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Economic Effects of R&D Supports

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Abstract

This study examines the economic effects of research and development (R&D) supports in the context of a program implemented in Türkiye between 2006-2019. Firms receiving the support differ positively from other firms in key economic indicators. Results indicate a 6% rise in patent registrations, 9% growth in value-added, 26% surge in total wages, 17% increase in per capita wages, 9% expansion in employment, 10% boost in productivity, 11% rise in exported product diversity, and 4% uptick in sales due to the support. Nonetheless, the effects on productivity and sales are statistically weaker than other impacts. The average impact of patents is also modest. Large-scale firms exhibit significant benefits, with a 33% rise in patent numbers and a 13% growth in sales. These firms effectively leverage support to commercialize R&D investments and innovations. Small-sized firms experience stronger productivity effects. Productivity gains grow with scale among SMEs, but large firms do not see positive productivity effects.

JEL codes: O31, O32, O38

Keywords: R&D supports, TEYDEB, innovation, matching

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Introduction

States may choose to support firms' R&D activities to sustain economic growth. Under the assumption that the benefits of R&D activities are not only obtained by the firm performing the activity but also spread to other segments of society, states' approaches to supporting these activities are also theoretically based (Lucking, Bloom and Van Reenen 2019).

This study analyzes the effects of the Scientific and Technological Research Council of Türkiye (TÜBİTAK) - Technology and Innovation Support Programs Presidency (TEYDEB) supports implemented between 2006-2019 on the economic performance of firms. TEYDEB supports exhibit positive effects, leading to a 6% rise in patent numbers, a 9% increase in value-added, a 26% boost in total wages, a 17% increase in wages per person, 9% growth in employment, a 10% improvement in productivity, 11% rise in exported product variety, and a positive effect of nearly 4% in sales. However, the impacts on productivity and sales are statistically weaker compared to the other effects, and the average impact of patents is economically moderate.

We dissect the effects by firm size, and find that large-scale firms experience a 33% increase in patents and a 13% rise in sales due to the support. These larger firms greatly benefit from multiple support mechanisms, demonstrating enhanced success in both R&D expenditure and the commercialization of innovative outputs. Conversely, smaller firms exhibit more significant productivity effects. Among SME-class firms, productivity gains expand as the scale increases, yet there is no positive impact on productivity in large firms.

Exploring the sub-programs, we observe average effects within the 1501 Industrial R&D program, which ceased to accept large firm applications as of 2019. The 1507 SME R&D Startup program shows slightly above-average investments and productivity increases. Notably, the 1511 Priority Areas program drives greater intangible capital investments growth compared to other programs. The patent numbers and productivity increase are more robust in the 1509 International Industry R&D program than in other programs.

We conduct our analyses using matching techniques and fixed-effect regressions. The decision to invest in R&D or apply for TEYDEB R&D support is viable only for firms possessing specific experience and capacity. Therefore, it is crucial to carefully determine the control group when evaluating the program's impact. All observations from firms that applied to the TEYDEB program in any given year are included in the sample during the production of baseline results. Consequently, the control group comprises a significant portion of rejected firms. Although including the rejected firms in the control group[1] raises doubts about possible selection and endogeneity problems, it also provides an opportunity for the above reasons.

[1]Regression discontinuity design (e.g., (Howell 2017), (Bronzini and Piselli 2016), (Dechezlepretre, et al. Forthcoming)) cannot be used for this analysis because program applications are not evaluated on a continuous scale.

Because the decision to apply for R&D support is not a random process (Meuleman and De Maeseneire 2012), (Blanes and Busom 2004).

Econometric matching methods offer a means to mitigate selection and endogeneity problems. Moreover, alternative results produced by the matching method, based on the data of all firms in the country regardless of their application to TEYDEB, closely align with the base results. We also conducted a robustness test on firms supported by only one project, revealing that the positive effects of the support persist, albeit to a diminishing degree. Nonetheless, while the favorable impacts on sales lose their statistical significance, the effects on the number of patents also lose their economic significance. Notably, as the number of supported projects increases, the positive impact on the number of patents and the commercialization effects demonstrates a marked increase, surpassing other effects.

1. Literature on the Economic Effects of R&D Supports

Examination of R&D supports through application data from many countries[2] revealed the importance of *additionality*. Additionality refers to excess inputs, outputs or firm behavior due to additional input. Measurement problems are less encountered when the independent and affected variables in input-side additionality are of the same nature, whereas measuring the impact in output additionality is more challenging.

When analyzing the impact of R&D support on firms' R&D expenditures, subtracting the support amount from post-impact R&D expenditure can determine whether R&D support leads to positive additionality, partial or complete substitution, or even a negative effect. However, there is less clarity for output additionality. For instance, when examining the impact of R&D support on outputs such as income, employment, or patent production, it is possible to determine whether there is a positive effect and whether the crowding-out effect is entirely or partially occurring. However, a definite preference among additionality, ineffectiveness, or partial crowding-out effects cannot be made.[3]

The theoretical literature that affirms public R&D support emphasizes the importance of the public sector's role due to market failures, such as positive externalities and asymmetric

[2] Different dimensions of R&D support were examined using data from Germany (Brautzsch, et al. 2015), (Hud and Hussinger 2015); United States (Howell 2017), Belgium (Meuleman and De Maeseneire 2012), United Kingdom (Dechezlepretre, et al. Forthcoming), China (Boeing 2016), Finland (Einiö 2014), France (Chiappini, et al. 2022), (Marino, et al. 2016), Ireland (Görg and Strobl 2007), Israel (Lach 2002) Italy (Bronzini and Piselli 2016), Spain (Huergo and Moreno 2017), Canada (Agrawal, Rosell and Simcoe 2020), and Türkiye (Szczygielskia , et al. 2017).

[3]Output additionalities are unclear because both the input and output units where the change occurs are different, and a direct and precise function cannot be determined between the input and output. (Lach 2002) found that R&D subsidies greatly encouraged firm-funded R&D spending for small firms but negatively impacted R&D for large firms. (Boeing 2016, Szczygielskia , et al. 2017) and (Marino, et al. 2016). R&D supports replace private R&D investments (crowd out) with data from China and France. (Einiö, 2014) rejected the hypothesis of exclusion of private R&D investments in the case of Finland.

information in firm-creditor relations (Arrow 1972), (Dimos and Pugh 2016). Furthermore, financial constraints are more prevalent, especially among small firms, which face higher capital costs. In contrast, large firms can finance their R&D investments internally (B. H. Hall 2002). Consequently, R&D expenditures may be inefficiently allocated across firms.

Empirical literature extensively investigates the input and output additionality of R&D supports. Findings from studies on tax deductions and incentives differ between periods before and after 2000 (Hall and Van Reenen 2000). Empirical research before 2000 commonly suggests public support leads to crowding-out effects in private sector R&D expenditures. However, subsequent studies show a growing consensus that support stimulates private R&D spending positively. (Dimos and Pugh 2016) conducted a meta-regression study on 52 input and output additionality studies after 2000. They argue that studies that do not consider endogeneity problems overestimate the effects. In addition, as a result of their meta-regression study, they deny the existence of the crowd-out effect, but cannot find an additionality effect.

Another finding is that subsidies increase R&D expenditures more in small than large firms. This may reflect that small firms' asymmetric information problems and financial constraints are more pronounced (Becker 2015). R&D and Innovation supports can serve as a signal about the quality of the firm, facilitating firms' access to finance on more favorable terms (Chiappini, et al. 2022), (Meuleman and De Maeseneire 2012), (Howell 2017).

A crucial justification for government R&D support is the diffusion of R&D activities within society, known as spillovers. To predict the impact of an R&D subsidy program, it is necessary to consider changes in industries or technological clusters to which supported firms belong, beyond the direct effects on the targeted firms' performance (Klette, Moen, and Griliches 2000). Different studies also indicate the positive effects of R&D tax incentives on not only a firm's own innovation but also the innovation of its technological neighbors (spillovers) (Dechezlepretre et al. Forthcoming), (Lucking, Bloom, and Van Reenen 2019).

Another critical issue when measuring the impact of incentives on R&D expenditures is the "relabeling" problem. Firms receiving R&D tax incentives might be motivated to classify their other expenditures as R&D expenses in some way, leading to the issue of mislabeling (Chen, et al. 2021). Firms not benefiting from incentives may not maintain detailed accounting records that clearly distinguish their R&D expenditures as such. While TEYDEB support may appear as direct assistance instead of tax incentives, the provision of opportunities for firms benefiting from support to enjoy tax reductions and incentives is sufficient to give rise to the mentioned problem. Furthermore, issues stemming from regulatory design can exacerbate this situation. In this study, since the focus will be on output additionality rather than input additionality, the relabeling issue will not apply to a significant portion of the results.

Positive effects of R&D subsidies on patent applications and innovation are observed (Bronzini and Piselli 2016), (Howell 2017), (Azoulay, et al. 2019). The interaction of incentives with the size of the firm ((Agrawal, Rosell and Simcoe 2020), (Özçelik and Taymaz 2008)), the

interaction of the R&D behavior with the firm's origin country (Görg and Strobl 2007), the superiority of R&D subsidies over other consumption subsidies (Brautzsch, et al. 2015), the dependency between private R&D activities in OECD countries (Montmartin and Herrera 2015), the economic conjuncture and the effectiveness of R&D subsidies (Hud and Hussinger 2015), the effectiveness of different types of supports (Huergo and Moreno 2017) were also discussed in the literature.

The following part of the study introduces the TEYDEB supports. The third part presents basic descriptive statistics about project acceptance and data sets. Then, while the methodology of the analysis is discussed in the fourth section, the analysis results are included in the fifth section.

2. About TEYDEB Supports

Technology and Innovation Support Programs Presidency (TEYDEB) supports projects with R&D features to improve the R&D capabilities of the private sector in Türkiye and to increase their innovation capacity and competitiveness, as stated in its directive. Table 1 presents the list of programs included in the analysis and implemented by TEYDEB between 2006-2019. A total of 4.15 billion TL grant was paid within the scope of TEYDEB between 2011 and 2019.[4] The number of paid projects column includes accepted and paid projects and cancelled projects.[5] Although the 1508 Techno-enterprise Program appears in Table 1, it was abolished in 2019. Sub-program definitions are available in TÜBİTAK resources, and only the programs that stand out in total grant volume have been analyzed.

Table 1: TEYDEB Programs, 2011-2019

Program Name	Number of Projects Paid	Pay Per Project	Total Grant Payments
1501 TÜBITAK Industry R&D Projects Support Program	8,425	372,002	3,134,114,660
1507 TÜBİTAK SME R&D Startup	7,368	218,600	1,610,641,116
1511 TÜBİTAK Priority Areas Research Technology Development and Innovation	952	633,911	603,483,558
1509 TÜBİTAK International Industry R&D	460	676,066	310,990,342
1512 Techno-enterprise Capital (BiGG)	1,380	132,263	182,522,636
1513 Technology Transfer Offices (TTO)	25	6,958,835	173,970,867
1601 Capacity Building in Innovation and Entrepreneurship	207	374,347	77,489,916

[4]Payments to projects are only observed for firms supported after 2011.

[5]There are also TEYDEB programs not shown in Table 1 because they cannot be analyzed due to the small number of observations (for example, 1514 Venture Capital Support Program, 1602 TUBITAK Patent Support Program, and 1503 Project Markets Support Program). The volumes of these programs are quite small.

1505 University-Industry Cooperation	254	271,512	68,964,165
1515 Pioneer R&D Laboratories	2	1,052,790	2,105,579
1508 Techno-enterprise	42	25,002	1,050,102
1505 University-Industry Cooperation Feasibility	29	15,308	443,931
Total	**19,144**[6]	**322,073 TL**	**6,165,769,341 TL**

Notes: TL numbers are in 2019 prices.

Figure 1 illustrates the distribution of total real grant payments among different programs. During the period under review, over half of the total grants paid were distributed under the 1501 Industrial R&D Program. Although this program was closed to applications from large companies in 2019, these companies could still benefit from it during the analyzed period. Secondly, the 1507 SME R&D Startup program holds a share of 26%, followed by the 1511 Priority Areas Research program with 9.8% share. These are succeeded by the 1509 International Industrial R&D program with a 5% share and the 1512 BiGG and 1513 TTO programs with shares ranging between 2.8% and 3%. The first four programs in Figure 1 account for 91.78% of the total grant payments made between 2011 and 2019, while the first seven programs make up 98.7%.

Figure 1TEYDEB Programs

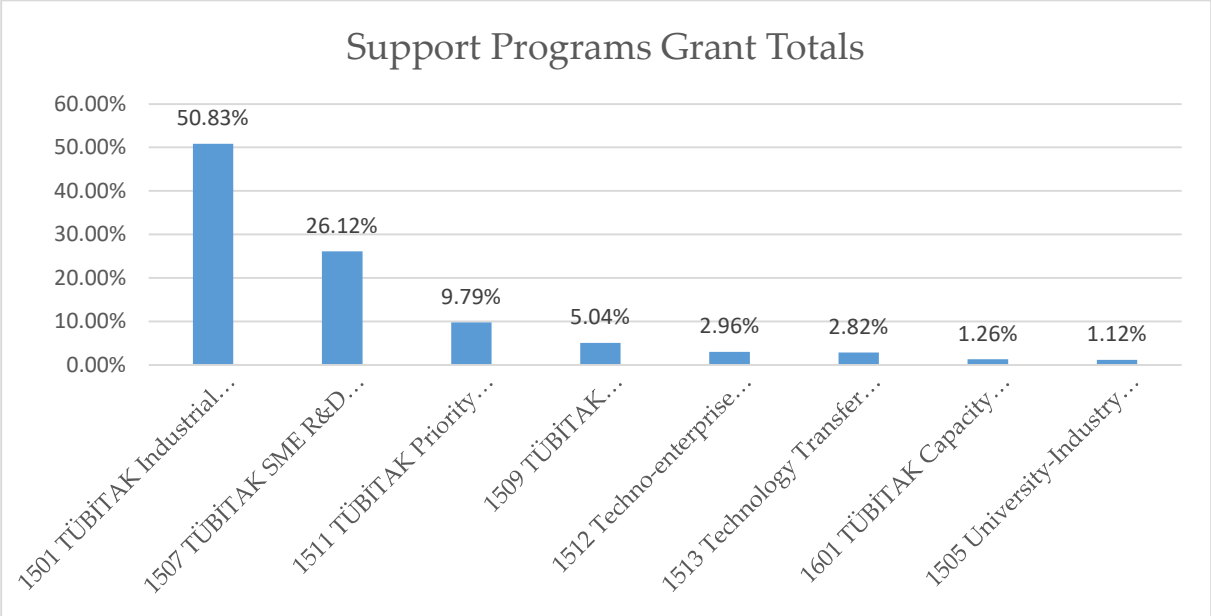

Table 2 examines the shares of programs with payments exceeding 1% over the years. Within the total amount of real grant disbursed during the period of 2011-2019, the share of the 1507 SME R&D Initiation program decreased after 2015, while the share of the 1511 Priority Areas program increased partially. With the inclusion of large firms to this program in 2019, the share of the 1511 Priority Areas program can be expected to increase. The share of the 1501

[6]It indicates that the project-firm pair exceeds the total number of accepted projects. More than one firm can receive support within the scope of a project.

program has remained stable, albeit with changes over time. Similarly, the stated change can be expected to lead to a reduction in the share of this program.

Table 2: TEYDEB Programs, 2011-2019 Grant Payments Program Shares

Program	2011	2012	2013	2014	2015	2016	2017	2018	2019
1501 TÜBİTAK Industrial R&D Projects	6.8%	6.7%	6.6%	5.8%	5.3%	4.0%	4.6%	5.7%	5.5%
1507 TÜBİTAK SME R&D Startup Support Program	2.6%	2.6%	3.3%	4.0%	4.0%	2.5%	2.6%	2.4%	2.0%
1511 TÜBİTAK Priority Areas Research Technology Development and Innovation	0.0%	0.0%	0.6%	1.4%	2.0%	1.1%	1.2%	1.7%	1.9%
1509 TÜBİTAK International Industrial R&D Projects	0.4%	0.5%	0.4%	0.5%	0.6%	0.5%	0.6%	0.7%	0.7%
1512 Techno-enterprise Capital Support Program (BiGG)	0.0%	0.0%	0.2%	0.4%	0.3%	0.3%	0.5%	0.9%	0.4%
1513 Technology Transfer Offices	0.0%	0.0%	0.3%	0.5%	0.6%	0.5%	0.5%	0.3%	0.3%
1601 Capacity Building in Innovation and Entrepreneurship	0.0%	0.0%	0.0%	0.0%	0.2%	0.2%	0.3%	0.3%	0.3%
1505 University-Industry Cooperation Support Program	0.0%	0.0%	0.1%	0.2%	0.2%	0.2%	0.1%	0.2%	0.2%

3. Dataset and Basic Descriptive Statistics

This study uses the project application data on TEYDEB supports as the primary data set. The data set includes information such as budget proposals, project definitions, project area codes, firm sector codes, applied program information, the current status of the project as of 2019, the roles of firms in the project (executive or partner organization) regarding the project applications made by firms between 2006-2019. The list includes grant payments made to projects between 2011-2019.[7] The TEYDEB Project Data Set has 36,953 project applications between 2006-2019. We augment this data with the micro-level datasets from the Entrepreneur Information System (EIS) for our analysis.

In Table 3, projects are categorized by their acceptance status. Completed and ongoing projects for which payments have been made but the process is still ongoing, were considered as supported projects. Of 14,154 projects, 394 that had payments made but were subsequently terminated were deemed unsupported. Consequently, 13,760 projects were identified as accepted and supported in the dataset. Hence, for a firm to have at least one supported project implies that it has been influenced by the independent variable used in the analysis since the project's inception.

[7]TEYDEB Project Data Set shows the payments made between 2011-2019. While the project application information of all firms that applied after 2011 is available, there may be deficiencies in the data of the firms that applied between 2006-2011. The results remain the same even when the analyses run only on the project sample after 2011.

Table 3: TEYDEB Project Dataset, Project Statuses

Project Status		Project Application	Number of Projects Paid
Created Status	Status Seen in Data		
Accepted	Completed	14135	11876
Those received payments are accepted, others uncertain.	In the monitoring process	1820	1658
	Support process started	1534	183
	Reviewed in committee	388	17
	To be reviewed by the committee	272	11th
	Missing completed	19	8
	Missing is expected	28	7
Uncertain	Pre-committee preparation	44	0
	Support decision cancelled	281	0
	No expense notification	8	0
	Under referee evaluation	921	0
	Under preliminary assessment	61	0
	Withdrawn during monitoring	38	0
	The proposal was withdrawn	604	0
Rejected	Rejected	15345	0
Cancelled	Terminated	1455	394
	Total	**36953**	**14154**

Table 4 shows the shares of the sectors in grant payments. The proportion of payments made to projects that do not have a sector code is in the range of 10-20%. Table 4 excludes these projects. The sector that benefits most from TEYDEB support is the informatics sector. Machinery manufacturing, automotive, electrical-electronics, telecommunications, pharmaceuticals, and defence industries are other prominent R&D sectors in grant payments.

Table 4: TEYDEB Project Dataset Grant Payments R&D Sector Shares

Sector	**2016**	**2017**	**2018**	**2019**
Informatics	27.8%	30.3%	30.7%	31.5%
Machinery Manufacturing	12.8%	12.2%	13.1%	12.0%
Electrical Electronics	12.2%	11.7%	10.9%	9.4%
Automotive	7.2%	5.8%	6.5%	10.8%
Telecommunication	6.7%	7.6%	7.9%	7.5%
Pharmaceuticals	4.4%	3.3%	3.7%	6.1%
Defense Industry Sector	2.9%	5.4%	6.1%	2.3%
Biomedical	5.0%	4.2%	3.1%	3,5%
Chemical	4.3%	3.3%	2.9%	3.4%
Energy	3.4%	3,5%	3.7%	2.9%
Agriculture	2.9%	2.2%	2.1%	1.7%
Food industry	1.9%	2.6%	2.2%	1.3%

Textile	1.6%	1.9%	1.4%	2.1%
Metallurgy	1.7%	1.1%	1.6%	1.5%
Aerospace	0.9%	1.1%	1.6%	0.4%
Material	1.2%	1.1%	0.6%	1.1%
Household appliances	1.0%	0.7%	0.7%	0.6%
Environmental Techn.	0.6%	0.5%	0.4%	0.5%
farming	0.8%	0.4%	0.2%	0.3%
Ship and Maritime	0.4%	0.6%	0.3%	0.5%
Mining	0.2%	0.3%	0.2%	0.4%
Seafood	0.1%	0.1%	0.001%	0.1%

Table 5 shows the project application and acceptance counts of firms. The first column represents the project application numbers, while the first row displays the project acceptance numbers. For instance, while there are 4,507 firms with one project application but no acceptance, 2,826 firms have received project acceptance. No firms with ten or more project applications have received rejections. The cumulative application/acceptance counts for associated firms are not presented in this matrix; however, the total applications of firm groups exceed the mentioned maximum figures. Within the TEYDEB Project Data Set, 13,858 firms have made project applications between 2006 and 2019. Payments made to a single company amount to a maximum of 1.93% of the total grant payments. 197 companies have more than 10 project acceptances. These companies have received a total grant payment of 1.29 billion TL in current values between 2011 and 2019, which accounts for approximately 33% of the total payments during the same period.

Table 5: TEYDEB Projects Application-Acceptance Matrix

Number of Applications / Number of Acceptances	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**	**Total**
1	4507	2826										**7333**
2	1029	1177	577									**2783**
3	225	507	404	173								**1309**
4	79	176	242	183	39							**719**
5	35	79	127	113	81	12						**447**
6	8	32	66	76	55	33	5					**275**
7	6	11	39	55	42	36	15	1				**205**
8	4	9	18	30	33	32	24	8	2			**160**
9	2	2	7	11	18	27	22	14	1	-		**104**

10+	-	4	15	21	44	56	66	44	50	26	197	**523**
Total	**5895**	**4823**	**1495**	**662**	**312**	**196**	**132**	**67**	**53**	**26**	**197**	**13858**

4. Methodology

When analyzing the effects of the TEYDEB program, it is necessary to define the status of being supported within the program as an independent variable. However, how the status of being supported is defined can influence the analysis results. For instance, TEYDEB projects can be jointly carried out by multiple firms, and the payments made under the support might only be distributed to some firms involved. In this case, it becomes essential to determine whether being classified as "supported" should only involve receiving payments or being part of the project implementation along with other collaborating firms. This study defines engaging in a TEYDEB project in the broadest sense as being supported by TEYDEB. Thus, it is assumed that firms involved in projects benefit from the prestige-related and non-grant (tax-related) benefits of TEYDEB and project outputs, even if they have not received grant payments.

Another aspect that emerges when analyzing TEYDEB effects is that some firms might have been supported under multiple projects (this can be observed in Table 5). Therefore, the adopted method initially applies to measure the average effect of being supported by TEYDEB regardless of the number of projects. Subsequent analyses then focus on examining the impact of being supported in a single project.

The question arises whether a firm supported by TEYDEB has shown performance improvement due to this support or whether firms that would already experience relatively higher performance are the ones being supported. The literature has introduced various methods to overcome these complexities. The availability of detailed micro-level data on firms (balance sheet data, inter-firm transactions, TEYDEB application-payment data, import-export data) makes matching methods suitable for analysis. Additionally, matching firms based on characteristics that could influence TEYDEB project acceptance processes and the dependent variables of interest helps minimize endogeneity concerns. If endogeneity arises from observable variables, the matching method is sufficient for analysis. In some matching analyses, to control for endogeneity caused by firm-specific and time-invariant effects, an alternative approach involves taking the annual differences of the dependent variables for the same firm, expressed as Dlog.

While studies employing matching methods use cross-sectional data, there are also research and methodological studies that apply matching techniques to unbalanced panel datasets (González and Pazó 2008), (Szücs 2020). Specific issues can arise when classic matching methods are applied to panel data. As mentioned by (Nielsen and Sheffield 2009), standard matching methods match observations instead of panels and tend to create potential

statistical problems. The authors also suggest that matching panels with themselves (i.e., the same firm's observations from different periods) can lead to biased estimates. The first concern can be minimized by reducing the matching characteristic value in firm observations for all years to that of a single year's characteristic. The second issue can be resolved by applying exact matching over the years. The second solution also ensures that observations from different years are not compared.

In the matching method, each cluster contains one supported observation and a determinable number of unsupported observations (nearest neighbors). Matching results are computed by averaging the outcomes generated within each nearest neighbor cluster (Abadie, et al. 2004). Similar outcomes are obtained when the number of unsupported observations in the clusters is one, two, three, or four, and to prevent the results from depending on a single observation, the number of nearest neighbors in the clusters is not allowed to be fewer than two.

Furthermore, the matching covariates should be characteristics that remain constant over time. Matching firms based on characteristics that change due to program effects or expectations can lead to an endogeneity problem. To overcome these mentioned issues, fixing the characteristics used for matching firms can be a solution. However, when firms have made numerous project applications, determining when these characteristics should be fixed becomes a consideration. Faced with these questions, results were generated using various specifications and these results were compared with firm-fixed effects regressions.

In the primary analysis, while investigating the average effect of the TEYDEB program regardless of the number of projects, characteristics are fixed to the years where project applications are observed. By fixing the matching characteristics in application years, firms are treated as new entities when making new applications. This method falls somewhere between matching panels (keeping firm matches between control and experimental groups constant over time) and matching each observation individually. To measure the robustness of these results, the analysis scope is further reduced to firms that have executed at most one project, ensuring matching firms across panels. These results are also consistent with the baseline scenario outcomes. Exact matching over the years ensures that firms are not matched with themselves. Additionally, since firms do not possess the characteristics of acceptance or rejection before their initial project application, pre-application observations are not included in matching analyses.

To measure matching performance, the pre-match and post-match distributions of firm size (total assets) and firm liability/asset ratio values, which are matching characteristics, are compared in Figures 2 and 3, respectively. Blue lines represent the control group, while red lines represent the experimental group. The fundamental specification for matching models, which transforms firms' characteristics into step functions by fixing them to application years and matches observations based on these characteristics, is employed in these graphs. The success of matching in achieving covariate balance is also evaluated.

The graphs indicate the success of the matching model. When looking at the left panels of the figures, it can be observed that in the absence of matching, the experimental group firms significantly deviate from the control group firms. This disparity is eliminated thanks to the matching method, and as shown in the right panels, similar firms are compared. A similar pattern is evident when examining the balance matrices of the other characteristics used in the matching process.

Figure 2: Matching Performance, Log (Real Total Assets)

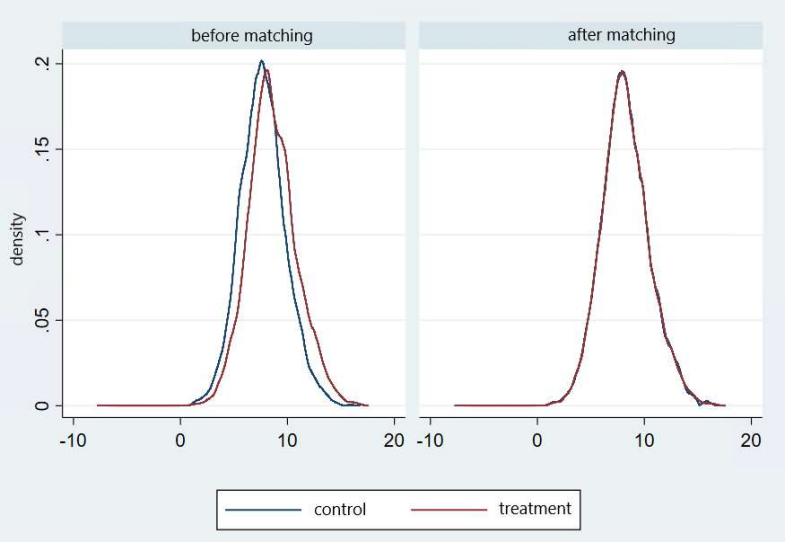

Figure 3: Matching Performance, Total Liabilities/Total Assets

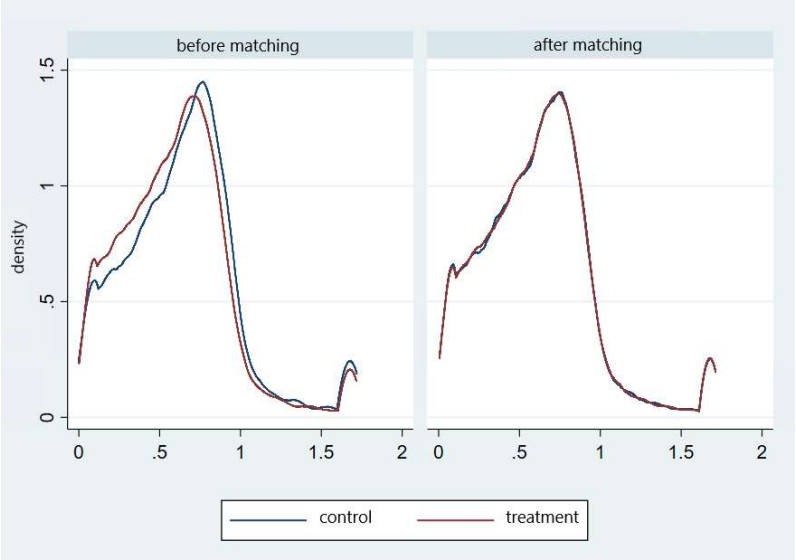

Table 6: Summary T - Statistical Values of Firms Supported by TEYDEB

	Count	Average (Unsupported)	Count	Average (Supported)	Difference
Number of Patents	74996	0.03	49352	0.47	-0.442***
Total Wages	74996	201761	49352	669801	-468040***
Employment	74996	88.44	49352	183.82	-95.377***
Δ (log (Employment))	58161	0.10	43643	0.04	0.06***
Δ (log (Total Fixed Assets))	74996	18045	49352	53288	-35242***
Tangible Fixed Assets	74996	9541.2	49352	28312	-18771***
Sales	74996	38696	49352	134178	-95483***
Δ (log (Sales))	63101	37737	46472	2525	35213
EBITDA	74985	3136	49344	15132	-11997***
Productivity	58256	78.2	40195	69.9	8.3***
Exported Products	74996	5.8	49352	13.6	-7.9***
Long-Term Debt Ratio	74756	0.16	49148	0.19	-0.03***
Bank loans rate	74994	0.13	49350	0.15	-0.02***
Total Liability Ratio	74994	0.62	49350	0.59	0.03***
Total Assets	74996	38640	49352	128598	-89959***
Export Dummy	74996	0.51	49352	0.61	-0.11***

Notes: Tangible fixed assets, Sales, and Total assets are in Thousand Tl. Wages are quarterly total wages and in TL.

Table 6 presents the average values for supported firms and observations that were not supported (rejected) for the control and outcome variables used in this study, along with the differences in means. This table uses current values for Turkish lira variables, whereas real values are employed in the analyses. The variable Exported Products represents the number of 12-digit HS-coded exported products. For the productivity variable, weights (elasticity) are measured for each industry using the method proposed by (Ackerberg, Caves and Frazer 2015), and total factor productivities are calculated using data for factor inputs.

The control group in the matching analyses consists of firms whose applications for TEYDEB support were rejected. However, in the fixed-effects robustness regressions, where rejected firms are primarily used as the control group, regressions are also conducted using firms that have made R&D expenditure at least once or have received R&D support from KOSGEB. The results from these analyses also exhibit consistency.

Rejected firms can provide an ideal sample base for evaluating the effects of the incentive program due to their similarity in characteristics and operation in the same market as accepted firms (Meuleman and De Maeseneire 2012), (Blanes and Busom 2004), (Klette, Moen and Griliches 2000). Comparing the performance of rejected firms with that of supported firms enables the measurement of the impact of the support program on firms' performance using specific methods. Additionally, in robustness analyses, firms that have conducted R&D expenditure at least once in the relevant period and firms supported within the KOSGEB SME-Development program are also included in the analysis sample.

In Table 7, when comparing the second and third rows, it becomes apparent that on average, a firm that applied to TEYDEB and got rejected employs more personnel, has higher revenue, engages in research and development (R&D) spending that is one hundred times higher, and possesses eighty times more patents compared to the general economy. On the other hand, an average firm with a supported project has ten times more patents, more than twenty-two times higher R&D expenditures, nearly four times the revenue level, and twice the personnel compared to an average firm with a rejected proposal.

Table 7: Average Outlook of Firms Supported by TEYDEB, 2018

Averages[8]	Number of Workers	Revenue	R&D Expenditure[9]	Patents Count	Number of Firms
Firms Receiving TEYDEB Support	180	198 MM	4.1 MM	0.47	6.410[10]
Firms Rejected by TEYDEB	78	55 MM	181 K	0.04	4,647[11]
All Firms Submitting B/S	10	7 MM	25 K	0.004	1.16 MM

The TEYDEB Supports dataset contains 13,858 firms with EIS identification numbers. The number of firms that match with financial statement data is 13,360. Payments to firms without

[8]Only the observations from firms that submitted balance sheets in 2018 have been used.

[9] Here, we present the averages over the capitalized expenses in the balance sheets. Tables 17-20 use balance sheet numbers, while 21 and 22 use R&D expense items taken from the income statements.

[10]Firms with at least one TUBITAK project approved by the end of 2018 and submitted financial statements in 2018 are included in the sample.

[11]Firms that have not had any TUBITAK projects approved by the end of 2018 and have submitted financial statements in 2018 are included in the sample.

balance sheet data, totalling 498, account for about 3% of the total payments, as they did not submit balance sheets for the entire 2006-2019 period. These firms have a total of 393 project acceptances. The primary sample for analysis consists of 124,348 observations from different years for 13,360 firms matched with financial statement data.

The model specifications used in the analyses are briefly as follows. First, probit analyses in Equation (1) were performed to identify variables determining the probability of project application acceptance:

$$I(Project\ accepted)_{ft} = \alpha + \beta Firm\ controls_{t-1} + \varepsilon_{ft} \quad (1)$$

Next, analyses employing matching and difference-in-differences methods were conducted to examine the effect of the support variable on various economic performance variables at the firm level. The specification for difference-in-differences models can be generally expressed as in Equation (2):

$$Dependent\ variable_{i,t} = \beta_0 + \beta_1 Suppport\ variable_{i,t-1} + \beta_2\ Firm\ controls_{i,t-1} + Firm\ FE_i + Year\ FE_t + Province\ FE_p + Sector\ FE_s + \varepsilon_{i,t} \quad (2)$$

All analyses employed inflation-adjusted real values using the Consumer Price Index (CPI). Independent variables represent values at time *t*; logarithmic dependent variables represent time *t+1*, and logarithmic difference (DLog) variables represent the difference *(t+1) – (t)*. The support variable is defined as a binary variable. Observations of *support variable* for unsupported firms and pre-support observations for supported firms are assigned a value of 0, while post-support observations for supported firms are assigned a value of 1.

5. Analysis Results

TEYDEB Supports are initially analyzed across all programs to measure average effects. For this purpose, a support dummy variable for firms supported by TEYDEB between 2006 and 2019 is calculated. This variable takes the value of 1 for the first year of support, 0 for previous years, and is marked as 0 for observations belonging to firms that applied but were rejected for all years. The results obtained through matching and difference-in-differences methods are presented sequentially.

Factors Determining Project Acceptance

We employed the matching method to address endogeneity issues through observed variables and used fixed effects regressions in subsequent analyses to control for variations at the single-layer level (firm and/or year) and unobservable variations. To determine which matching characteristics or control variables to use in the analyses, we identified variables explaining the probability of project acceptance from TEYDEB. This approach also aims to address selection problems. To explore the optimal variable set, we conducted multiple probit

analyses using financial ratios derived from EIS data, firm indicators, firm size indicators, export, innovation outputs, firm age, and numerous other variables.

Table 8 examines the factors influencing the likelihood of firms' project acceptance. These factors include prior support history, the number of project applications made by the firm in that year, firm size (total assets or employment), long-term and total debt ratios, export status, and the number of patents. All these factors have a positive impact, but firm age has a negative effect. In general, we used the variables in Table 8 as matching covariates in matching analyses. Additionally, we matched firms based on sector (2-digit NACE code), province, and year.

Table 8 and other tables do not report standard errors but provide statistical significance. The triple asterisk (***) symbol denotes 99% statistical significance ($p < 0.01$), the double asterisk (**) symbol denotes 95% statistical significance ($p < 0.05$), and the single asterisk (*) symbol denotes 90% statistical significance ($p < 0.1$).[12]

Table 8: Project Acceptance Probability - Probit Analysis

	Project Acceptance		
Being Supported	0.212***	0.145***	0.141***
Number of Applications		0.248***	0.242***
log(Total Assets)	0.0635***	0.0399***	0.0402***
Long-Term Debt Ratio	-0.150***	-0.133***	-0.132***
Export Dummy	0.0513***	0.0730***	0.0783***
Total Debt Ratio	-0.0521**	-0.0752***	-0.0808***
Firm Age			-0.0186*
log(Number of Patents)			0.0614***
Constant	-0.603***	-0.711***	-0.690***
Number of Observations	23,326	23,326	23,326

Effects of TEYDEB Programs on Firms

In this section, we analyze how the performance and sizes of firms supported by any TEYDEB program change compared to rejected firms. By comparing the results of various methods, we investigate the sensitivity of the outcomes to different specifications. First, in the matching analyses, firms' relevant characteristics are fixed at their values for each project application date, and subsequent-year observations are measured based on these characteristics.

[12] The variables used in the analysis, Δlog (Fixed Assets) and Δlog (Employment), have been winsorized at both tails of the distribution at the level of 0.5%. Long-Term Debt Ratio, Δlog (Sales), and Δlog (Total Fixed Assets) variables have been winsorized at 1%, and Total Debt Ratio and After-Tax Profit/Assets variables have been winsorized at 2.5%.

After the initial matching analysis, a second matching analysis is conducted with year-based exact matching in addition to the used characteristics. This strategy prevents different observations of the same firm (supported and rejected) from being evaluated within the same cluster in different years.

Matching Results

When the results presented in Table 9 are examined, it is observed that the support of TEYDEB positively affects the number of patents, wages, employment, sales, profit rates, total fixed asset growth, tangible asset growth, and productivity. The economic significance of the positive effects on the number of patents is limited, but the dimensions of the effects on other indicators, especially productivity, are quite high.

Looking at the results reproduced by exact matching on every year in Table 10, it is seen that the coefficients (except for sales) remained similar despite a slight decrease. As a result, TEYDEB supports are found to have more than a 5% positive effect on the number of patents, 10% on value-added and productivity, and 9% and 17% on employment and per capita wages. In addition, the number of products exported increases by 11%. Although sales initially showed more than 5% positive impact, this effect becomes statistically insignificant when year-based exact matching is applied. Positive effects on after-tax profit should also be evaluated considering the potential influence of tax incentives or grants.

Table 9: Average Effects of TEYDEB Supports [13], Matching 1

	log(Number of Patents)	Log(Total Wages)	Log(Wage Per Person)	Log(Employment)	Δlog (Employment)	Δlog (Total Fixed Assets)
TEYDEB Support	0.0532***	0.267***	0.168***	0.0940***	0.0350***	0.0398***
Number of Observations	63,581	60,364	60,383	60,383	59,756	62,710
	log(Sales)	Δlog (Sales)	Profit/Assets After Taxes	log(Productivity)	log(Productivity 20+)[14]	Δ log (Tangible Fixed Asset)
TEYDEB Support	0.0385***	0.0536***	0.0334***	0.106***	0.112***	0.0234***

[13]The matching models in Table 8 and the following tables use debt ratios, total asset level and the export dummy as matching characteristics. In addition, in Table 8, firms are matched based on the count of project applications they have made. Notably, the results remain consistent in their direction even upon after including province and sector variables.

[14] Productivity is calculated for firms employing at least 20 workers.

Number of Observations	63,468	63,428	63,581	53,122	30,981	62,047
Matching Characteristics:	Long-Term Debt Ratio, Total Debt Ratio, Total Assets, Export Dummy Variable, Number of Project Applications					

Table 10: Average Effects of TEYDEB Supports, Matching 2

	log (Number of Patents)	log (Total Wages)	log (Per Person Wages)	log (Employment)	log (Exported Products)
TEYDEB Support	0.0582***	0.259***	0.167***	0.0887***	0.110***
Number of Observations	63,581	60,364	60,383	60,383	53,881
	log (Sales)	Profit/Assets After Taxes	log (Productivity)	log (Productivity 20+)	log (Value-added)
TEYDEB Support	0.0197	0.0336***	0.0971***	0.134***	0.0959***
Number of Observations	63,468	63,581	53,122	30,981	55,272
Matching Characteristics:	Year (Exact Matching), Long-Term Debt Ratio, Total Debt Ratio, Total Assets, Export Dummy Variable				

The Difference Model of Differences

When the results estimated by the difference of differences model and shared in Table 11 are examined, it is observed that although the coefficients of the effects of TEYDEB supports change (except for productivity), the effects do not change direction. While matching analyzes show positive effects on productivity, there is a low negative effect in the presence of firm fixed effects. On the other hand, positive effects on value-added, sales, employment, wages and export diversity are preserved.

Table 11: Average Effects of TEYDEB Supports, Difference of Differences

Difference of Differences	log (Number of Patents)	log (Total Wages)	log (Per Person Wages)	log (Employment)	log (Exported Products)
TEYDEB Support	0.018***	0.077***	0.021**	0.054***	0.060***

Number of Observations	98,091	93,230	93,255	93,255	82,655
R2	0.514	0.921	0.794	0.922	0.79

	log (Sales)	Profit/Assets After Taxes	log (Productivity)	log (Productivity 20+)	log (Value-added)[15]
TEYDEB Support	0.041**	0.003**	-0.015**	-0.002	0.040***
Number of Observations	97,820	98,090	81,287	45,534	84,525
R2	0.883	0.622	0.607	0.678	0.861
Fixed effects:	Firm, year, sector, province fixed effects				
Control Variables:	Exporter firm dummy variable, short- and long-term debt ratios, log (total assets)				

Firms Receiving Support Once

Some firms can benefit more intensively from being supported by multiple projects. To eliminate this disparity among firms and investigate whether the effects persist specifically for firms that receive support only once, the treated group is restricted to the subset of firms supported only once. Out of the 13,858 firms in the dataset, 5,895 firms had their applications rejected, 4,823 firms had only one application accepted, and 3,140 firms had multiple applications accepted (Table 5). Table 12 examines whether the effects are persistent for 4,823 firms supported only once within the treatment group. In comparison, the observations of 5,895 rejected firms are examined in the control group of the analysis.

Table 12: Impact of One-Time Support, Matching

	log (Number of Patents)	log (Total Wages)	log (Per Person Wages)	log (Employment)	log (Exported Products)
TEYDEB Support	0.00776***	0.158***	0.0935***	0.0615***	0.0574***
Number of Observations	41,880	39,152	39,163	39,163	34,287

	log (Sales)	Profit/Assets After Taxes	log (Productivity)	log (Productivity 20+)	log (Value-added)
TEYDEB Support	0.0129	0.0104***	0.0357***	0.0228	0.0511***
Number of Observations	41,880	41,880	34,094	17,514	35,910

[15]The value-added variable is calculated by subtracting the purchases (declared purchase-sales) made by the firms from their total sales (income declaration).

Matching Characteristics:	Year (Exact Matching), Long-Term Debt Ratio, Total Debt Ratio, Total Assets, Export Dummy Variable

According to Table 12, receiving TEYDEB support only once has significant positive impacts on all variables except sales. However, the already limited effect on the number of patents has lost its economic significance. There are significant positive effects on value-added, wages, employment, productivity, and the diversity of exported products. Nevertheless, the positive effects on productivity lose their statistical significance in the presence of firm fixed effects when the differences-in-differences model is applied (Table 13). Although the impact of support on sales appears to be positive, it is not statistically significant.

Table 13: Impact of One-Time Support, Difference in Differences

Difference of Differences	log (Number of Patents)	log (Total Wages)	log (Per Person Wages)	log (Employment)	Log (Exported Products)
TEYDEB Support	0.006***	0.031**	0.007*	0.021**	0.047***
Number of Observations	69562	65503	65518	65518	56965
R2	0.263	0.903	0.785	0.904	0.750
	log (Sales)	Profit/Assets After Taxes	log (Productivity)	log (Productivity 20+)	log (Value-added)
TEYDEB Support	0.003	0.002	-0.008	0.005	0.022*
Number of Observations	69365	69561	56621	28552	59350
R2	0.863	0.615	0.607	0.674	0.838
Fixed effects:	Firm, year, sector, province fixed effects				
Control Variables:	Exporter firm dummy variable, short and long-term debt ratios, total assets				

Within the scope of TEYDEB programs, it has been observed that conducting only one project has significant positive effects on value-added, wages, employment, and the diversity of exported products. The effects on productivity are only observable in the matching model, while the impact of a project on the number of patents is not economically significant.

Program-Specific Effects

In this section, the effects of different sub-programs are examined in detail. Four significant programs with over 90% of the total payments between 2011 and 2019 have been analyzed separately. The results for programs coded 1501, 1507, 1509, and 1511 are presented along with the descriptions and objectives of the programs.

1501 - TUBITAK Industrial R&D Projects Support Program

The objective of the 1501 program for the period after 2019 is stated on TÜBİTAK's website as follows: "The 1501 Industrial R&D Support Program aims to support project-based [16] research, technology development, and innovation activities of Small and Medium-Sized Enterprises (SMEs)." Before 2019, this program provided support to both SMEs and large firms. The exclusive support program for SMEs within the scope of this analysis (2006-2019) is only the 1507 program.

The results in Table 14 show that the 1501 program leads to a 10% increase in patents and productivity. The increase in productivity is observed in the matching models but not in the fixed effects analysis. Regarding its impact on the number of patents, the 1501 program surpasses the average effects. However, tangible asset growth (investment) effects fall below average (compared to Tables 9 and 10).

Table 14: 1501 - TÜBİTAK Industry R&D Projects, Twinning

1501 Industry	log (Number of Patents)	Log (Total Wages)	Log (Wage Per Person)	Log (Employment)	Log (Employment)	Log (Total Fixed Assets)
TEYDEB Support	0.0956***	0.238***	0.140***	0.0996***	-0.0158***	-0.0163**
Number of Observations	27,190	26,473	26,478	26,478	26,331	26,978
	Δ log (Tangible Fixed Asset)	log (Sales)	Log (Sales)	(Profit/Assets After Taxes)	log (Productivity)	log (Productivity 20+)
TEYDEB Support	-0.0234***	0.00940	-0.00565	0.0230***	0.0914***	0.117***
Number of Observations	26,814	27,136	27,115	27,190	23,463	17,948

[16] https://www.tubitak.gov.tr/tr/destekler/sanayi/ulusal-destek-programlari/icerik-1501-tubitak-sanayi-ar-ge-projeleri-destekleme-programi

Matching Characteristics:	Year (Exact Matching), Long-Term Debt Ratio, Total Debt Ratio, Total Assets, Export Dummy Variable

1507 - TÜBİTAK SME R&D Start-Up Support Program

The 1507 program exclusively supports SMEs. The results for this program are presented in Table 15, and it has been found that the program has positive effects on all examined indicators of firms except for their revenue levels. There are slightly above-average positive effects detected on the number of patents and employment and slightly below-average positive effects observed on investment and productivity variables. The increase in productivity in supported SMEs is more pronounced than in larger firms, as evident in the firm scale analysis. While both large firms and SMEs are supported in the 1501 program, only SMEs are supported in the 1507 program.

Table 15: 1507 - TÜBİTAK SME R&D Startup- Matching

1507 SME R&D Startup	log (Number of Patents)	Log (Total Wages)	Log (Wage Per Person)	Log (Employment)	Log (Employment)	Log (Total Fixed Assets)
TEYDEB Support	0.0205***	0.159***	0.133***	0.0217**	0.0316***	0.0403***
Number of Observations	44,053	41,558	41,572	41,572	41,068	43,394
	Δ log (Tangible Fixed Asset)	log (Sales)	Log (Sales)	Profit/Assets After Taxes	log (Productivity)	log (Productivity 20+)
TEYDEB Support	0.0320***	-0.00138	0.0421***	0.0263***	0.105***	0.139***
Number of Observations	42,905	44,009	43,990	44,053	36,775	18,088
Matching Characteristics:	Year (Exact Matching), Long-Term Debt Ratio, Total Debt Ratio, Total Assets, Export Dummy Variable					

1509 - TUBITAK International Industry R&D Projects Support Program

According to the information on TÜBİTAK's website, the 1509 program aims to support organizations based in Türkiye that conduct international R&D and innovation projects. The goal is to enhance the technical competence and knowledge accumulation in Türkiye, facilitate

access to international technological expertise and technology transfer, internalize acquired technological knowledge and experience within organizations, accelerate the development of original technologies, and contribute to the participation of organizations in international markets. As a result, only organizations participating in the EUREKA program and based in Türkiye are eligible to apply for this program.[17]

Table 16: 1509 - TÜBİTAK International Industry R&D, Matching

1509 International Industry R&D	log (Number of Patents)	Log (Total Wages)	Log (Wage Per Person)	Log (Employment)	Log (Employment)	Log (Total Fixed Assets)
TEYDEB Support	0.196***	0.118*	0.157***	-0.0363	-0.0215	-0.0104
Number of Observations	4,273	4,109	4,112	4,112	4,057	4,246
	Δ log (Tangible Fixed Assets)	log (Sales)	Log (Sales)	(Profit/Assets After Taxes)	log (Productivity)	log (Productivity 20+)
TEYDEB Support	-0.0250	-0.204*	-0.0487	0.0260*	0.183***	0.252***
Number of Observations	4,185	4,254	4,248	4,273	3,523	2,428
Matching Characteristics:	Year (Exact Matching), Long-Term Debt Ratio, Total Debt Ratio, Total Assets, Export Dummy Variable					

As seen in Table 16, the firms supported by the 1509 program exhibit a significant increase in patent numbers, per capita wages, and productivity indicators. However, strong, and significant effects could not be found on other indicators. The increase in patent numbers and productivity observed within this program signifies a valuable return on integrating international support, emphasizing its importance. The increase in per capita wages and patent counts are consistent with existing R&D and productivity literature.[18]

[17]For detailed information, see: https://www.tubitak.gov.tr/tr/destekler/sanayi/uluslararasi-ortakli-destek-programlari/icerik-1509-tubitak-uluslararasi-sanayi-ar-ge-projeleri-destekleme- schedule

[18] (König, Liu, & Zenou, 2019) and (Banal-Estanol, Duso, Sldeslachts, & Szcs, 2022) demonstrate that R&D collaborations among companies have a positive and significant impact on output and profit. However, (Beck, Lopes-Bento, & Schenker-Wicki, 2016) show that R&D collaborations do not lead to additional improvements in policy influence in the Swiss example.

1511 - TÜBİTAK Priority Areas Research Technology Development and Innovation Program

The 1511 program has considerably higher average support amounts compared to 1501 and 1507 (Table 1), and it is a program that issues calls based on a priority products list. Starting from 2019, large firms are directed towards the 1511 program instead of 1501 and 1507. As defined on TÜBİTAK's website: "This program aims to develop the production capacity of critical products and with high future potential for Türkiye." In firms supported by this program, patent numbers and per capita wages increase above the average. For firms supported by the 1511 Program, a similar level of productivity increase, as presented in Table 9, can be observed. This program is not expected to increase sales or profitability immediately. The most notable result is the significant differentiation in total fixed and tangible fixed assets growth, specifically within this program. Firms supported by this program show increased investments in intangible fixed assets (R&D expenditures, trademarks, patents, and so on.).

Table 17: 1511 - TÜBİTAK Priority Areas, Twinning

1511 Priority Areas	log (Number of Patents)	Log (Total Wages)	Log (Wage Per Person)	Log (Employment)	Log (Employment)	Log (Total Fixed Assets)
TEYDEB Support	0.0675***	0.0363	0.155***	-0.116***	0.0189	0.0464***
Number of Observations	11,197	10,737	10,742	10,742	10,592	11,084
	Δ log (Tangible Fixed Asset)	log (Sales)	Δlog (Sales)	Profit/Assets After Taxes	log (Productivity)	log (Productivity 20+)
TEYDEB Support	-0.00172	-0.116***	0.00786	-0.0205***	0.0439	0.132***
Number of Observations	10,976	11,168	11,150	11,197	9,313	5,521
Matching Characteristics:	Year (Exact Matching), Long-Term Debt Ratio, Total Debt Ratio, Total Assets, Export Dummy Variable					

Breakdown of Effects by Firm Size

In this section, the effects of TEYDEB supports are examined based on firm size. Results are presented for micro, small, medium, and large-scale firms using the SME definitions from the EIS dataset. Compared to the average effects in Tables 8 and 9, the effects on patent numbers for micro and small-scale firms are below average, medium-scale firms are at the average level, and large-scale firms are significantly above average at around 36%. Only large firms have positive impacts on sales, while other scales do not exhibit significant positive effects. This situation indicates the success of large firms in patent production and commercialization of the patented outputs. Similarly, export effects increase with scale.

The increase in productivity among SMEs increases as the scale grows, but this effect is absent in large firms. The higher increase in productivity among SMEs compared to large firms could be due to these firms operating below the optimum scale. Up to the threshold of large firms, the increase in productivity with scale among SMEs could be attributed to the growth of the internal spread of R&D outputs as the scale increases. Therefore, two different relationships exist between firm size and the impact of R&D supports on productivity, which shows effects in different directions.

Employment and R&D expenditures increase in the largest firms but are below average in medium-sized firms. As expected, per capita wage increases decrease as the firm size grows.

Table 18: Effects of TEYDEB Supports on Micro-Scale Firms

		log(Number of Patents)	Log(R&D Expenditure)	log (Value Added)	Log (Wage Per Person)	Log (Employment)	log (Sales)	Profit/Assets After Taxes	log (Productivity)	Export / Sales	log (Exported Products)
Micro[19]	TEYDEB Support	0.0164***	0.806***	0.0679***	0.226***	0.0401***	-0.0181	0.0340***	0.0758***	0.00457	-0.00185
	Number of Observations	20,846	4,968	15,884	18,000	18,000	20,785	20,846	14,170	20,775	14,148
Small	TEYDEB Support	0.0255***	0.842***	0.121***	0.163***	0.0729***	0.0194	0.0343***	0.130***	0.0101***	0.0849***
	Number of Observations	22,558	4,983	20,903	22,322	22,322	22,538	22,558	20,586	22,536	20,186
Middle	TEYDEB Support	0.0619***	0.547***	0.0629***	0.144***	0.0469***	-0.038**	0.0321***	0.156***	0.0145***	0.165***
	Number of Observations	13,175	3,986	12,225	13,082	13,082	13,157	13,175	12,128	13,156	12,689
Big	TEYDEB Support	0.356***	1.494***	0.118***	0.0973***	0.135***	0.138***	0.0295***	0.0276	0.0196**	0.263***
	Number of Observations	7,002	3,287	6,260	6,979	6,979	6,988	7,002	6,238	6,988	6,858

[19]Micro enterprises are classified as enterprises with less than ten employees, small enterprises with less than 50 employees, and medium enterprises as enterprises with less than 250 employees.

Robustness Analysis

In previous analyses, firms whose TEYDEB applications were rejected were used as the control group. This section aims to test the sensitivity of the results to the choice of the control group by using a different set of firms. This firm set consists of companies that declared R&D expenditures in their income statements at least once between 2011 and 2019 and firms supported under the KOSGEB SME-Development Support Program. These firms have R&D activities and a certain level of R&D competence. Table 19 confirms that the significant positive effects of TEYDEB supports on R&D expenditures, brand-patent numbers, revenue, employment, total assets, and value-added are also validated with a different control group.

Table 19: Effects of SME-Development Supports on Firm Performance, Alternative Control Group

	log (Value-added)	log (Productivity)	log (Number of Patents)	log (Brand, Patent, Model, Design)	log (R&D Expenditure)	log (Sales)	log (Total Wages)	log (Net Profit)
TEYDEB Support	0.133***	0.047*	0.016***	0.058***	1.488***	0.138***	0.059	0.252***
KOSGEB Support (SME-Development)	0.073***	0.060***	0.003	0.026***	0.155***	0.016	-0.114***	0.073***
log (Employment)	0.358***	-0.134***	0.002***	0.017***	0.215***	0.557***	1.275***	0.257***
log (Total Assets)	0.199***	0.113***	0.001***	0.006***	0.059***	0.254***	0.082***	0.119***
Other Firm Controls[20]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Provincial Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	161737	144322	205700	205700	204874	205667	205700	155978
R2	0.822	0.667	0.401	0.451	0.593	0.830	0.810	0.813

In the analyses conducted on employment and total asset levels, additional auto-regressive analyses were performed for robustness due to the possibility of inertia based on previous-year observations for these variables. Table 20 shows that even in auto-regressive regressions, there is a positive effect on employment and total asset levels. Compared to the effects of the KOSGEB SME-Development Support Program, TEYDEB programs have a higher average effect on most variables except for productivity. In firms supported under the KOSGEB program, a higher level of increase in productivity has been observed.

[20]What is meant by other firm controls are long-term and total debt ratios.

Table 20: Effects of SME-Development Supports on Firm Dynamics, Alternative Control Group

	log (Employment)			Δ log (Employment.)	log (Total Assets)		Δ log (Total. Yes)	log (Cost of Sales)	
TEYDEB Support	0.186***	0.088***	0.058***	0.044***	0.231***	0.156***	0.070***	-0.256***	-0.030
KOSGEB Support (SME-Development)	0.022*	-0.112***	-0.054***	-0.046***	0.130***	0.084***	0.026***	-0.301***	-0.035
log (Employment) $_{t-1}$	-	0.151***	0.518***	-0.397***	0.343***	0.207***	0.057***	0.789***	0.786***
log (Total Assets) $_{t-1}$	0.178***	0.041***	0.039***	0.030***	-	0.336***	-0.349***	0.276***	0.339***
Other Firm Controls $_{t-1}$	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	-	Yes	Yes	Yes	Yes	Yes	-	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Provincial Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	205700	205700	205700	205700	205700	205700	205700	205460	205460
R2	0.887	0.885	0.912	0.378	0.813	0.820	0.407	0.781	0.783

6. Conclusion

In conclusion, the TEYDEB supports yield favorable outcomes, including a 6% increase in patent counts, a 9% increase in value-added, a 26% increase in total wages, a 17% increase in per capita wages, a 9% increase in employment, a 10% increase in productivity, and an 11% increase in product export diversity. However, the productivity effect is not apparent when firm fixed effects are present.

When examining sub-programs individually, it becomes evident that within the 1501 program, patent effects are slightly more pronounced, while investment effects remain below average. Other impacts (wages, productivity, employment) align with the average levels of TEYDEB effects. The 1507 R&D Startup program exclusively caters to SMEs and has average support amounts lower than the 1501 program. However, this should be considered in the context of the smaller average size of the supported firms. In the 1507 program, investments, productivity, and revenue growth rates increase more than the average effects, while patent counts, employment, and total wages increase below the average, and per capita wages increase at the average level.

The 1509 program is tied to international support, and its effects should be evaluated in this context. Notably, in this program, the increase in productivity and patent counts among

supported firms is much higher than the average. Per capita wage increase is average, while changes in other indicators are below average.

As for the 1511 Priority Areas Program, which shifted focus to large firms in 2019 after the closure of the 1501 program, it operates through calls based on priority product lists. Considering this program is more R&D-intensive than the 1501 and 1507 programs, its effects are expected to spread over a more extended period. Up to 2019, the effects revealed that for firms with more than 20 employees under this program, average positive effects were found on productivity, patent counts, and per capita wages. However, negative effects were seen on sales, profitability, and employment. The most striking effect of this program is the concentration of intangible capital investment, which is significantly higher than other programs.

When examined by firm scale, positive effects on productivity increase within SME limits, while no increase in productivity is observed in large firms. The contribution of support to productivity increase may be due to firms being below their optimal scale in the year of receiving support. On the other hand, as firm size increases, there could be a positive relationship between scale and the effect on productivity due to the expansion of project outputs within the firm. The increase in patent generation and the ability to commercialize and export innovation outputs are considered a capacity that grows with the firm's size. The effects of support also confirm this trend. As firm size grows, the number of supports and their amounts also increase. The effect of support on R&D expenditures is positive across all scales and has a stronger impact on larger firms. The positive effect on per capita wages decreases as the firm size grows. Positive effects on employment fluctuate based on firm size, with larger firms having greater effects.

Analyzing the effects on firms that receive support only once reveals that while the positive direction of effects continues, the effect on employment witnesses a considerable decrease. Similarly, the effects on sales and patent counts experience a significant decline. This phenomenon can be attributed to the fact that firms supported multiple times tend to be larger. Additionally, it can be considered that if support continues as a continuation of the same project or through different projects, the innovation outputs will become more pronounced. The effects of TEYDEB are not only limited to rejected firms; they also hold significance for qualified firms across the economy capable of conducting R&D expenditures.

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