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The Innovation Behaviour of Turkish Manufacturing Firms: An Analysis of Additionality

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Innovation and R&D activities have significant effects on economic development and firm success. Innovation is a key factor in economic development through productivity gains. However, firms do not perform the socially optimal level of innovation due to market failures. Therefore, innovation activity is largely supported by governments for both developed and developing countries with the aim of creating additionality. While additionality effects from government supports are widely discussed for developed countries, there is scarce evidence for developing countries. The aim of this article is to analyse innovation behaviour of Turkish firms based on firm characteristics. Further, the behavioural additionality of government support is also analysed in order to provide a full picture. For this aim, the innovation structure is analysed using a multinomial logit model and the additionality effects are analysed using the propensity score matching (PSM) technique. Results indicate that firms that are profit-oriented, produce for the internal market and have an internal R&D unit, are more likely to implement organization and/or marketing innovation in comparison with product innovation. In addition, the same pattern is observed in companies that received government support. The results additionality indicate positive effects on behavioural additionality; however, this effect is evaluated to be limited.

1. Introduction

Innovation is widely accepted as a key factor in terms of economic development. Theoretical and empirical evidence suggest that innovation fosters development on both regional and national levels (Dimos and Pugh 2016; Krugman 1979). It has also important and positive effects on firm success, and market structure (Jiménez-Jiménez and Sanz-Valle 2011).

Innovation in economic theory appears especially in Schumpeter's studies and the Neo-Schumpeterian approaches that followed. Schumpeter (1934) revealed that innovation is a process and highlighted the entrepreneur as the creator of innovation. Schumpeter defines innovations caused by the entrepreneur in five categories. These are the creation of a new commodity, a new source of raw materials, new techniques, new forms of organization and new demand conditions.

In Schumpeter's analysis, the entrepreneur provides technological development, and innovation is the main internal element of economic and social change in this context. New combinations change the parameters of the old competitive structure, leading to the deterioration of the existing equilibrium in the economy and new equilibrium and imbalance situations. This process, which is defined as the creative destruction process, causes a qualitative change in the economic and social structure. This change is deemed 'permanent' and 'irreversible' (Schumpeter 1934) and is an important part of economic development.

In this framework, elements such as Research and Development (R&D) activities, product and process patents are seen as the building blocks of economic development. Innovation activities not only affect economic development, but also the competitiveness of companies and work through spillover effects. The cost advantage that innovating companies, whether large or small, achieve through innovation and, therefore, technological development creates positive effects on competition (Schumpeter 1934, 1943). From this point of view, it can be argued that innovation activities affect economic structure at both micro and macro levels.

It is clear that innovation has a huge impact on competitiveness and productivity and, hence, economic development. It is worth noting that there is substantial empirical evidence pointing to a paradoxical situation where firms, despite being considered the primary catalysts and proponents of innovation within the economy, often fall short in terms of their own innovation endeavours. This intriguing observation underscores the fact that, even though firms play a pivotal role in driving innovation across various sectors, they themselves do not consistently excel in innovating within their own organizational structures. In other words, while firms are pivotal in promoting innovation at a broader level, they may face challenges or limitations when it comes to implementing innovative practices within their own operations. This discrepancy between their role as drivers of innovation and their own capacity for innovation raises important questions and merits further investigation (Mulligan et al. 2019; Dimos and Pugh 2016). Firms either hold back on engaging in R&D activities and innovation as a whole or innovate less than the socially optimal level due to two main factors that can mainly be attributed to market

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failures. Since R&D and innovation activities can be treated as a public good due to their non-rivalry and non-excludability characteristics, firms are hesitant to engage in such activities (Dimos and Pugh 2016). Furthermore, the risk involved in such activities makes it harder to finance R&D and innovation activities privately (Görg and Strobl 2007; Méndez-Morales and Muñoz 2019). These public goods characteristics, on the other hand, are the main reason why innovation activities cause spillover effects and increase the innovative activity and productivity from a wider perspective.

The suboptimal level of innovation compared with the potential benefits is the main reason why government support is needed. Governments are using a variety of tools such as subsidies, grants, loans and tax exemptions in order to support private R&D and innovation activity (Dimos and Pugh 2016). These government supports are accepted to decrease the unit cost of innovation activities, and hence stimulate private firms and increase the number of firms engaging in R&D and innovation activity as well as the amount of such activity within each firm (Mulligan et al. 2019).

The main expectation from government support is to create 'additionality', i.e. lowering the cost of the innovation activity to make previously unprofitable and unattractive activities profitable. Hence, it is expected that firms are willing to undertake new innovation activities or increase the amount they invest in R&D and innovation activities with government support (Görg and Strobl 2007).

Additionality is observed in three forms: input, output and behavioural additionality. Input additionality is the increase observed in R&D expenditures or in the level of skilled employment that would yield higher innovation activities within a firm. Output additionality is the increased number of patents, useful models or any other type of innovation output. Finally, behavioural additionality is any increase/change in terms of innovation behaviour such as an increase in propensity to innovate – even if it does not yield a patent, or any other kind of innovation output (Méndez-Morales and Muñoz 2019).

Schumpeter introduced the process of economic change by a theoretical model in his work entitled *The Theory of Economic Development* (1934). The changes in the economic structure do not resemble the process of convergence to equilibrium or the *circular flow* mechanism in the theory of economic development of Schumpeter. Schumpeter emphasized change (*vision*) as discontinuous, spontaneous and endogenous. According to Schumpeter, different from the circular flow, the previous state of equilibrium cannot be reached again if any deviation from equilibrium occurs during the process of change (Schumpeter 1934). Therefore, in economic and social life, the structural changes are the phenomenon that Schumpeter concentrates on. According to Schumpeter, when there is innovation and new combinations are introduced to economic and social life, there is economic change (economic development). In this respect, when access is gained to new raw material resources, new markets and new ways of organization are exploited, new production techniques are adopted and a new product is produced, innovation occurs. These are the five different types of innovation in Schumpeter. The innovative/creative actions of the entrepreneur play a crucial role in the change

stemming from economic development and innovations (Schumpeter 1934, Güler Aydın and Özer-İmer 2019).

It can be argued that Schumpeter defined the concept of innovation theoretically to set forth the development course of twentieth-century capitalism. Towards the end of the same century, empirical studies on the concept of innovation intensified and the Oslo Manual 'focusing on technological product and process innovation (TPP) in manufacturing' was created by OECD and Eurostat in 1992 in order to provide consistency in the set of tools brought by the concept of innovation. In later editions of the Manual, the concepts of marketing and organizational innovation have been included, in addition to the concept of TPP innovation because of studies in the field and various requirements (OECD 2005; Çakmak 2020). Thus, the Oslo Manual (OECD 2005) defines innovation as 'the realization of a new or significantly improved product (good or service), process, new marketing method or new organizational method in the business organization or external relations'. Schumpeter emphasizes the concept of 'new' while exemplifying innovation as a commodity that has never been used or a raw material that has never been accessed, etc. In the innovation defined in the Oslo Manual, it is stated that as a minimum condition for innovation activity, the method must be 'new to the firm' and be 'realized' in any innovation type (OECD 2005). Therefore, it can be argued that the Schumpeterian concept of innovation can be a theoretical basis for innovation in the Oslo Manual, especially when considering the goal of developing a new product.

In this context, prior research has emphasized that to fully understand the factors affecting innovation, it is important to distinguish between the types of innovation (Downs and Mohr 1976). According to the Oslo Manual, innovation consists of four types namely product, process, marketing and organizational (OECD 2005).

According to the Oslo guidelines, for an innovation to be considered as a 'product innovation', the product's features and intended use must be different from previously produced products. On the other hand, process innovation has been defined as a new or significantly improved production or the delivery method, and includes significant changes in techniques, equipment and/or software. Marketing innovation is defined as a new marketing method that involves significant changes in product design, packaging, positioning, promotion or pricing. One of the most important distinguishing features of marketing innovation is the implementation of a marketing method that has not been used before by the company. Finally, organizational innovation is the application of a new organizational method in the firm's business practices, workplace organization or external relations. The concept of innovation differs considerably on its types. Firms can do one of these types of innovation or can do more than one at the same time. However, it is very important to analyse what benefit each type of innovation adds to the firms or which types of firms are focusing on which types of innovation.

The first objective of this article is to analyse the innovation behaviour of firms based on firm characteristics, structure, and type of innovations. To achieve this, the study will use a panel multinomial logit model. This model is a statistical technique used to analyse the relationship between multiple variables and the likelihood of an

outcome occurring, in this case, the likelihood of a firm engaging in innovation. The study will use firm-level data from the Turkish manufacturing industry to analyse this relationship.

The second objective is to investigate the behavioural additionality of government support for firms in the Turkish manufacturing industry. For this objective, the study will use a Propensity Score Matching (PSM) method. This method involves selecting a group of firms that received government support and comparing them with a similar group of firms that did not receive government support. By using this method, the study aims to determine whether the government support had an additional effect on the firms' behaviour beyond what they would have done anyway.

Overall, the study aims to provide insights into the innovation behaviour of firms in the Turkish manufacturing industry and the effectiveness of government support in promoting innovation.

The article has been organized in the following way. The second section provides related literature, and a brief overview of innovation supports in Turkey. The third section describes the data and the variables used in the analysis as well as the key descriptive statistics and the methodology employed. The fourth section summarizes the key findings and the final section discusses these findings and policy implications, the shortcomings of the analysis and potential directions for future research.

2. Related Literature

One branch of the existing literature indicates a positive association between innovation and firm performance in terms of productivity, profitability, value added and sales (Crepon *et al*. 1998; Thornhill 2006; Cassiman *et al*. 2010). Another branch of the existing literature focuses on determining the relationship between R&D expenditures and innovation (Wakelin 2001; Morris 2018).

A large and growing body of literature has investigated the relation between public support and innovation since innovative activity is widely subsidized by governments. Researchers are keen to examine whether these supports create additionality effects, i.e. whether the innovation policy is efficient. The majority of literature investigates such an issue for developed countries and most of that research focuses on input and output innovation (Méndez-Morales and Muñoz 2019). The evidence from the literature is mixed on all cases. Public subsidy should ideally complement private R&D activity but there is evidence for complementing (Hewitt-Dundas and Roper 2018; Czarnitzki and Hussinger 2018; Corchuelo and Martinez-Ros 2010), substituting (Hud and Hussinger 2015) or no effects (Radicic and Pugh 2017) from government support.

In the case of Turkey, it is important to mention three pioneer studies in the existing literature relating to the public support for innovation. First, Özçelik and Taymaz (2008) assessed the effect of direct subsidy programmes on private R&D investment using firm level data for Turkish manufacturing industry. Their study is the first attempt in the existing literature to test whether public R&D grants/loans have 'additionality' effects on Turkish manufacturing firms. In their propensity score

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matching analysis, they found crowding-in effects of public R&D incentives on private R&D. In addition, their findings indicate that smaller firms participate more in R&D support programmes as compared with large ones and have higher R&D investment per output.

Second, Tandoğan and Pamukçu (2011) investigated the impact of direct public incentives granted to R&D expenditures provided by the Scientific and Technological Research Council of Turkey (TUBITAK) and the output of R&D activity using a semi-parametric matching technique.

The final study for Turkey, Szczygielski *et al.* (2017), examined the effectiveness of government support for R&D activities on the innovation performance of firms in Turkey and Poland using data from 2010 innovation surveys. Their results showed that public support for R&D activities leads to better innovation performance of the firms in both countries.

As mentioned above, it is well-known that innovation activity is widely subsidized in both developed and developing countries; however, in order to achieve and implement an effective innovation policy, it is crucial to evaluate the effects of government support on innovative activity. This study focuses on behavioural additionality effects of government support for Turkish manufacturing firms. The motivation behind this study is to fill the gap in the existing literature by providing firm level evidence from Turkey relating to the effectiveness of public support on innovation activities by dividing innovation into its types. In this regard, this study differs from the studies conducted for Turkey mainly in three aspects. First, it analyses the effect of government R&D subsidies on innovation activities according to the innovation categories, namely product, process, marketing, and organizational innovation. Second, considering the periods covered by the previous studies, Özçelik and Taymaz (2008) conducted their analysis for 1993–2001 whereas Tandoğan and Pamukçu (2011) carried out the analysis for the 2003–2006 period. Therefore, it can be argued that this current study extends the existing literature by handling the nearest period in terms of public support for innovation. Finally, different from other studies, this study considers subsidies provided by all types of organizations, namely the Scientific and Technological Research Council of Turkey (TUBITAK), Small and Medium-size Industry Development Organization (KOSGEB), development agencies and the European Union (EU) funds.

2.1. A Brief Overview of Innovation Supports in Turkey

Although innovation supports are also provided by private enterprises and EU grants in Turkey, government is the main actor in this environment. According to the Turkish Statistical Institute (TURKSTAT) database, it is seen that the amount of the central government budget on R&D expenditures and appropriations increased 3.5 times from 2010 to 2020 in local currency. In TURKSTAT (2021) the areas with the highest funding in 2020 are universities (48.8%), defence (13.4%) and industrial production and technology (10.4%). TUBITAK is the leading institution in terms of innovation support in Turkey. The institution is affiliated with the Ministry of Industry and Technology,

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supports academic and industrial R&D activities and innovations, and also acts as the secretariat of the Supreme Council of Science and Technology (SCST), Turkey's top industry and technology policymaker (TUBITAK 2021).

KOSGEB, another institution affiliated with the Ministry of Industry and Technology, provides reimbursable and/or grant support especially to SMEs, and aims to reveal SMEs that use high technology, have a high R&D and innovative capacity and make a difference in global competition. As well as grants and support, KOSGEB also provides technical and administrative recommendations and training programs to SMEs. Supports are provided to the applicants under support programmes such as R&D and innovation, strategic product, SME development, foreign market, and business development (KOSGEB 2020).

Other institutions that provide support to companies are the Development Agencies. These are non-profit development units with their own working and financing mechanism and public legal entity, established by the decision of the Council of Ministers and under the coordination of the Ministry of Industry and Technology. Development agencies provide training within the scope of technical support to companies and assist in project preparations. In the context of financial support, some project basis grants are provided under the headings of interest-free loans and direct financing support.

The term 'support' within the context of this article encompasses a comprehensive array of assistance mechanisms extended by the public sector, with particular emphasis on entities such as TÜBİTAK and KOSGEB. Furthermore, this variable encompasses the various forms of support accessible from local municipalities and the EU. It is noteworthy that, in Turkey, EU funding initiatives are channelled through TÜBİTAK. Consequently, the all-encompassing variable denoted as 'government support' within this study encapsulates the entire spectrum of support categories available to enterprises. To summarize, 'support' encompasses a comprehensive range of support modalities accessible to companies.

3. Data and Methodology

This research employs two distinct methodological approaches to comprehensively elucidate the behavioural additionality of innovations within Turkish manufacturing firms. Initially, a panel multinomial logistic estimation is employed to discern disparities in the primary determinants of innovation across various categories. Subsequently, the study endeavours to ascertain whether these innovations engender significant economic externalities through the application of a propensity score matching technique.

3.1. Analysis of Innovation Determinants

To examine the microeconomic determinants of different types of innovation in Turkish manufacturing firms, a panel multinomial logit model is used in this study. The merged data from Innovation Survey and Annual Industry and Service

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Statistics, both received from the Turkish Statistical Institute are used in the empirical analysis and only responses from innovating firms are considered in the analysis. In the context of our research, the deliberate exclusion of non-innovating firms in favour of a focus on innovating firms does not inherently entail sample selection bias. This approach aligns with the specific research question and objectives, which are centred on the examination of innovation and its associated attributes within the subset of innovating firms. Such a targeted sampling strategy corresponds to the practice of purposive or selective sampling, wherein a subset of the population is intentionally chosen to suit the research inquiry.

Sample selection bias typically arises when the sample selection process introduces systematic errors or biases that compromise the extrapolation of findings to the broader population. In this particular research context, the focus on innovating firms is well-justified given the research's core objective, which is to gain insights into the fundamental attributes of innovation categories within the specific subset of innovating firms. Consequently, the outcomes and interpretations are confined to the context of innovating firms, and any broad generalizations concerning non-innovating firms or the entirety of firms are prudently avoided. A panel dataset consisting of 15,615 observations covering the 2004–2014 period (in two-year periods) was obtained by combining Annual Industry and Service Statistics and Innovation Surveys. Since the dataset for Annual Industry and Service Statistics after 2014 and data from Innovation Surveys after 2016 are not compatible with prior years, 2004–2014 is the latest and largest available dataset for this evaluation.

The dependent variable in the analysis is the type of innovation activity of the enterprise (1 = product innovation, 2 = process innovation, 3 = organizational innovation, 4 = marketing innovation, 5 = multiple innovation activity, which includes a combination of several innovation activities from 1 to 4). Since the dependent variable in question cannot be ordered in any meaningful way, the multinomial logit model was preferred for the estimation of the model.

The multinomial logistic regression method is an extended version of the logistic regression method with at least three or more variable levels. Let us assume that the dependent variable is three-level and code it as $Y = 0,1,2$. Considering the logistic regression model for the two-level dependent variable, a single logit transform is applied as $Y = 0$ versus $Y = 1$. For the three-level Y variable, two logit transformations must be made separately for $Y = 1$ and $Y = 2$, with $Y = 0$ being the reference category (Hosmer and Lemeshow 2000). For the model with p variables and constant terms, the logit function can be arranged as follows:

$$g_1(x) = \log\left(\frac{P\left(y = \frac{1}{x}\right)}{p\left(y = \frac{0}{x}\right)}\right) = \beta_{10+}\beta_{11}x_1 + \ldots + \beta_{1p}x_p$$

$$g_2(x) = \log\left(\frac{P\left(y = \frac{2}{x}\right)}{P\left(y = \frac{0}{x}\right)}\right) = \beta_{20+}\beta_{21}x_1 + \ldots + \beta_{2p}x_p \quad (1)$$

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The conditional probability functions are:

$$lP(Y = 0/x) = \frac{1}{1 + e^{g_1(x)} + e^{g_2(x)}}$$

$$P(Y = 1/x) = \frac{e^{g_1(x)}}{1 + e^{g_1(x)} + e^{g_2(x)}} \tag{2}$$

$$P(Y = 2/x) = \frac{e^{g_2(x)}}{1 + e^{g_1(x)} + e^{g_2(x)}}$$

If the expression is generalized for the g group, the conditional probability function for any variable j can be written as follows where $\beta_0 = 0$ and $g_0(x) = 0$ (Hosmer *et al.* 2013):

$$P(Y = j/x) = \frac{e^{g_j(x)}}{\sum_{j=0}^{g-1} e^{g_j(x)}} \tag{3}$$

The definitions of explanatory variables are provided in Table 1. The independent variables were chosen in line with the existing literature in order to understand the structure of the market and the firm. The question of whether the firm produces only for the Turkish market or for both Turkey and the foreign market is used to represent the level of competition the firm faces. In other words, firms producing only for the domestic market are expected to be located in a relatively less competitive environment and, therefore, innovation activities will be limited. In a similar vein, it is possible to argue that with the innovation being new for the market or for the enterprise, the export–import capacity of the firms and the foreign capital shares are also associated with the competitive power of the firm and are expected to have an impact on innovation activities. It is widely recognized that the performance of exports and imports varies across sectors. To establish a correlation between innovation and export or import intensity, two widely adopted measures are used. The first method involves using a dummy variable to distinguish between exporters (importers) and non-exporters (non-importers). The second method involves calculating export (import) intensities by dividing exports (imports) by total revenue (Kirbach and Schmiedeberg 2008). In addition, sectoral dummies are commonly employed to highlight the differences between sectors, as mentioned earlier. In this study, we adopted an approach that uses a dummy variable to identify firms with high levels of exports (imports) within a given sector. To determine this, we utilized sectoral averages as a benchmark. Firms with a higher ratio of exports (imports) to total revenue than the sectoral average of innovators are assigned a value of 1 for the export (import) dummy. This methodology allowed us to incorporate sectoral export (import) intensity in assessing its impact on innovation. Firms with an internal R&D department and firms engaged in continuous R&D activities are expected to have a higher probability and success of innovation. The dataset includes information pertaining to the geographical locations of companies' corporate headquarters. Upon close examination, it became evident that the companies under investigation operate across a diverse array of provinces. Originally, the intention was to

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Table 1. Explanatory variable definitions

Variable	Survey question	Explanation
Turkish market	To which market does your enterprise offer goods and services?	Only Turkish market = 1 Other = 0
New for the market	What is the status of the innovations you made in the relevant period?	New for the whole market = 1 Other = 0
New for the enterprise	What is the status of the innovations you made in the relevant period?	New to enterprise = 1 Other = 0
Internal R&D	Did you carry out R&D activities within your enterprise in the relevant period?	Yes = 1 No = 0
Continuous R&D	How often did you carry out R&D activities in the relevant period?	Continuously = 1 When needed = 0
Collaboration	During the relevant period, did you cooperate with any other initiative or organization in any of your innovation activities?	Yes = 1 No = 0
Support	Did you receive support for your innovation activities from the government or the EU	Yes = 1 No = 0
R&D expenditures	Share of R&D expenditure in total expenditure	If above average = 1 Other = 0
Import	Ratio of imports to total revenue	If above sectoral average = 1 Other = 0
Export	Ratio of exports to total revenue	If above sectoral average = 1 Other = 0
Turnover	Changes in the turnover due to innovations.	If above average = 1 Other = 0
Central Region	Region of the enterprise	Istanbul, Aegean, Western Anatolia or Eastern Marmara (central) = 1 Other (periphery) = 0
Foreign capital	Capital distribution of the enterprise	If there is foreign capital = 1 Entirely domestic capital = 0

incorporate this geographical diversity into the analysis under various regional definitions. However, it became apparent that the principal disparities in terms of concentration were observed primarily among the central regions, notably including Istanbul, the Ankara-centred central Anatolia region, and the Aegean region, in contrast to the remaining regions. Consequently, regional information was incorporated into the analysis as a binary categorical variable, with the purpose of accounting for the influence of regional concentration.

The present exposition briefly elucidates the theoretical underpinning of the explanatory variables, expounding upon their respective definitions within the context of this study. It is imperative to note that a substantial body of literature has expounded upon the pivotal significance of these independent variables in the realm of innovation processes. For instance, extant scholarly works have elucidated the salient role of R&D expenditures (Silva *et al.* 2021; Kučera and Fil'a 2022), the introduction of novel products (Sok and O'Cass 2015; Hottenrott and Lopes-Bento 2016), and the provision of support throughout the innovation process (Wei and Liu 2015; Szczygielski *et al.* 2017).

Furthermore, extant investigations have underscored the notion that the R&D capacity of firms stands as a pivotal determinant of their innovative undertakings, positing that an escalation in R&D outsourcing may concomitantly diminish a firm's innovative output (Berchicci 2013). Within this particular context, akin to the present study, the prospect of variations in innovation potentiality contingent upon a firm's continuity in R&D endeavours and the presence of internal R&D units warrants empirical scrutiny.

In the context of international trade, Aristei, Castellani, and Franco (2013) proffer empirical evidence substantiating a positive influence on the sales performance of exporting firms, particularly those actively engaged in product innovation. Collaborative endeavours, conversely, have emerged as a contentious and vigorously debated topic within the purview of innovation performance. While prevailing research contends that collaborations manifest a profound significance (Xie *et al.* 2023), it is noteworthy that certain studies have articulated reservations regarding the efficacy of collaborations that are discontinued, interrupted (Belderbos *et al.* 2015), or characterized by a dearth of mutual trust (Lai *et al.* 2011), positing that these factors may engender deleterious effects on innovation performance.

Additionally, the extant literature has also engaged in comparative analyses of the innovation performance between indigenous firms and those with a global operational reach (Bernard *et al.* 2009).

Descriptive statistics for the dependent variables and explanatory variables are provided in Tables 2 and 3, respectively. Although our analysis exclusively focuses on innovator firms, we have included descriptive statistics for the entire sample in order to present a comprehensive overview of the dataset. While the ratio of innovating firms among all firms considered is 31%, it is observed that a significant part of these firms make a product innovation (45%).

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Table 2. Descriptive statistics regarding dependent variable

Innovation type	*n*	%
Product innovation	2,233	45.38
Process innovation	575	11.68
Organizational innovation	770	15.65
Marketing innovation	1,159	23.55
Multiple innovation activity	184	3.74
Total innovative firm number	4,921	31.51
Observation (includes non-innovating firms)	15,615	

Table 3. Descriptive statistics

Variables	*N*	% (mean value for continuous variables)
Turkish Market	2,952	59.98
New for the Market	2,537	51.55
New for the Enterprise	2,483	50.40
Internal R&D	2,643	53.70
Continuous R&D	876	17.80
Collaboration	1,316	26.74
Support	1,595	32.41
R&D Expenditures Share	4,921	0.796
Import Share	4,921	0.536
Export Share	4,921	0.542
Turnover	4,921	0.962
Central Region	1,667	33.87
Foreign Capital	2,675	54.35
Obs = 4,921		

3.2. Analysing the Effects of Government Support on Innovation Behaviour

The evaluation of the effect of a subsidy on innovation behaviour is subject to a selection problem, which can compromise the validity of the study results. It is plausible to argue that subsidies are not randomly assigned, and that the allocation of subsidies is influenced by various factors. For instance, governments may allocate subsidies in a manner that maximizes the likelihood of achieving the policy goal, such as promoting innovation or supporting specific sectors of the economy. Therefore, firms that receive subsidies may be those that are deemed most likely to achieve the desired outcome, rather than being a random selection, which can be referred to as the 'picking the winner' strategy.

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Additionally, firms that apply for and receive subsidies may differ from those that do not in terms of their characteristics, such as their level of information, past innovation success, or level of human capital. These factors can affect the likelihood of receiving a subsidy, and may also influence the effect of the subsidy on innovation behaviour. For instance, firms with high levels of human capital may be more likely to innovate in response to a subsidy, as they have the necessary skills and resources to take advantage of the funding.

Addressing the selection problem is important to ensure that the study results accurately reflect the effect of the subsidy on innovation behaviour, rather than being biased by the factors that influence the allocation of subsidies. This can be achieved through various methods, such as employing rigorous statistical techniques to account for selection bias, or using natural experiments to compare the outcomes of firms that receive subsidies to those that do not, while controlling for other relevant factors. (Mulligan *et al.* 2019). Even if it is the 'picking the winner' strategy or self-selection on behalf of the firms, subsidy evaluation is prone to a selection bias. In order to overcome this endogeneity problem, several methodologies have been offered. PSM is one of those non-parametric matching methodologies to be employed in this study. PSM allows researchers to match subsidy recipients and non-recipients on selected, key characteristics, which yield a similar propensity to innovate after a subsidy (Görg and Strobl 2007).

In this study, the PSM method is used to examine the effects of government support on innovation behaviour on enterprises. PSM is a statistical technique utilized to mitigate bias in research studies (Wang 2021). Due to the inability to randomly allocate individuals or observations into different groups, there is a possibility that the groups being compared are not truly comparable. Propensity score matching addresses this issue by creating a 'pseudo-randomized' comparison between groups with similar characteristics.

PSM involves matching observations from treatment and control groups based on their estimated propensity scores. This process entails selecting individuals from the treatment group who have similar propensity scores to individuals in the control group, and vice versa. Various methods, including one-to-one matching, nearest neighbour, and caliper matching (Torche and Costa-Riberio 2012), can be employed to match individuals. Following matching, the balance of covariates between the treatment and control groups is assessed to ensure that they are comparable. A primary benefit of PSM is that it helps to reduce bias by balancing the covariates between treatment and control groups, resulting in similar characteristics and reduced risk of confounding.

To summarize, the steps involved in PSM analysis include the acquisition of representative and comparable data for both treatment and control groups, the estimation of observations using probit, logit, or other discrete choice models as a function of observable characteristics, and the matching of pairs using techniques such as nearest neighbours, nonlinear matching, or multiple matches. Once matching is complete, the impact is calculated by comparing the means of outcomes across observations and their matched pairs.

PSM has the advantage of improving the precision of the estimated treatment effect by reducing the variance of the treatment effect estimator. This can be particularly important in small sample sizes or when there is a large number of covariates that need to be controlled for. Additionally, propensity score matching is a flexible method that can accommodate both binary and continuous treatments or exposures and can be used with a variety of statistical models.

However, researchers should also be aware of the potential disadvantages of propensity score matching. This method can only control for observed confounding variables, and it cannot account for unobserved confounders. This means that there is still a risk of bias if there are important confounding variables that are not included in the analysis. Furthermore, propensity score matching relies on the assumption that individuals who receive the treatment or exposure have the same propensity to receive it as those who do not receive it. If there is selection bias in the observational data, the propensity scores may not accurately reflect the true likelihood of receiving the treatment or exposure.

Propensity score matching can also result in a loss of sample size if there are no suitable matches for some individuals in the treatment group. This can reduce the statistical power of the analysis and increase the risk of Type II errors. Additionally, the results of the analysis can be sensitive to the choice of model and the inclusion/exclusion of certain variables, and the method may be difficult to interpret for non-experts.

While propensity score matching has some limitations, it can still be a useful method for estimating treatment effects in observational studies. In the case of innovation, research often involves observational studies, where individuals or firms are not randomly assigned to receive the innovation or not. In such cases, as mentioned above, confounding variables may influence the outcome of interest, and without proper control for these variables it is difficult to isolate the effect of innovation. Propensity score matching can help to address this issue by creating a comparison group that is similar to the treatment group in terms of observed characteristics, thereby reducing the bias that may arise from uncontrolled confounding variables. Furthermore, PSM can also improve the precision of the estimated treatment effect by reducing the variance of the treatment effect estimator. This can be particularly important in innovation research, where the effects of innovation may be small or difficult to detect without precise estimates.

In this context, innovative firms that do not receive any government support constitute the control group, while firms that are supported by the government compose the experimental group. Balanced and stabled blocks are formed by using observable characteristics in each group and matching these characteristics with the PSM method. It is possible to calculate propensity scores of these blocks by using parametric or semi-parametric methods. PSM involves estimating the probability of receiving the treatment (propensity score) based on observable characteristics, and then matching individuals with similar propensity scores between the treatment and control groups. There are two main approaches for estimating the propensity score: parametric and semi-parametric methods.

Parametric methods assume a functional form for the relationship between the covariates and the treatment assignment, such as a logistic regression model. The advantage of parametric methods is that they can produce more precise estimates of the propensity score, especially when the functional form is correctly specified. However, if the model is misspecified, the estimates can be biased.

Semi-parametric methods, on the other hand, do not make strong assumptions about the functional form of the relationship between the covariates and the treatment assignment. Examples of semi-parametric methods include generalized boosted models (GBM) and generalized additive models (GAM). The advantage of semi-parametric methods is their flexibility, as they can capture complex relationships between covariates and treatment assignment. However, they may produce less precise estimates of the propensity score than parametric methods.

Once the propensity scores are estimated using either parametric or semi-parametric methods, matching can be performed using various techniques, such as nearest neighbour matching or kernel matching. The goal is to create balanced and stable blocks of individuals with similar propensity scores in the treatment and control groups, so that any differences in outcomes can be attributed to the treatment effect rather than confounding variables.

In summary, both parametric and semi-parametric methods can be used to estimate propensity scores in PSM, with parametric methods providing more precise estimates but requiring stronger assumptions, and semi-parametric methods offering more flexibility but potentially less precision. The choice of method should depend on the specific research question and data characteristics.

In this study, the probit method which is used in the literature widely is chosen for the calculation. Following the calculation of propensity score with the probit method, the average effects of the intervention on the intervened by the PSM method can be defined using equation (4) (Cameron and Trivedi 2009).

$$ATT = E(Y_1 - Y_0|D = 1) = E(Y_1|D = 1) - E(Y_0|D = 1) \tag{4}$$

where Y_1 and Y_0 in equation (4) denote the presence and absence of the intervention by D, respectively. The calculation of the expected value of Y_1 in this equation is quite easy, but $E(Y_0|D=1)$ is not observable by definition. In this case, it is necessary to calculate propensity scores in order to calculate ATT. By using propensity scores, it is possible to select firms with at least as much intervention possibility as the experimental group but not to be intervened. In this case, the PSM estimate of ATT can be made through equation (5).

$$ATT_{PSM} = E_{P(X)|D=1}\{E[Y_1|D = 1, P(X)] - E[Y_0|D = 0, P(X)]\} \tag{5}$$

Here, $P(X)$ is the conditional probability function of the intervention. In this study, it represents the possibility of a firm receiving government support for innovation activities and can be estimated using observable variables.

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First, propensity scores are calculated by the probit method for the PSM analysis, then using these scores, the effects of intervention are calculated by the PSM analysis. When estimating equation (5), various matching methods are used for the robustness check. These methods are basically the same but differ only in the selection and weighting techniques of non-treated observations (Caliendo and Kopeinig 2008).

4. Results

4.1. Multinomial Analysis Results

Table 4 demonstrates the estimation results for the panel multinomial logit model for different types of innovation. In multinomial logit estimations, in order to facilitate interpretation, product innovation is chosen as the base category.

The estimation results indicate that firms producing only for the national market are less likely to engage in process and marketing innovation activities compared with product innovation. Firms producing new products for the foreign market are more likely to implement other types of innovation. Firms producing new products for the enterprise are more likely to engage in organizational and marketing innovation activities.

Firms with an internal R&D unit are more likely to adopt marketing innovation whereas firms that carry out continuous R&D activities are more likely to implement organizational innovation. Collaborative firms and organizations are more likely to carry out organizational and marketing innovation activities. In addition, firms with a higher-than-average ratio of R&D expenditures to total expenditure are less likely to make organization innovation. Firms with a high export share are more likely to make process innovations. Profit-oriented firms represented by the turnover variable are more likely to engage in marketing innovation.

Firms that receive support from the government and EU funds are more likely to carry out marketing innovation. Finally, firms are more likely to implement process and marketing innovations when foreign capital is involved.

4.2. PSM Analysis Results

As mentioned above, PSM estimation can be used to analyse the specific effects of an existing policy. Since the firms who are receiving and not receiving support are not randomly determined, propensity scores are estimated in order to avoid biased results in the determination of experimental and control groups. Experimental and control groups are formed by taking these propensity scores into consideration. Therefore, first the propensity score estimates and then the results of the PSM model are presented. Nearest neighbour matching method is chosen as the matching method. Table 5 shows the propensity scores. Propensity score estimates are obtained by the probit method. The variables used in the prediction of propensity score are the variables that are thought to be related to the firms' ability to innovate and receive support in this regard. The outcome variables are chosen to be types of

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Table 4. Estimation results for the multinomial logit model

Variable	Coefficients			
	2 (process innovation)	3 (organizational innovation)	4 (marketing innovation)	5 (multiple innovation activity)
Turkish market	–0.458***	0.29	–0.4670**	0.1855
	(0.1765)	(0.2338)	(0.1977)	(0.2666)
New for the market	0.5926***	0.6317***	2.163***	–65.497
	(0.1819)	(0.2341)	(0.4179)	(0.0)
New for the enterprise	0.2657	0.652***	2.132***	–65.170
	(0.1794)	(0.2385)	(0.4341)	(0.0)
Internal R&D	–0.194	0.3291	1.259***	–0.06960
	(0.2028)	(0.2708)	(0.281)	(0.1834)
Continuous R&D	–0.2260	0.8214**	0.1829	–0.0934
	(0.2762)	(0.3302)	(0.2634)	(0.3215)
Collaboration	–0.1989	20.112***	0.4367**	–0.4375
	(0.2077)	(0.2535)	(0.2135)	(0.5772)
Support	0.1511	0.374	0.4748**	–0.368
	(0.1953)	(0.2444)	(0.23)	(0.4986)
R&D Expenditures	–0.0999	–0.4859*	0.06124	0.0392
	(0.2109)	(0.2745)	(0.2191)	(0.1873)
Export	0.4959*	0.2169	0.3328	0.0447
	(0.2604)	(0.38)	(0.2985)	(0.222)
Import	–0.3136	0.1772	–0.1152	–0.1651
	(0.2624)	(0.3859)	(0.2953)	(0.3013)
Turnover	0.14	0.0456	0.6092***	24.13417
	(0.1871)	(0.2338)	(0.2217)	(0.0)
Central Region	0.165	0.3553	–0.0092	–0.14175
	(0.205)	(0.3043)	(0.2134)	(0.2387)
Foreign capital	0.398*	0.03639	0.822***	–0.07838
	(0.2044)	(0.2539)	(0.2443)	(0.1929)

Note: *** $p<0.01$, ** $p<0.05$, * $p<0.1$, values within parentheses are standard errors.

Table 5. Propensity score estimates

Variables	Coefficient	SE
Foreign capital	–0.2836809	0.1167951**
Internal R&D	0.5733414	0.1379189***
Continuous R&D	0.2054672	0.1025477**
Turkish market	–0.1242695	0.0996709
Collaboration	0.3789826	0.0942549***
Regional office	0.1087584	0.1373677
Constant	–0.8049832	0.2557455***

Note: Obs = 4,921, Pseudo $R^2 = 0.0638$, *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Variance inflation factor (VIF) test explodes multicollinearity.

Table 6. PSM results

	5NN	
Variables	ATT	SE
Product innovation	0.828478964	0.068618249
Process innovation	0.220064725	0.056580605
Organizational innovation	0.233009709	0.053356958
Marketing innovation	0.313915858	0.063118865*
Patent application	1.50970874	0.06609596**
PhD R&D staff	0.174757282	0.049966349
No treated on support	3,191	
No treated total	4,921	
No non-treated	1,730	

Notes: *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Standard error (SE) is estimated with a 200-replication bootstrap procedure. Method: five nearest neighbours (5NN).

innovation, patent applications and the number of R&D personnel. The results of the PSM application is presented in Table 6, which shows PSM results.

The PSM analysis is conducted through the utilization of diverse matching techniques, including Kernel, 5-Nearest Neighbour (5NN) Trim, and Caliper. This multiplicity of approaches serves as a robustness check for the present study. These methods diverge in their methodologies for selecting and assigning weights to non-treated firms, as well as in their respective abilities to balance the trade-off between mitigating bias and optimizing the precision of estimations. Notably, the results exhibit robustness across these methods, thereby prompting the exclusive presentation of the findings derived from the 5NN procedure.

Throughout the implementation of all aforementioned matching techniques, we rigorously adhere to the 'common support condition' ($P(D = 1|X, 1)$). Furthermore, meticulous scrutiny is applied to assess the quality of the matching process,

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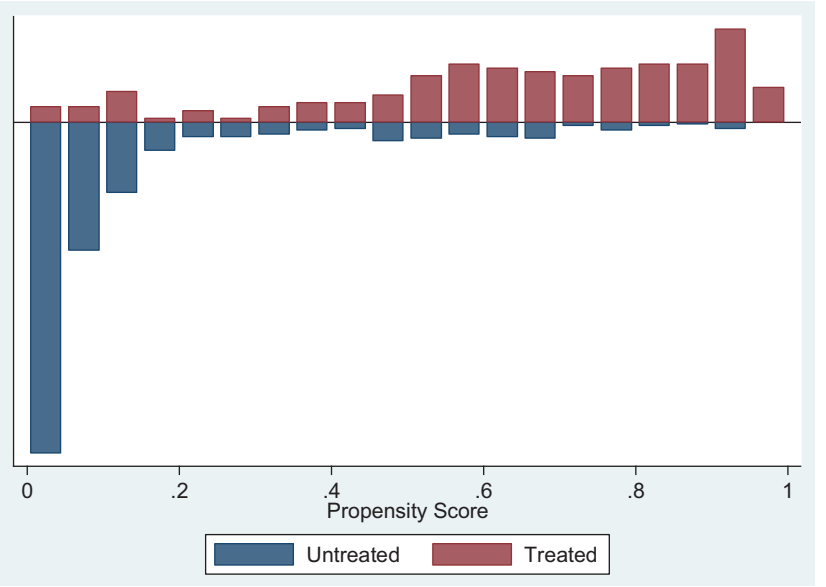

Figure 1. Propensity score histogram by treatment status

specifically by ensuring the appropriate alignment of beneficiaries and control subjects concerning the vector of covariates X. This meticulous assessment is undertaken to validate the effectiveness and integrity of the matching procedures employed. Figure 1 presents a graphical representation of the common support.

The estimation results indicate that government support increases marketing innovation activities and patent applications of firms. However, there is no statistically significant effect in terms of overall innovative activities and product, process, or organizational innovation activities. Furthermore, government support has no statistically significant effect on the number of skilled R&D personnel. Therefore, it is possible to conclude that government supports have positive behavioural additionality in Turkish manufacturing firms; however, this additionality effect is very limited.

5. Discussion and Conclusion

This study seeks to identify the determinants of the types of innovation adopted in Turkish manufacturing firms and to analyse behavioural additionality of government support in Turkey. For these purposes, a multinomial logit analysis of the determinants of different types of innovation is carried out and the PSM method is conducted for the period 2004–2014. Considering the recent literature in the Turkish manufacturing industry, which mainly focuses on the connection between innovation and productivity, as seen in studies such as Fazlıoglu *et al.* (2019), Tuncel and Oktay

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(2022), and Fedyunina and Radosevic (2022), this study stands out for its research question. It aims to explain innovation in the Turkish manufacturing industry by categorizing it into different types and uncovering how government support impacts innovation. The estimation results of the multinomial logit model demonstrate that profit-oriented firms, firms that produce for the Turkish market only, firms that receive support for innovation, and firms that have an internal R&D unit are more likely to carry out organizational and marketing innovation as compared with product innovation. This finding is partly in line with the existing literature regarding the determinants of innovation (see, for example, Adeyeye *et al.*, 2016 for Nigeria; Amara *et al.*, 2008 for Canada; Catozzella and Vivarelli, 2014 for Italy). However, when it comes to the determinants of different types of innovations, the main finding of this current study shows that the firms engaged in innovation activities in Turkey prefer activities such as organizational and marketing innovation that will result in higher profit levels with lower costs in the short run, acting mainly with a profit motivation. In the framework of the Schumpeterian and neo-Schumpeterian analysis, the main feature of entrepreneurship and innovation is that it allows for structural change. Therefore, it can be argued that the idea of innovation for Turkish manufacturing firms points to structural problems. Innovation in the Turkish manufacturing sector does not cause structural change and maintains the existing structure.

The study's findings also indicate that, when contrasting product innovation and organizational innovation, firms that engage in organizational innovation tend to allocate fewer resources to research and development (R&D) expenditures in comparison with firms primarily focused on product innovation. This discrepancy can be attributed to the cost differential associated with these two forms of innovation. Organizational innovation typically necessitates lower expenditures due to its inherent nature and content, as posited by Lee *et al.* (2010). Conversely, product innovation is renowned for being the most financially demanding and risk-intensive type of innovation, in accordance with Cooper and Kleinschmidt (2010) and corroborated by recent research (Brown *et al.*, 2022). Consequently, firms equipped with substantial financial resources and a dedicated commitment to R&D investment are more inclined to prioritize product innovation as it aligns with their capabilities.

The study unveils a structural challenge within Turkey's innovation landscape, wherein firms exhibit a propensity to favour other forms of innovation over product innovation. This predilection is evident across various independent variables scrutinized in the study. For instance, the analysis reveals that companies engaged in collaborative innovation activities tend to gravitate toward alternative forms of innovation, as they seek more immediate effects. A similar inclination is discernible among firms with foreign capital investments, as they, too, prefer investing in marketing innovation rather than venturing into the more resource-intensive domain of product innovation. It is noteworthy that if firms can harness external sources of human capital and financial support for product innovation, they stand to significantly enhance their profitability, as suggested by Kuzma *et al.* (2020).

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Furthermore, a proliferation of product innovation-focused firms holds the potential to stimulate development, as evidenced by studies such as those by Lundvall and Christensen (2004) and Song *et al.* (2020). The presence of an increased number of firms specializing in product innovation can yield positive impacts at the macroeconomic level, contributing to higher employment rates and fostering overall economic development.

The capitalist development process progresses in a similar trend with technological progress and innovation. Notably, innovations embraced within the manufacturing sector are anticipated to serve as a potent driver of economic development. The PSM Analysis results reveal that the relevant support has a statistically significant effect on marketing innovations that generate short-term profits rather than value-added product innovations. This finding is not in agreement with some of the studies in the most recent existing literature analysing the effects of public supports on different types of innovation (see, for example, Mascarini *et al.*, 2022 for Brazil), whereas it confirms the findings of other studies conducted especially for developing countries (Berrutti and Bianchi, 2020 for Uruguay; Chundakkadan and Sasidharan, 2020 for 100 developing economies). In this case, it is possible to assert the following: although it is seen that a substantial amount of innovative activities are undertaken and incentives are given in the Turkish manufacturing industry, efforts for innovation are primarily focused on short-term profit-oriented types of innovation.

Although this study has the novelty of being the first attempt at focusing on the determinants of different types of innovation in Turkey using a panel dataset, it has some limitations. First, as the analysis was based on self-reported data provided by the firms, it should be kept in mind that their judgement becomes important when it comes to the novelty of the innovations they introduced. Second, this current study deals with only the propensity of adopting innovation due to the unavailability of data regarding the intensity of innovation. From this perspective, for future research, examining the innovation in both propensity and intensity approaches would be an important contribution to the literature but this depends on the availability of the relevant longitudinal data, which are not currently available for Turkey.

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Competing Interests

The authors declare there are no competing interests.

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