friendly*, *Exports*, and *FDI* show firm characteristics in the pre-treatment phase (i.e. year 2011), the *Treated* variable shows if a firm has been selected for treatment during the period 2011-2014, and *Labor productivity* shows the status of the firm two years after the end of the intervention (i.e. 2016). We assign 0 and 1 values to

[2] For our estimation we use the Stata commands *pscore* (Becker & Ichino, 2002) and *psmatch2* [97] respectively. Becker and Ichino have developed a command (*pscore*) for propensity score matching estimators i.e. nearest-neighbor, kernel, and radius. Leuven and Sianesi (2018) have developed the command *psmatch2* that includes routines for covariate imbalance testing (pstest) and common support graphing (psgraph).

the variables after elaboration of data extracted from MIS, as follows.

1. *Treated*: takes the value of 1 if a firm has received funding and 0 otherwise.
2. *Labor productivity*: We use a firm's total revenue as an output metric [102] and average working units (AWUs), which essentially is a headcount, as a labor metric. For the calculation of AWU, we consider that an employee, who worked full time within an enterprise during an entire year, counts as one unit. Part-time staff, seasonal workers, and those who did not work the full year are treated as fractions of one unit, [103].
3. The *Shareholders* variable refers to whether most shareholders of the firm participated in any business entity with net positive earnings for more than three years, during the last five years. In that case, the variable takes the value of 1 and 0 otherwise.
4. The *Management* variable rates the most experienced executive (among Chairman, Board of Directors, and Managing Director). If one of these executives has management experience of at least two years during the last five years, then the variable takes the value of 1. If less, it takes the value of 0.
5. The *Specialization* variable takes the value of 1 if one of the executives has postgraduate studies or business experience in a field related to the main activity of the investment. If none of the executives have any experience the value is 0.
6. The *Age* variable takes the value of 1 if the firm operates for at least three fiscal years with positive net profits. Otherwise, the value is 0.
7. The *Education* variable shows the educational characteristics of the firm. It is coded by the MIS as 1 if the percentage of graduate employees per total employees is more than 25%. Otherwise, the value is 0.
8. The *Innovation* variable takes the value of 1 if the firm has introduced in its production innovative techniques such as research and development (R&D), product design, quality assurance, certification systems and patents. Otherwise, the value is 0.
9. The *Eco-friendly* variable takes the value of 1 if the firm includes in the production process technologies that reduce environmental impact i.e. renewable energy, recycling. Otherwise, the value is 0.
10. The *Exports* variable takes the value of 1 for firms with exporting revenues at 30% of the total revenues. Otherwise, the value is 0.
11. The *FDI* variable takes the value of 1 when at least 25% of the financial contribution for the project to be financed comes from investors located in another country. Otherwise, the value is 0.

We evaluate the impact of DL2011 two years after the end of the submission deadline. According to Bondonio, [104] this period is considered appropriate to assess the impact of a program. Bergstom, [105] agrees by stating that very short time evaluation will misrepresent the impact of a program while evaluating in a longer time would hinder the isolation of the effects of the program. On the same vein, Antonioli et al., [106], and Autio & Rannikko, [107], define as a reliable threshold a 2-year period after the program submission deadline.

Table 4 summarizes the variables and their description and shows the characteristics of the sample. Most firms of our sample have an experienced management team, are already in the market for more than three years, have a small percentage of graduate employees, have exporting activities, do not use eco-friendly technologies, and use funds from domestic sources.

Table 4. Observed characteristics of firms.

Variable	Short description	% of sample with value 1 (except vars with *)
*Treated	Categorical variable, indicates successful application for funding.	
*Labor Productivity	Outcome variable, calculated as annual revenue (€k) /average working units.	Average (all firms) = 372
Shareholders	Control variable, participating in a business entity with net earnings of at least three years.	44%
Management	Control variable, management experience of at least two years.	97%
Specialization	Control variable, management specialization in the area.	44%
Age	Control variable, firms with more than three years of operation.	81%
Education	Control variable, percentage of graduates per total employees is more than 25%.	25%
Innovation	Control variable, use of innovative techniques.	54%
Eco-friendly	Control variable, type of production process.	33%
Exports	Control variable, exporting revenue per total revenue is more than 30%.	80%
FDI	Control variable, financial contribution from foreign resources at least 25% of total contribution.	5%

Note: 135 observations (69 treated, 66 non-treated).
Source: Own elaboration.

7.2 Calculation of Propensity Scores

We estimate the propensity scores[3], using probit regression, [78], [98]. We use the pre-treatment variables as predictors of a firm being assigned the treatment. All firms are assigned a propensity score showing the predicted probability of receiving treatment. For a review of propensity score calculation refer to Khandker et al., [75].

7.3 Matching Estimation

We assess the comparability of treated and non-treated firms. To do this we estimate the "common support area", another basis of propensity score matching. It is the area where the mean propensity scores of treated and non-treated are similar. Within this area, a firm can be potentially observed with treatment and without treatment. Firms that have low or high propensity scores and have no counterpart from the other group are excluded. In our case, propensity scores below 0.2 come from only non-treated firms while scores upwards of 0,8 come only from treated ones. Therefore, the common support is between 0.2 and 0.8 (see

) and all firms with propensity scores falling outside this range are discarded from our analysis. The common support area of our study includes 131 firms.

Following the identification of the above range, we classify firms into blocks based on their propensity score. This classification ensures that the mean propensity score is not different for treated and controls in each block. The number of blocks

[3] Propensity scores and other statistics are available on request.

calculated with this procedure is 5, as shown in Table 5.

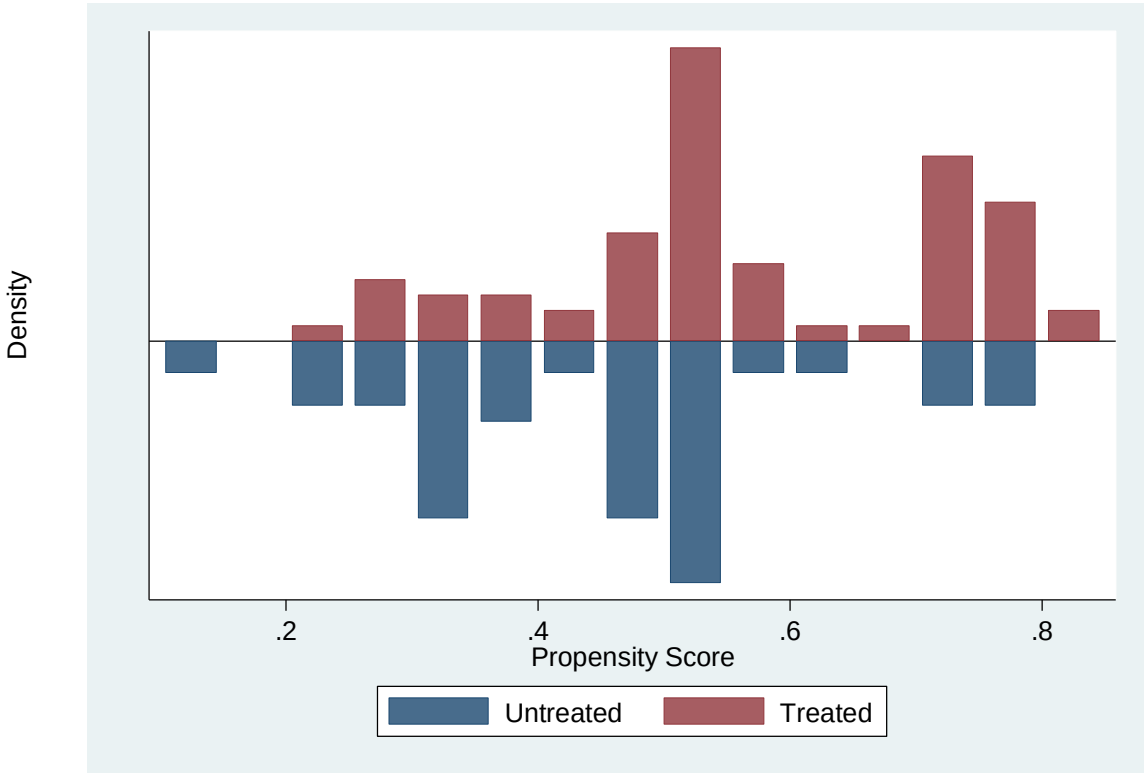


Fig. 1: Balance between control and treatment groups.
Source: Own calculations

Table 5. Blocks of propensity score.

Propensity score	Treated		Total no. of firms
	0	1	
0.2	22	11	33
0.4	30	33	63
0.6	10	23	33
0.8	0	2	2
Total	62	69	131

Source: Own elaboration.

Then, we perform a second classification based on the comparison of the observable characteristics of the firms, to check for the possibility of close matching. Close matching would offer a perfect balance between treated and non-treated firms, making treatment assignment looking random, providing evidence for the validity of the conditional independence assumption.

Exact matching of treated and non-treated firms cannot be achieved most of the time. The closest scenario to exact matching is to find the nearest firm from the control group in terms of the propensity score.

To do this, we first use a stratification estimator. Rosenbaum & Rubin, [76], showed that estimates based on stratification represent estimates of real average treatment effects.

Stratification ensures that estimates can have accuracy in the sub-samples and comparison between sub-samples can be performed with equal statistical power.

Then, to test whether the estimated results are sensitive to different model specifications we perform our analysis using another estimator called Radius estimator. In this case each treated firm is matched with a non treated firm whose propensity

score lies within a predefined caliper. The propensity range allows more than one non-treated firm to be selected for matching. The method reduces poor matching since non-treated firms outside of the range are excluded.

Finally, we use a Kernel estimator. In this case, the propensity scores of non-treated firms receive a weight in proportion to its distance from the matched treated firm. Each treated firm is assigned a weight of one. The non-treated firms with the closest propensity score receive the highest weight. All non-treated firms that lie within the specified bandwidth, i.e. the common support area, are included in the calculation. Thus, a group of non-treated firms with weighted propensity scores is used to create a match with a treated firm.

7.4 Diagnosis of Matching Quality

We check whether the above matching estimators improve the balance of a covariate's distribution within the blocks of propensity score, [108], [109]. Rosenbaum & Rubin, [76] suggested checking the standardized differences and distributions before and after matching.

The standardised % bias is the percentage difference of the sample means in the treated and non-treated groups as a percentage of the square root of the average of the sample variances in the treated and non-treated groups, [81]. Values close to zero represent minimum bias. This method is used in many studies, [79], [110]–[113]. It is preferred compared to t-test for checking the balance of covariates. The scope is to diagnose the properties of treated and non-treated groups and not to provide inferences about the total population. The degree to which the standardized difference is improved after matching, provides indication of the balancing performance. The strictest acceptable level is reported from Caliendo & Kopeinig, [94], who state that if the absolute standardized bias is reduced to less than 5% the matching method is effective. Harder et al., [114], and Stuart, [78], stated that a standardized bias not exceeding 25% is acceptable. Rosenbaum and Rubin, [81] suggested that standardized differences should be less than 20%.

Plots including all covariates in y axis and standardized bias in x axis are included in the appendix (Fig.A.*1*, A.2, A.3). For each covariate the standardized bias is presented before and after matching. We observe that before matching the variables *FDI*, *Specialization*, *Shareholders*, and *Innovation* were above the threshold of 20% standardized bias, thus presenting evidence of imbalance. After incorporating matching methods, we observe reductions in imbalance and firms from treatment and control groups have identical means on all covariates.

In addition, histograms (Hist.A.1, A.2, A.3) provide a visual representation of the distribution of the differences for the covariates that are included in the analysis. After matching, all standardized differences in covariate means are substantially reduced. Since standardised bias is quite small, this is an indicator that reliable estimates can be produced.

7.5 Calculation of Average Treatment on Treated Effect

The average treatment on treated (ATT) effect, [74], [96] is the causal effect of the treatment (DL2011) on an outcome of interest (firm productivity). Thus, we need to calculate the outcome of a firm with the treatment (financial aid) and the outcome of the same firm with no treatment. The difference would be the treatment effect of the intervention. Since we cannot observe the same firm being in both statuses at a certain point of time, the challenge is to find firms with similar characteristics. Based on theory, characteristics that affect both the participation in the program and the outcome of the intervention are included in the analysis (see variables selection section). So, each firm is characterized based on a set of observable characteristics. The propensity score is used to convert this multidimensional vector of observable characteristics to a single composite variable. All firms are assigned a propensity score showing the predicted probability of receiving treatment. As explained above, we have restricted our analysis within the common support area where the mean propensity scores of treated and non-treated are similar. Using matching techniques (see matching estimation section), we find the most comparable counterparts for the analysis (see diagnosis of matching quality section). The average difference in outcome (here: productivity) between the treated and their respective control(s) is the average treatment on treated.

Since we compare the characteristics of one firm with another firm, we cannot have a matching in absolute terms. Depending on the characteristics of each technique aiming to find the closest counterpart the average treatment on treated effect varies. As we see in Table 6 all three matching estimators (see matching estimation section) show that treated firms experience a negative impact from €73 to €8,270 on annual sales per average working unit. Thus, in our case all firms of our sample applied for state aid, and some receive treatment while others do not. The negative figures suggest that two years after the end of the interventions,

firms operating in the industrial sector which received state aid do not receive a benefit in terms of labor productivity. If we consider that treated firms have an average of €368,971 annual sales per average working unit, the magnitude of the negative impact is not high. In addition, the state aid cost per new job position is €317,589 (based on data of

Table *1*, the financial support of the state to 1,261 firms was €1.95bn and resulted in 6,140 new job positions). Compared with similar estimations from other scholars this cost is high. Indicatively, [115] reports that state aid in the automotive industry of the US is 200,000 dollars per new job, and Bondonio et al., [64], report €230,000 per new job in Italy. This can be seen as an indication that DL2011 does not provide good value for money, since a high level of financial support to firms does not seem to offer high levels of productivity.

8 Discussion

We may highlight two observations about the effect of DL2011 on treated firms. The first observation is related to the human capital of firms. As planned investments materialize, the technological status of the firm changes; thus, it might take time for employees to become familiar with it. This lag between technological development and personnel readiness could result in a low utilization of firm capital, leading to lower productivity levels. This could be supported by the fact that 75% of the firms of our sample have employees with relatively low education. The same reasoning could also be applicable to the new employees that join the firm as a result of the investment. If their skills are not suited to the requirements of the production facility, the quantity of the employees does not accurately depict the real workforce of the firm. The managerial team also plays an important role in communicating with, and supporting, employees to familiarize with new goals. In our case, nearly all firms (97%) have an experienced management team but less than half (44%) have a specialized management team. The second observation is related to firm output. All firms of our sample are already operating at the time of their application and most of them (81%) are in operation for more than three years. This means that they have an established portfolio of goods and services. The lower capital costs, due to state aid support, might encourage firms to undertake a new investment. The fact that state aid programs are not continuously available strengthens our explanation as they may seem as windfalls to be used whenever they appear, instead of submitting the application whenever this is suitable to the strategic plan of firms. The state aid programs come at specific and unknown points in time when the state believes that there is a market failure that can be solved by providing non-refundable subsidies to firms. At the time that a call for applications is open, a firm might be not in a position to proceed with a new investment (e.g. because it might have not reached its full capacity utilization), but in order to apply for 'free money' the firm brings forward (sometimes hastily) an investment which would be better left to be executed at a later stage. Besides the potential capacity of the firms, the type of the new investment might have an implication on firm output. If the new investment provides the same goods and services, then state aid functions similarly to a reduction in the existing production costs. Lower production costs should result in better prices, thus attracting customers from other competitors. On the other hand, if the new investment provides goods and services that are not already in the existing portfolio, then state aid works as a tool to overcome entry barriers to a new market.

Table 6. Average Treatment on Treated.

Method	Treated	Control	ATT (€)	Std. Error	t
Stratification	69	44	–3,022	93,099	0.255
Radius Matching	69	62	–73	98,958	-0.001
Kernel Matching	69	62	–8,270	85,265	-0.097

Source: Own calculations.

In our case, the business plans of the firms include the establishment of new production units and not the expansion of existing ones. This could be one explanation of the poor performance since the firms have to develop a new marketing strategy, new communication channels, new logistics processes, etc., for the new portfolio; and these activities put a burden on existing managerial and other human resources and might take time to materialize. Based on the above observations, we can make two recommendations to policy makers. The first recommendation is related to the design of the policy. DL2011 objectives should be (a) realistic and measurable and (b) designed in a manner that long term benefits are enhanced. Concerning the design of realistic and measurable objectives, DL2011 is arguably an expensive law in terms of budget spending, thus the expectations from policy makers seem rather optimistic. As we note in the introduction, DL2011 has a wide range of objectives but its impact on the economy remains unknown since there are no measurable criteria to quantify the progress. A useful change would be the creation of a list of objectives like the ones (i.e. basic, specific, additional benefits) used from Gabor & Sauvant, [116] to describe the "Authorized Sustainable Investor", combined with the list of sustainability characteristics of investments (economic, social, environmental) used from Sauvant & Mann, [117].

The second recommendation is about the focus on long term results. Policy makers know that the results of the policy will come at a later phase and at that time they will (most probably) not be still in the same position, thus it seems that they use DL2011 to achieve short term political rewards. Short term rewards may come by designing a policy which attracts a high number of new investments. To attract a high number of investments the selection criteria cover a wider area of firms that are not necessarily able to achieve the objectives of the intervention. This is totally understandable if we hypothetically consider a scenario with a DL2011 bearing very strict and targeted selection criteria. This intervention could only attract a small portion of firms since only few could fulfil the strict criteria. This result could harm the political reputation of the policy makers, since it is difficult to communicate to the public that the strict criteria would ensure a successful implementation of the investments providing benefits for the economy. To prevent ineffective design, policy makers should use evidence from experience. Policy makers together with data experts can develop a data-driven policy making procedure based on feedback loops from the implementing authorities.

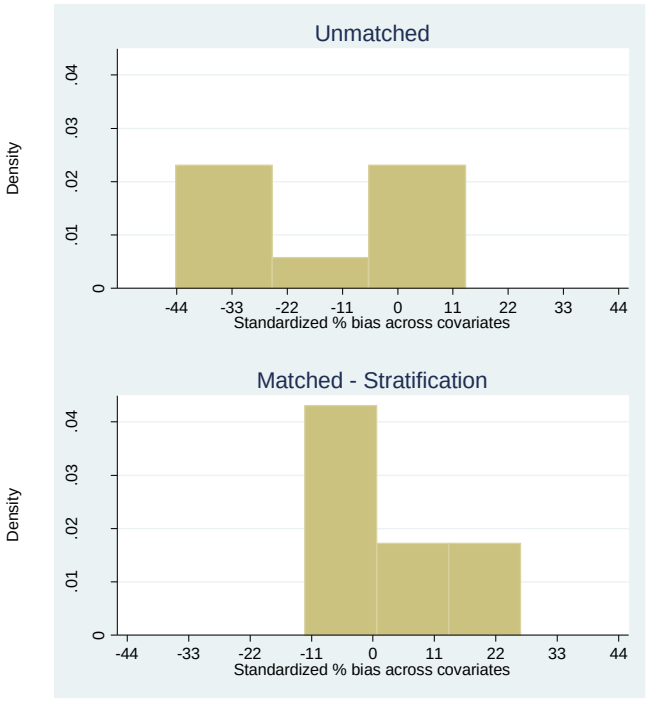
Our second recommendation is about the implementation of the policy. The informational advantage of implementing authorities should be the interconnection link with policy design. A strong public organization must be in place to support implementation problems. DL2011 includes high budget investments that usually take time to implement. During this period, it is not unusual for firms to face challenges that were not foreseen during the preparation of the application. These implementation issues are not communicated to the implementing authorities since firms have no obligation to do it. The official communication process is mainly performed after the implementation of the project. If we combine this information gap with our findings on rather poor performance, this could be a reason why part of the approved investments is never completed; problems have never been identified so they never had the opportunity to be fixed. Thus, a performance monitoring process should be in place to ascertain whether firms are still operating and developing the approved business plans. A monitoring process could include: (1) an updated monitoring process to meet the needs of implementing authorities; and (2) an improved information system to provide reliable data from the monitoring process to policy makers.

9 Conclusion and Future Directions

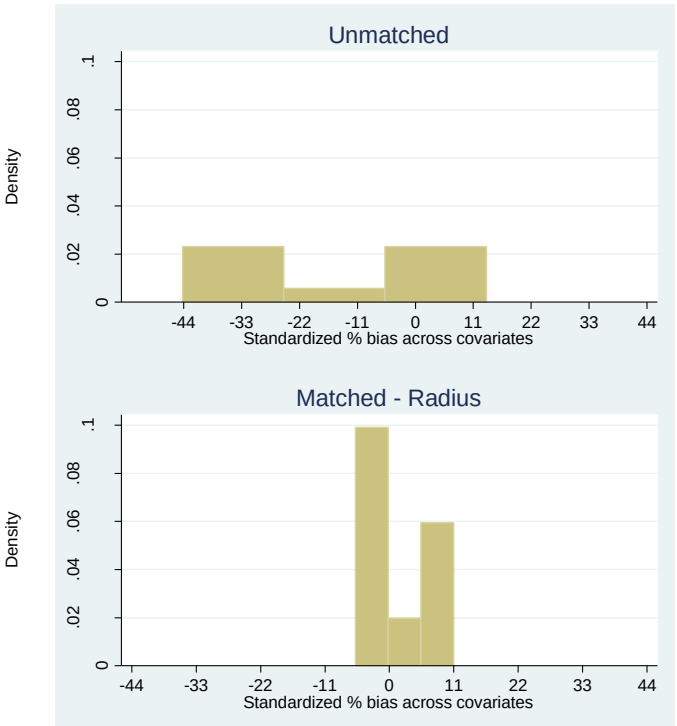
In this study we have conducted an impact assessment for a Greek state aid policy. Our results show that DL2011 has a minor negative impact on labor productivity of the firms that received financial support, a finding consistent with other recent national studies [37]–[40], [46], [49], [50], [52], [53], [58], [59], [64], [68]–[70]. Our findings, based on a dataset from the Ministry of Economy covering the period 2011-2014, contribute to the state aid effectiveness discussion providing empirical evidence that such policies might not offer advantages to firms receiving the aid. We came to this conclusion using propensity score matching analysis on a sample of manufacturing firms which we observed for the first few years after program closure. Although we have identified a negative impact of development law 3908/2011 on labor productivity of the treated (funded) firms, we are unable to assess/evaluate the effectiveness of the policy based solely on our findings. We believe that our study should be used together with other state aid studies, giving emphasis not only on the results but to all actions and assumptions made which are connected to these results. Then, policy makers could more easily convert the research knowledge

into an evidence-based state aid policy based on the customized needs of each policy program.

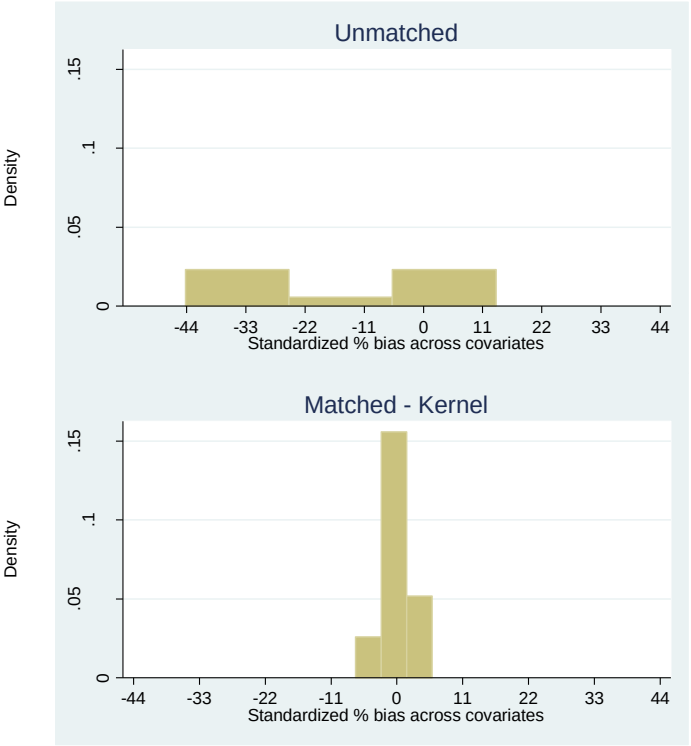
Appendix



Hist.A.1. Standardized percentage bias across covariates before and after matching (Stratification).



Hist.A.2. Standardized percentage bias across covariates before and after matching (Radius).



Hist.A.3. Standardized percentage bias across covariates before and after matching (Kernel)

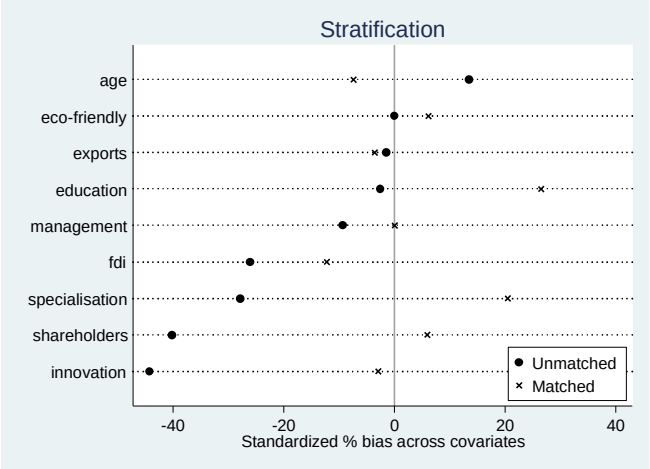


Fig.A.1. Standardized percentage bias across covariates before and after matching (Stratification)

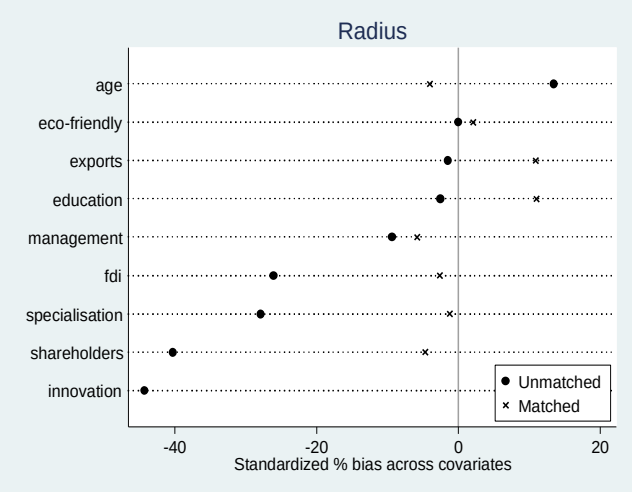


Fig.A.2. Standardized percentage bias across covariates before and after matching (Radius).

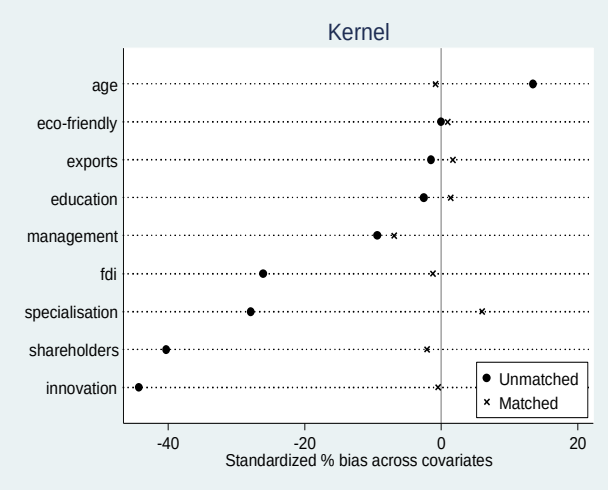


Fig.A.3. Standardized percentage bias across covariates before and after matching (Kernel).

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