Journal of Science and Technology Policy Management

Government's financial vs non-financial support and firms' innovation performance: evidence from Thailand

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Received 15 May 2025
Revised 12 March 2026
Accepted 20 March 2026

Abstract

Purpose – The purpose of this study is to examine the effects of the government's financial and non-financial support and the combination of the two supports on firms' innovation performance (i.e. new product introduction).

Design/methodology/approach – This study is based on data from 423 manufacturing firms in Thailand collected through the authors' administered survey. The authors use propensity score matching to control for selection bias that may arise when financial or non-financial support is likely to be given to firms with particular characteristics. Then the authors use the negative binomial regression to estimate the treatment effects.

Findings – Key findings of this study are as follows. First, the effect of financial support is positive and significant, suggesting that firms receiving financial support are likely to introduce more product innovations. Second, non-financial support is also significant for innovation performance. Firms receiving this type of support are expected to introduce more new products than those without support. Finally, the authors find that firms that receive both types of support tend to introduce more product innovations than those without support, suggesting the crucial effects of combined support on firms' innovation.

Originality/value – This study contributes to the existing literature by analyzing financial and non-financial types of support separately and comparing their effects on firms' innovations, which differs from previous

Funding: This study was supported by Thailand Science Research and Innovation (No. ORG6340007, 2020).

Competing interest: The authors declare no conflict of interest.

Journal of Science and Technology Policy Management

2053-4620
DOI 10.1108/JSTPM-05-2025-0220

studies that focus on either type of support. Moreover, while most studies on government support and firms' innovation focus on developed economies, this study examines a developing country (Thailand) with relatively less technological progress.

Keywords Government support, Firm innovation, Financial support, Non-financial support, Thailand

Paper type Research paper

1. Introduction

Governments worldwide establish a variety of programs to support corporate research, development and innovation (RDI). This essentially rests on the fundamental argument that, under free-market conditions, firms may underinvest in innovation relative to the socially optimal level (Arrow, 1972; Nelson, 1959). Despite the widespread use of these RDI support programs, a substantial body of empirical literature has produced inconclusive evidence regarding their overall effectiveness. While some studies find that government support can foster firms' R&D investment (Bellucci *et al.*, 2019; Szücs, 2020), knowledge networking (Chapman *et al.*, 2018) and innovation performance (Bérubé and Mohnen, 2009; Gao *et al.*, 2021; Wei and Liu, 2015), others suggest that such support is insignificant or may even crowd out private innovative effort (Rochina Barrachina and Rodríguez Moreno, 2024; Teng *et al.*, 2020). These conflicting findings suggest that the impact of government RDI support is not universal. Its effectiveness in promoting corporate innovation may be contingent on the specific context, including firms' technological capabilities, sectoral dynamics and, ultimately, the design and implementation of support programs.

A notable gap in the extant literature is the tendency to treat government support as a homogenous measure. Most studies do not distinguish between different types of support. Specifically, there is limited research that separately examines the effects of financial support (e.g. research grants, subsidies, tax reduction, loans) and non-financial support (e.g. training, advisory services, networking) and investigates whether their effects on firms' innovation performance differ. This distinction is theoretically and practically relevant. The theoretical foundation of financial support is the market failure thesis, which highlights the capital market's inability to adequately finance risky, innovative activities (Arrow, 1972; Clausen, 2009). By contrast, the rationale for non-financial support is closely aligned with human capital theory, focusing on enhancing firms' innovative capabilities through training, skill upgrading and external knowledge networking (Gyamfi *et al.*, 2024; Nguyen *et al.*, 2023). By disentangling these support types, we can gain a more nuanced understanding of the mechanisms through which government RDI support can foster firms' innovation.

Furthermore, the existing knowledge is disproportionately drawn from developed economies with mature innovation systems and robust governance structures. Little is known about whether different types of RDI support yield innovative outcomes in developing countries, where institutional settings and firm capabilities differ fundamentally (Watkins *et al.*, 2015). Lessons learned from developed economies may not be directly transferable to contexts characterized by a high prevalence of small and medium enterprises (SMEs) with low technological capabilities and weaker innovation systems.

This study aims to address these gaps by examining the effects of government financial and non-financial support on firms' innovation performance in Thailand, a typical developing economy. Thailand presents a compelling case. Its science, technology and innovation (STI) landscape shares key characteristics with many other developing nations, such as a vast majority of SMEs (about 99.5%) with limited technical capabilities, low R&D expenditure and limited innovative outputs (WIPO, 2024) [1]. Acknowledging these weaknesses, the Thai government has undertaken considerable

efforts over the past decade to upgrade its innovative capabilities. This has included a significant and sustained increase in the national STI budget, from THB 87.93bn in 2014 to THB 146.07bn in 2024, and a major institutional reform with the establishment of the Thailand Science, Research and Innovation (TSRI) agency and specialized program management units (PMUs) to allocate research funding strategically (NXPO, 2023). Despite these substantial investments and institutional changes, no empirical study has yet assessed their effectiveness in promoting firm-level innovation.

Our study contributes to the literature in two important ways. First, we move beyond a monolithic view of government support by separately assessing the effects of financial and non-financial RDI support on firms' innovative performance. This analysis allows us to test the implications of different theoretical perspectives – market failure versus human capital – and, from a practical standpoint, provides governments with crucial insights for prioritizing limited resources and designing more effective, context-sensitive policy mixes. Second, by focusing on Thailand, we provide novel evidence from a developing-country context, offering a valuable counterpoint to existing research and generating timely policy implications for Thailand and other similar economies striving to build their national innovation systems.

The remaining part of this paper is divided into six sections. Section 2 discusses the theoretical foundation of this study, based on a review of theoretical and empirical literature on the government's financial and non-financial support and firm innovation. Sections 3 and 4 explain the data and analytical strategies, respectively. Sections 5 and 6 present and discuss the results. Finally, Section 7 concludes and highlights the limitations and implications for future studies.

2. Literature review

2.1 Government's financial support and firm innovation

The theoretical foundation for government financial support of corporate innovation activities stems from the market-failure perspective. It is argued that, due to the public-good characteristics of knowledge (non-excludability and non-rivalry) and information asymmetries in the capital market, private investment in innovations falls below the socially optimal level (Arrow, 1972; Nelson, 1959). As knowledge is non-excludable, it is likely to spill over to those who did not invest in its creation. Moreover, the non-rivalry characteristic suggests that multiple uses of knowledge do not diminish its quality or quantity. Thus, these knowledge externalities, benefiting others more when repeatedly used, reduce private incentives to create new knowledge and encourage free-riding behavior (Stiglitz and Rosengard, 2015).

In addition, the success of innovation projects is hard to assess. There are some technological and market uncertainties involved. Firms also tend to withhold key technological information to prevent knowledge leakage, making it difficult for financiers to evaluate feasibility and potential returns. As a result, this information asymmetry makes private financial institutions unwilling to fund risky R&D projects, leading to underinvestment in promising projects (Stiglitz and Rosengard, 2015). Government financial support is thus proposed as a mechanism to address these failures and as a positive signal, certifying project quality and attracting private investment (Kleer, 2010; Wu *et al.*, 2020).

The management literature provides two key mechanisms through which financial support translates into innovation. First, from an organizational learning (OL) perspective, government RDI funding enables firms to engage in exploratory learning, helping them search for novel insights beyond their existing knowledge base, which is risky yet essential for breakthrough innovation (March, 1991; Gao *et al.*, 2021). Second, the absorptive capacity (AC) theory posits that R&D investment has a dual role: it directly generates innovation while simultaneously building a firm's ability to recognize, assimilate and exploit external knowledge (Cohen and Levinthal, 1990; Ramayah *et al.*, 2020). In this sense,

government financial support can strengthen firms' R&D investment, thereby enhancing their AC (Kang and Park, 2012; Ahn *et al.*, 2020).

While the theoretical foundation for government financial support of corporate innovation is strong, recent empirical studies reveal some conflicting results and contingent outcomes. Recent research documents heterogeneity in the effects of government RDI support and identifies both stimulating and crowding-out effects. Several studies highlight a positive relationship between public financial support and firm innovation, especially for firms with financial constraints. For instance, Gao *et al.* (2023) show that subsidies promote innovation in Chinese private enterprises. The effect of subsidies is particularly strong for firms facing financial constraints, as government subsidies reduce financial costs and increase private innovation inputs. Shao and Wang (2023) use data on unlisted companies in the Shanghai and Shenzhen A-share markets in China from 2012 to 2020 and demonstrate a significant stimulatory effect of financial subsidies on firms' technological innovation. These authors also reveal that the subsidy effects are moderated by entrepreneurial spirit, firm size, ownership and regional characteristics. Hu *et al.* (2021) analyze data on Chinese listed companies from 2006 to 2018. They show that government subsidies positively affect firms' green product and process innovations, and that the effect of subsidies is significantly contingent on firms' AC and market turbulence. Cecere *et al.* (2020) find that, for European SMEs, public funding is most effective when firms already have sufficient internal or external funding, as public finance and other sources are complementary.

However, some recent studies have underscored the risk of crowding out. Xu and Xiao (2024) analyze Chinese listed firms and find that different types of subsidies exert heterogeneous impacts on innovations. While total subsidies promote persistence in innovation, technological subsidies can paradoxically inhibit self-sustaining firm innovation. These findings imply that the distinction among subsidy types is critical. Similarly, Wu *et al.* (2022) examine the effect of government subsidies on innovation among new energy firms in China. They highlight the inverted-U-shaped relationship, suggesting that the crowding-out effect is present at high subsidy levels.

In sum, though the theoretical argument for government financial support is strong and widely acknowledged, empirical studies yield conflicting results, suggesting that public financing may stimulate or crowd out private innovative efforts and that its positive impact may be conditional on various factors (e.g. program types and designs).

2.2 Government's non-financial support and firm innovation

While the government's financial support is necessary to fill the financial resource gap and encourage firms to invest more in promising innovative activities, non-financial support is also vital for fostering firms' knowledge, skills and human capital (Cano-Kollmann *et al.*, 2017; Gyamfi *et al.*, 2024; Widodo and Mahi, 2022). The government's non-financial support can be divided into three main types:

(1) capacity building and human resource upgrading;

(2) providing consultation, information, and technical services; and

(3) creating an appropriate environment to promote corporate innovation (e.g. setting up new industrial standards, protecting intellectual property rights and promoting competitive market environment) (Bloom *et al.*, 2019; Jeong *et al.*, 2021; Nguyen *et al.*, 2023).

In this study, we focus on the first two types because we are interested in assessing the effects of public support at the micro level (i.e. support programs). Also, for methodological reasons, we can separate firms that receive support from those that do not and compare their innovation performance.

Theoretically, firms receiving non-financial support are more likely than non-recipients to innovate. According to human capital theory, the accumulation of human capital, including managers' and workers' knowledge and skills, is perceived as the primary enabler of firms' efficient acquisition and utilization of knowledge. Human capital can also augment firms' AC by enhancing the efficiency of learning and knowledge accumulation (Lund Vinding, 2006; Vega-Jurado *et al.*, 2008). In fact, there has been some evidence that AC is not only accumulated through firms' formal R&D activities but also through human resource practices such as training, information sharing and skill upgrading (Lund Vinding, 2006; Martínez-Sánchez *et al.*, 2020; Roy, 2018). On this basis, government non-financial support that focuses on capacity building and provides information and consultation services can foster firms' human capital, thereby enhancing their AC and strengthening their innovative capabilities.

Moreover, based on the resource-based view (RBV), possessing specialized, unique resources that differ from competitors' is key to firms' long-term competitiveness (Barney, 1991). A set of diverse information, knowledge and skills embedded in firms' managers and employees is a strategic resource that can be combined to generate firms' innovations (Hadjimanolis, 2000). In this sense, the government's non-financial support (such as training programs and consultation services) aimed at upgrading managers' and employees' knowledge and skills can directly stimulate firms' innovative capabilities (Njinyah *et al.*, 2023).

Despite limited studies on the effects of non-financial support on firms' innovation performance, compared with studies on financial support, available studies indicate that non-financial support is vital for firms' innovativeness. Nguyen *et al.* (2023), based on a panel data set of 1,081 manufacturing SMEs in Vietnam, demonstrate that government support for staff training and technological development improves firms' ability to introduce product and process innovations. Njinyah *et al.* (2023) examine how government non-financial support moderates the relationship between firms' regulatory compliance and innovativeness using the World Bank Enterprise Survey (WBES) database. These authors argue that, with the government's non-financial support (e.g. training and assistance with research and development and marketing innovations), firms can better comply with government regulations and, in turn, innovate more. Hence, non-financial support positively moderates the relationship between regulatory compliance and innovation performance.

Chundakkadan and Sasidharan (2020) use the WBES data set to analyze governments' non-financial support for firm innovation under different levels of financial constraints in 100 countries. They find that governments' non-financial support positively affects firm innovation, and that this effect is more pronounced in countries with greater financial constraints. Moreover, Jeong *et al.* (2021) examine the effect of different types of government support on the innovation performance of Korean food SMEs. They find that certification support, one of the non-financial support methods, is positively and significantly associated with firms' innovation. This result highlights the importance of government certification as a solution to the problem of imperfect information in the innovation market, thereby increasing the likelihood that firms' innovations will succeed. This finding is similar to that of Hu and Liu (2022) for 229 Chinese cities, which shows that governments' standardization support stimulates firms' patenting activities.

Essentially, the review of the theoretical and empirical literature on government support and firm innovation performance can inform our research in some important ways. First, the existing literature tends to focus on either financial or non-financial support. Studies that examine both support types and compare their effects on firms' innovation are rare. As financial and non-financial support are based on different theoretical foundations, we propose investigating and comparing their individual effects on innovation. Second, there has been limited work on the combined effect of financial and non-financial support on

innovation. Consequently, it is less known to what extent the combined support affects firms' innovations. Thus, our research aims to examine this issue, exploring whether and to what extent combined support is significant for firms' innovation performance.

3. Data

This study is part of a research project that assesses the effectiveness of the government's RDI support programs implemented between 2016 and 2020. The TSRI provided a list of targeted programs, including financial and non-financial programs. As shown in Table 1, there are 12 financial support programs and eight non-financial support programs, with 13 government agencies involved. Financial support includes R&D grants, low-interest loans for RDI investments, credit guarantees and tax reductions for R&D investments. For non-financial support, key programs include training and capacity-building (e.g. tech-startup incubation services, IPR protection training), information and consultation services, standardization and certification of new technologies and advertising innovations for public procurement.

Data collection was done using a questionnaire-based survey. Our research team developed a draft questionnaire based on relevant literature. For instance, key concepts such as innovation inputs and outputs are adopted from the OECD's Oslo Manual (OECD/Eurostat, 2018). We also

Table 1. Thai government RDI support programs covered by the survey

No.	Program titles	Program type	Responsible agencies
1	Financial Support for Innovation Networking	FS	NIA
2	From Technology to Capital	FS	NIA
3	Technical Research Grant	FS	NIA
4	Zero Loan Interest for Potential Innovations	FS	NIA
5	Innovation Coupon	FS	NIA
6	Low-interest Loan for Technology Development	FS	NSTDA
7	Innovation Technology Assistance Program (ITAP)	FS	NSTDA
8	Talent Mobility (Secondment of university researchers to firms)	FS	STI/OHEC
9	The 10 Targeted Industries Research Grant	FS	TRF
10	Research and Researchers for Industry	FS	TRF
11	300% Tax Deduction for R&D Investment	FS	MOF/NSTDA
12	Startup and Innovative Business Credit Guarantee	FS	TCG/NSTDA
13	IPR Licensing Support	NFS	NSTDA
14	Science Park Services	NFS	NSTDA
15	Tech-business Incubation Services	NFS	NSTDA
16	Thai Innovation Listing (Certifying and advertising innovations for public procurement)	NFS	NSTDA/CGD
17	Thai Invention Listing (for technology standardization)	NFS	NRCT
18	IPR Consultation Services	NFS	DIP
19	SME StandardUP (Technological upgrading of SMEs' production system)	NFS	MOI
20	Thailand Trust Mark (Branding and certifying of innovative products)	NFS	DITP

Note(s): FS = Financial support; NFS = Non-financial support; NIA = National Innovation Agency; NSTDA = National Science and Technology Development Agency; TRF = Thailand Research Fund; STI = National Science Technology and Innovation Office; OHEC = Office of The Higher Education Commission; TCG = Thai Credit Guarantee Corporation; MOF = Ministry of Finance; CGD = The Comptroller General's Department; NRCT = National Research Council of Thailand; DIP = Department of Intellectual Property; MOI = Ministry of Industry; DITP = Department of International Trade Promotion; MOST = Ministry of Science and Technology
Source(s): Authors' own work

consulted with TSRI managers on how to formulate the questionnaire to ensure it aligns with program assessment objectives. To enhance its validity, the questionnaire was also reviewed by five experts in innovation management. It was then revised based on the experts' comments and suggestions.

The sample for this study includes manufacturing firms regardless of whether they received government support. The sample of 5,000 firms was randomly selected from the database of 73,000 firms (as of January 2021) registered with the Department of Industry Work (DIW). This database has notable advantages, including frequent updates and free access to firms' basic information, including names, addresses, contact information, registered capital and the number of employees.

The first round of the survey was conducted between March and May 2021. In this round, we sent questionnaires to 5,000 sample firms, accompanied by a cover letter explaining the study's rationale, requesting that the firm's owner or top management provide answers and promising to keep the firms' information confidential. By the end of May, only 193 questionnaires had been returned with complete information, yielding a response rate of 3.86%. Due to the low response rate, the second-round survey was conducted in June and August 2021. In this round, we sent questionnaires to firms that did not respond to the first-round survey and, wherever possible, made telephone calls and emails to follow up. By the end of August, we received 230 complete questionnaires. Therefore, the sample in our study consists of 423 manufacturing firms.

We assessed non-response bias by comparing firms' age, number of employees, export share and foreign investment share between the first- and second-round surveys using the independent *t*-test statistic (Lahaut *et al.*, 2003). We found no statistically significant differences between the two subsamples, suggesting no serious non-response bias in our data.

We divide the 423 sample firms into three mutually exclusive treatment groups based on their record of receiving RDI support from programs listed in Table 1:

(1) firms that received only non-financial support (S_{nf});

(2) firms that received only financial support (S_f); and

(3) firms that received both non-financial and financial support (S_{nff}).

In the sample, there are 32 (7.57%), 46 (10.76%) and 56 (13.24%) firms i*n* S_{nf}, S_f, and S_{nff}, respectively. The remaining 289 firms (68.34%) that received no support from any of the listed programs serve as the potential control group. We use this information for the subsequent analysis of the treatment effects (see 4.2).

4. Analytical strategies

4.1 Outcome variable – new product count

In this study, the outcome variable is firm-level product innovation, serving as an indicator of corporate innovation performance, consistent with the definitions outlined in the Oslo Manual (OECD/Eurostat, 2018). Product innovation is operationalized as the number of new products introduced by a firm (*NewProd*), based on responses to the survey question: "*How many new products did your firm introduce over the past three years*?"

Table 2 reports descriptive statistics for the new product count across the full sample and various subsamples. The descriptive measures reveal several important characteristics of the data. First, the mean values across all groups are substantially lower than the corresponding standard deviations and variances, indicating considerable dispersion in innovation output among firms. Second, the skewness and kurtosis statistics are markedly high for all samples, suggesting that the distribution of new product counts is positively skewed and heavy-tailed. This implies that while most firms introduce few or no new products, a small number of firms

Table 2. Descriptive statistics for *NewProd*

Descriptive statistics	Whole sample	S_{nff} *sample*	S_f sample	S_{nf} sample
Mean	3.388	2.320	2.223	1.803
SD	9.679	7.252	7.811	6.111
Variance	93.674	52.591	61.011	37.344
Skewness	5.311	6.102	7.836	8.103
Kurtosis	33.957	50.869	77.262	90.738
N	423	344	328	320

Source(s): Authors' own work

report very high levels of innovation activity, resulting in a distribution that deviates significantly from normality.

4.2 Propensity score matching

Many previous studies measuring the effectiveness of government support often suffer from selection bias. This problem arises when the likelihood of receiving support is not determined randomly but by choices made by program administrators or firms themselves (Bai *et al.*, 2019; Caliendo and Kopeinig, 2008). For instance, public RDI program managers may favor firms with particular characteristics that increase the likelihood of program success. Consequently, using standard linear estimation methods without accounting for this nonrandom selection process will likely produce biased estimates of the support effect (Kim *et al.*, 2021).

This study uses propensity score matching (PSM) to address such selection bias. The PSM is a quasi-experimental statistical technique used to reduce selection bias in observational studies. It works by calculating the probability (propensity score) that a unit receives a treatment (e.g. government support) based on observed characteristics. Treated units are then matched to non-treated units with similar propensity scores, creating a synthetic control group (Beal and Kupzyk, 2014). In the context of government RDI support programs, PSM addresses the issue that supported firms are not randomly selected. By comparing supported firms to statistically similar non-supported firms, PSM mimics the conditions of a randomized controlled trial (Bérubé and Mohnen, 2009). In this study, we apply the PSM in the following sequential steps.

4.2.1 Estimating the propensity score. Following the existing literature, we estimate the propensity score using probit regression (PR). Our dependent variable is a binary dummy variable that equals 1 if a firm received support, and 0 otherwise. The PR produces propensity scores as expected probabilities of receiving support conditional on a set of covariates – $P(S = 1|X)$.

In this study, we are interested in comparing the effectiveness of different forms of government-supported RDI. Based on the information in Table 1, we categorize firms receiving support into three groups: firms receiving non-financial support only (S_{nf}), firms with financial support only (S_f) and firms receiving combined support (both non-financial and financial) (S_{nff}). S_{nf}, S_f and S_{nff} are used to create binary dependent variables. S_{nf} is coded as 1 if a firm received non-financial support from one of the programs numbered 13–20 in Table 1, and as 0 if it did not receive support from any of the 20 programs listed in the table. Similarly, S_f is coded as 1 if a firm received financial support from one of the programs 1–12, and 0 if it did not receive any support. Finally, S_{nff} equals 1 if a firm received both financial and non-financial support, and 0 if it received no support.

For each of our three main analyses, we estimate a separate propensity score model in which the treatment group is clearly defined, and the control group consistently consists of firms that received no support from any of the 20 programs. Firms that received a different type of support are excluded from that analysis to avoid contaminating the control group with other treatment types. Specifically:

(1) Model for financial support only: The treatment group is S_f ($n = 46$). The control group is the 289 firms that received no support. Firms in S_{nf} and S_{nff} are excluded from this analysis.

(2) Model for non-financial support only: The treatment group is S_{nf} ($n = 32$). The control group is again the 289 firms that received no support. Firms in S_f and S_{nff} are excluded from this analysis.

(3) Model for combined support: The treatment group is S_{nff} ($n = 56$). The control group is also the 289 firms that received no support. Firms in S_{nf} and S_f are excluded from this analysis.

To run a PR analysis and produce propensity scores, we need to identify the set of confounding covariates X that may influence the likelihood that firms receive support. It is suggested that selecting covariates should be based on relevant theories or previous studies (Caliendo and Kopeinig, 2008). Therefore, based on data availability and previous studies' findings, we selected independent variables that capture firms' characteristics that may affect the probability of receiving RDI support, including R&D investment, age, size, human capital, technology content, location in a large industrial agglomeration and export orientation. The data used to construct these variables come from our survey. Table 3 presents the independent variables, their measurements and prior studies that used them to estimate treatment assignment probabilities and produce propensity scores.

R&D investment (*R&D*) is measured using annual R&D investment (in Thai baht) over the past three years. Firms' age (*Age*) is the number of years firms have been operating since their establishment. Firms' size (*Size*) is the number of their full-time employees. These variables are transformed using the natural logarithm to reduce dispersion in the data. Few studies incorporate firms' human capital into their analyses. Kim and Park (2021) use firms' share of researchers with master or doctoral degrees to measure human capital. Based on available data, we use the share of employees with higher education to capture firms' human capital (*HCap*). Previous studies measure firms' technological intensity in different ways. In this study, we use a binary dummy variable denoting high-tech sector firms (*HiTech*). It equals 1 if a firm is in the high-technology sector (manufacture of medical and pharmaceutical products, computer, electronic and optical products, chemicals and chemical products, machinery and equipment and automobiles); otherwise, it equals 0. Many studies include firms' location in the industrial agglomeration as a determinant of receiving support. In this study, we use a dummy variable denoting firms' location in the Bangkok Metropolitan Region (BMR) to capture the agglomeration effect, as the BMR is well known as Thailand's largest industrial agglomeration. In fact, most public agencies responsible for RDI programs are located in this region. Thus, firms in the BMR may be in a favorable position to access information about support and contact agencies that provide it. This variable equals 1 if sample firms are in the BMR, and 0 otherwise. Finally, export-oriented firms may possess higher technological capabilities compared to those that concentrate on the domestic market. Consequently, they may be prioritized by policymakers and are more likely to receive government support. In this study, the variable *Export* is a binary dummy variable equal to 1 if the majority of a firm's sales are from exports, and 0 otherwise [2].

Table 3. Covariates used for estimating the propensity score

Covariates	Measurement	Relevant studies
R&D investment	• R&D: Average annual R&D investment (in Thai baht) (log)	• Dai and Wang (2019), • Fernández-Sastre and Montalvo-Quizhpi (2019), • Kim and Park (2021), • Kim *et al*. (2021)
Firm's age	• Age: Firms' age (in years) since their official establishment (log)	• Dai and Wang (2019), • González and Pazó (2008), • Hottenrott et al. (2017), • Wu *et al*. (2020)
Firms' size	• Size: Number of full-time employees (log)	• Bai *et al*. (2019), • Bérubé and Mohnen (2009), • Fernández-Sastre and Montalvo-Quizhpi (2019), • González and Pazó (2008), • Hottenrott *et al*. (2017), • Kim and Park (2021), • Kim *et al*. (2021), • Wu *et al*. (2020)
Human capital	• HCap: Share of employees with higher education	• Kim and Park (2021)
Technological intensity	• HiTech: Binary dummy variable (One if a firm is in the high-tech sector, and zero otherwise)	• Bérubé and Mohnen (2009), • Fernández-Sastre and Montalvo-Quizhpi (2019), • González and Pazó (2008), • Kim *et al*. (2021)
Agglomeration location	• BMR: Binary dummy variable (One if a firm is located in Bangkok and Metropolitan Region (BMR), and zero otherwise)	• Bérubé and Mohnen (2009), • Fernández-Sastre and Montalvo-Quizhpi (2019), • Kim *et al*. (2021), • González and Pazó (2008)
Export orientation	• Export: Binary dummy variable (one if a firm is export-oriented, and zero otherwise)	• Chapman *et al*. (2018), • Kim *et al*. (2021), • Wu *et al*. (2020), • Zhang and Xu (2019)

Source(s): Authors' own work

To estimate propensity scores for different types of government support, we use probit models that account for the binary nature of the treatment indicators. Given that our treatments represent mutually exclusive categories – firms can receive no support, both financial and non-financial support, financial support only or non-financial support only – we estimate separate probit models for each support type against the common control group of non-recipients. We specify the probit model as follows:

$$Pr\left(S_{nffi} = 1 | X_i\right) = \Phi(\alpha_0 + \alpha X_i) \quad (1)$$

$$Pr\left(S_{fi} = 1 | X_i\right) = \Phi(\beta_0 + \beta X_i) \quad (2)$$

$$Pr\left(S_{nfi} = 1 | X_i\right) = \Phi(\gamma_0 + \gamma X_i) \quad (3)$$

where S_{nffi}, S_{fi} and S_{nfi} are binary indicators for receiving both financial and non-financial support, financial support only and non-financial support only, respectively. X_i represents the

vector of pretreatment covariates listed in Table 3. $\Phi(\cdot)$ represents the cumulative distribution function of the standard normal distribution, which ensures that predicted probabilities lie between 0 and 1.

4.2.2 Matching firms in the treatment and control groups. Several matching algorithms can be used to match propensity scores between treated and untreated observations, including kernel matching (KM), nearest-neighbor matching (NNM), radius matching (RM) and stratification methods (SM). These methods have notable advantages and disadvantages when applied to empirical analysis (Caliendo and Kopeinig, 2008). In the KM, weighted averages of all observations in the control group are used to construct the counterfactual outcome for the treated observation. The SM partitions propensity scores into strata and estimates the mean differences between treated and untreated observations within each stratum. In the NNM, each observation in the treatment group can be matched to one or more observations in the control group based on their closest propensity scores. The RM matches a treated observation with untreated observations with propensity scores in a specified propensity range (Beal and Kupzyk, 2014; Caliendo and Kopeinig, 2008).

We primarily rely on the KM due to its notable strength in reducing estimation variance. By using a weighted average of all control units rather than relying on discrete matching decisions, KM leverages more information, which enhances the efficiency and precision of the estimated treatment effects (Beal and Kupzyk, 2014; Stuart, 2010). However, the NNM and RM will also be used to assess the robustness of the results.

4.2.3 Checking common support and balancing property. To achieve quality matching, there should be sufficient overlap in propensity scores between the treatment and control groups. To do so, we use the minima-maxima comparison method (Caliendo and Kopeinig, 2008). We first compute the kernel density estimates of the propensity score distributions for both groups. Then, we visually compare the propensity score distributions between the two groups to see whether they fall at the same (or similar) maximum and minimum points.

To validate the PSM procedure, we also assessed covariate balance by comparing standardized mean differences (SMDs) before and after matching, along with other balancing diagnostics to ensure the quality of the matching.

4.3 Negative binomial regression

As shown in Table 2, the outcome variable (new product count) is highly skewed and over-dispersed. To address these issues, we estimate the effect of government support using an NBR model within the propensity-score-matched samples. We specify the NBR models as follows:

$$E(NewProdS_{nffi}, X_i) = exp(a_0 + a_1 S_{nff_i} + aX_i) \tag{4}$$

$$E(NewProd\ S_{fi}, X_i) = exp(\beta_0 + \beta_1 S_{f_i} + \beta X_i) \tag{5}$$

$$E(NewProd\ S_{nfi}, X_i) = exp(\gamma_0 + \gamma_1 S_{nff_i} + \gamma X_i) \tag{6}$$

where S_{nff}, S_{fi} and S_{nfi} are the treatment indicators for government support, including financial and non-financial support, financial support only and non-financial support only, respectively. The coefficients of interest (a_1, β_1 and γ_1) represent the effects of different forms of support on firms' product innovation, conditional on the covariates X_i listed in Table 3 and included in the model. By applying the NBR to the matched sample, we combine the bias-reduction advantage of PSM with the distributional appropriateness of the count model.

5. Results

5.1 Likelihood of receiving research, development and innovation support

Table 4 shows the results of the PR analysis for the likelihood of receiving government support. In the S_{nff} model, we find that the likelihood of receiving combined support increases with firms' R&D investment, size and human capital, with statistical significance at $p < 0.01$, $p < 0.10$ and $p < 0.01$, respectively. However, firms' age, technological sophistication, location in the BMR region and export orientation are not statistically significant predictors of obtaining both support. Similarly, in the S_f model, R&D investment, size and human capital are the only significant variables explaining the likelihood of receiving financial support. The results from S_{nf} model differ slightly from those of the two previous models. In this model, R&D and human capital are still positive and statistically significant ($p < 0.05$), but firm size is no longer significant. However, firms in the hi-tech sector are more likely to receive non-financial support than those in other sectors, with moderate statistical significance at $p < 0.10$.

In sum, the most robust predictors of receiving RDI support are R&D investment and human capital. We can also argue that the Thai government's RDI support programs favor firms with strong R&D capacity and capable human resources. By contrast, firms' age, export orientation and location within the national economic and administrative center (BMR) do not significantly increase the likelihood of obtaining support.

5.2 Common support and balancing property

We produce the propensity scores from the three PRs above. Then, we compute the kernel density estimates of the propensity score distributions for the treatment and control groups for each type of support. The results are displayed in Figure 1, 2 and 3. In Figure 1, the lines representing the propensity-score distributions of the treatment group (S_{nff} firms) and the control group (firms with no support) overlap closely. The region of common support is between the propensity scores of 0.042 and 0.760. Almost all firms in both groups fall into this region. The distribution lines in Figures 2 and 3 are similar to those in Figure 1. In Figure 2, the region of common support lines between 0.043 and 0.544, where the propensity scores of all firms receiving only financial support and those without support fall. In Figure 3, the common support region is between 0.022 and 0.489. Again, almost all firms with only

Table 4. Probit regression results

	S_{nff} model		S_f model		S_{nf} model	
Variable	Coef.	SE	Coef.	SE	Coef.	SE
Constant	−1.702***	0.408	−1.529***	0.421	−2.264***	0.478
Age	−0.086	0.108	−0.149	0.115	−0.046	0.121
Size	0.117*	0.066	0.160**	0.075	0.091	0.082
Hcap	1.029***	0.383	1.049**	0.410	1.077**	0.427
R&D	0.080***	0.014	0.060***	0.015	0.043**	0.018
HiTech	0.120	0.185	−0.306	0.208	0.565*	0.311
BMR	−0.174	0.193	−0.343	0.201	0.265	0.246
Export	−0.285	0.181	−0.125	0.190	0.023	0.205
Log-likelihood	−119.567		−103.923		−89.551	
LR chi-square	62.230***		35.400***		24.520***	
Pseudo R^2	0.2091		0.146		0.120	
Observations	344		328		320	

Note(s): ***, ** and * denote statistical significance levels at $p < 0.01$; $p < 0.05$ and $p < 0.10$, respectively
Source(s): Authors' own work

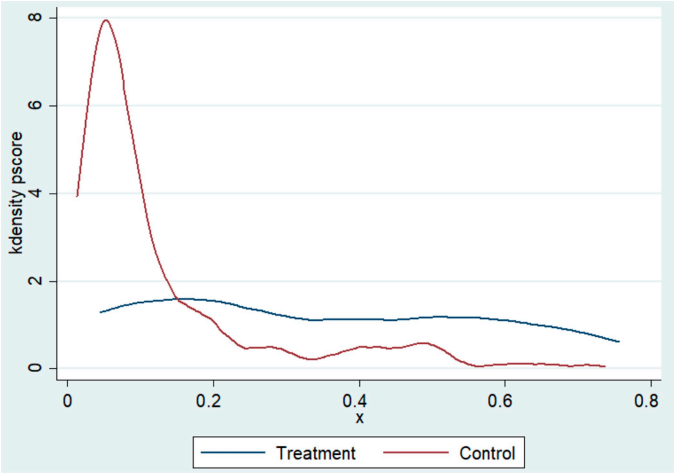

Figure 1. Propensity score distribution: S_{nff} vs no support
Source: Authors' own work

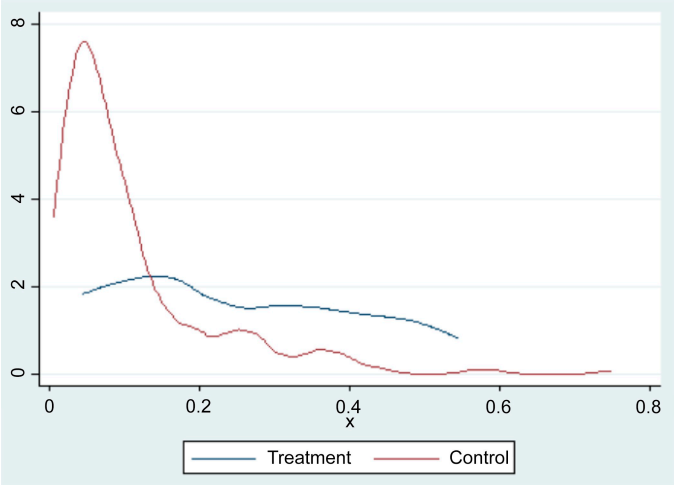

Figure 2. Propensity score distribution: S_f vs no support
Source: Authors' own work

non-financial support, as well as those without support, have propensity scores in this region. Thus, these figures suggest sufficient overlap to identify appropriate matches between firms in the treatment and control groups for each type of support.

Tables 5 and 6 present the covariate balance tests for the KM-based propensity score matching across three samples. Before matching, significant differences existed between treated and control firms for several covariates (e.g. *Size*, *Hcap*, *R&D*). After matching, these

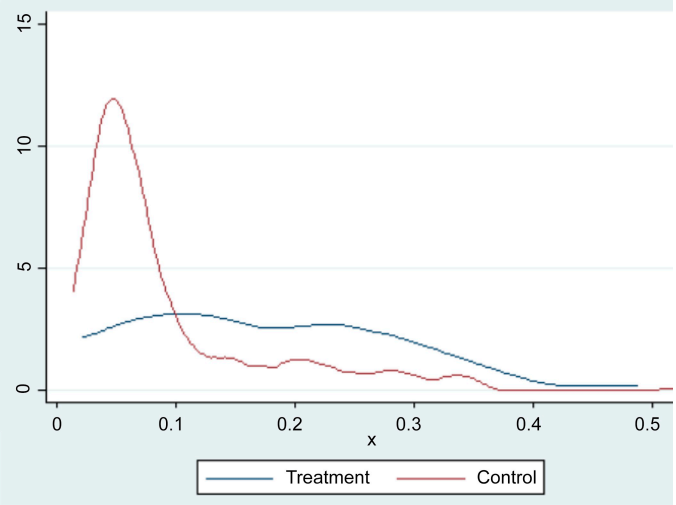

Figure 3. Propensity score distribution: S_{nf} vs no support
Source: Authors' own work

differences are substantially reduced, and no covariate exhibits a statistically significant *t*-test. While the percentage bias for a few variables exceeds the conventional 10% threshold in the matched samples, the overall diagnostic statistics in Table 6 confirm that the balancing property is satisfied. Across all three samples, the Pseudo-R^2 drops to near zero, and the likelihood ratio test becomes statistically insignificant after matching. Both the mean and median biases are reduced to below 10%. Rubin's B (less than 25 for two samples, marginally higher for one) and Rubin's R (well within the 0.5–2.0 range for all samples) indicate that the propensity score distributions are adequately balanced. Furthermore, the percentage of variance imbalance is reduced to zero in every case. These diagnostics collectively demonstrate that the matching procedure effectively balanced the observable characteristics (Guo and Fraser, 2014; Rubin, 2001).

5.3 Main results – the effects of research, development and innovation support on firms' product innovation

Table 7 presents the results of the negative binomial regression (NBR) with robust standard errors based on the propensity score-matched samples. The first thing to notice is that the model's Wald chi-square test is significant in all three samples, confirming the joint explanatory power of the independent variables. The estimated alpha parameters are significantly greater than zero in all cases, justifying the use of the NBR given the presence of overdispersion in the new product count.

In the case of the S_{nf} sample, the S_{nf} coefficient is positive and statistically significant ($\beta = 0.653$, $p < 0.05$), indicating that, within the matched sample, firms that receive only non-financial support introduce significantly more new products than their unsupported counterparts. The incidence rate ratio (IRR), calculated as $\exp(0.653) = 1.92$, suggests that, holding all other variables constant, firms receiving only non-financial support are approximately 1.92 times more likely to introduce new products than firms that did not receive support.

Table 5. Covariate balance before and after matching

		S_{nff} *sample*					S_f *sample*					S_{nf} *sample*				
		Mean		%Bias	*t*-test		Mean		%Bias	*t*-test		Mean		%Bias	*t*-test	
Variable	Unmatched matched	Treated	Control		*t*	*p*>|t|	Treated	Control		*t*	*p*>|t|	Treated	Control		*t*	*p*>|t|
Age	U	2.88	2.83	6.10	0.41	0.68	2.69	2.83	−14.60	−0.94	0.35	2.90	2.83	7.50	0.43	0.67
	M	2.86	2.96	−10.80	−0.57	0.57	2.69	2.68	0.50	0.02	0.98	2.99	2.96	3.20	0.13	0.90
Size	U	4.56	3.78	46.50	3.40	0.00	4.68	3.78	50.30	3.54	0.00	4.26	3.78	30.90	1.70	0.09
	M	4.48	4.57	−5.40	−0.30	0.77	4.27	4.42	−8.50	−0.41	0.68	4.26	4.26	0.50	0.02	0.99
Hcap	U	0.36	0.24	50.10	3.53	0.00	0.43	0.24	63.80	4.59	0.00	0.37	0.24	56.90	2.97	0.00
	M	0.36	0.35	5.20	0.26	0.80	0.35	0.30	18.50	0.87	0.39	0.36	0.37	−2.80	−0.10	0.92
R&D	U	8.97	1.98	110.70	8.86	0.00	8.18	1.98	95.50	7.25	0.00	6.32	1.98	70.40	4.49	0.00
	M	8.80	8.40	6.30	0.28	0.78	6.79	6.82	−0.50	−0.02	0.99	6.07	6.05	0.40	0.01	0.99
HiTech	U	0.46	0.40	12.70	0.87	0.38	0.33	0.40	−15.60	−0.97	0.33	0.50	0.40	19.70	1.07	0.28
	M	0.47	0.47	0.00	0.00	1.00	0.38	0.49	−24.70	−1.07	0.29	0.48	0.50	−2.20	−0.09	0.93
BMR	U	0.61	0.64	−6.10	−0.42	0.68	0.59	0.64	−10.10	−0.65	0.52	0.81	0.64	39.80	1.99	0.05
	M	0.62	0.54	15.10	0.78	0.44	0.55	0.58	−5.40	−0.24	0.81	0.81	0.74	14.20	0.58	0.56
Export	U	0.45	0.56	−22.20	−1.50	0.13	0.48	0.56	−15.90	−0.99	0.32	0.53	0.56	−5.50	−0.29	0.77
	M	0.45	0.49	−7.90	−0.42	0.68	0.50	0.49	1.80	0.08	0.94	0.55	0.56	−3.10	−0.12	0.90

Source(s): Authors' own work

Table 6. Diagnostic statistics for the balancing test

Diagnostic statistics	Unmatched Matched	S_{nff} Sample	S_f Sample	S_{nf} Sample
Pseudo-R^2	U	0.22	0.21	0.22
	M	0.01	0.02	0.01
LR chi^2	U	66.54**	55.87**	66.54**
	M	1.56	2.49	1.22
Mean bias	U	36.30	38.00	36.30
	M	9.40	8.60	7.30
Median bias	U	22.20	15.90	22.20
	M	8.70	5.40	6.30
Rubin's B	U	127.30	114.3	127.30
	M	24.10	35.1	21.00
Rubin's R	U	1.60	2.70	1.6
	M	1.03	0.81	0.99
%Variance	U	20.00	40.00	20.00
	M	0.00	0.00	0.00

Note(s): **statistical significance at $p < 0.01$
Source(s): Authors' own work

For the S_f sample, the coefficient of S_f is positive and statistically significant ($\beta = 0.767$, $p < 0.01$). This finding indicates that receiving government financial support is associated with a higher expected number of new products. Specifically, firms that receive only financial support are expected to introduce new products at a rate approximately 2.15 times that of their matched counterparts that did not receive support (exp (0.767) = 2.15).

Finally, the S_{nff} variable also yields a positive and statistically significant coefficient ($\beta = 0.772$, $p < 0.01$). This result can be interpreted as receiving both financial and non-financial support increases the likelihood that firms will introduce product innovations. Firms that receive both types of RDI support are expected to generate new products at a rate approximately 2.16 times higher than firms that received no support.

In sum, the NBR results reveal that all types of government RDI support are crucial for firms' product innovation. The treatment effect of combined support tends to be higher than that of the other two types, but their differences are only marginal.

Regarding control variables, R&D emerges as the most robust and consistent predictor of firms' product innovation, exhibiting a positive and statistically significant ($p < 0.01$) across all three matched samples. This finding underscores the fundamental role of firms' own R&D investment in fostering innovative capabilities, regardless of the type of government support received. *HiTech* is negative and statistically significant in both the S_{nff} and S_f samples, suggesting that operating in the high-tech sector does not increase the likelihood of introducing new products relative to other sectors. The possible explanation is that many Thai firms operating in the hi-tech sector are original equipment manufacturing (OEM) firms, focusing on manufacturing by order rather than their own-designed products. In fact, according to Tippakoon *et al.* (2024), firms in this sector are likely to introduce process innovation but not product innovation. *Size* and *BMR* are positive and significant only in the S_f sample, suggesting that scale and locational advantages are present primarily when paired with financial support. Firms' human capital (*Hcap*) exhibits a significant negative effect in the S_{nf} sample, warranting further investigation. Finally, firm age and export orientation are not statistically significant in any of the three models.

Table 7. Negative binomial regression results

	S_{nff} *sample*				S_f *sample*				S_{nf} *sample*			
Variable	Coef.	Robust SE	[95% Conf.	Interval]	Coef.	Robust SE	[95% Conf.	Interval]	Coef.	Robust SE	[95% Conf.	Interval]
Constant	−0.588	0.605	−1.774	0.598	−1.560*	0.671	−2.875	−0.246	0.022	0.594	−1.143	1.186
S_{nff}	0.772**	0.275	0.234	1.310								
S_f					0.767**	0.257	0.264	1.271				
S_{nf}									0.653*	0.324	0.019	1.288
Age	0.038	0.157	−0.269	0.345	0.096	0.117	−0.134	0.325	−0.147	0.237	−0.612	0.318
Size	0.036	0.078	−0.116	0.189	0.317**	0.107	0.108	0.526	0.148	0.147	−0.141	0.437
Hcap	−0.298	0.589	−1.452	0.856	−0.264	0.580	−1.401	0.873	−1.972**	0.647	−3.239	−0.704
R&D	0.108**	0.018	0.073	0.143	0.058**	0.016	0.027	0.090	0.083**	0.027	0.030	0.136
HiTech	−0.900**	0.275	−1.438	−0.361	−0.512*	0.252	−1.005	−0.018	−0.400	0.296	−0.980	0.181
BMR	0.384	0.288	−0.181	0.948	0.631*	0.297	0.049	1.213	0.695	0.363	−0.016	1.407
Export	0.404	0.257	−0.100	0.909	0.216	0.278	−0.328	0.761	0.306	0.286	−0.254	0.865
Alpha	1.839**	0.382	1.224	2.764	1.764**	0.389	1.144	2.719	2.185**	0.436	1.478	3.230
Wald chi^2			88.570***				69.830**				38.200**	
Pseudo R^2			0.083				0.080				0.051	
N			344				328				320	

Note(s): ** and * denote statistical significance levels at $p < 0.01$ and $p < 0.05$, respectively
Source(s): Authors' own work

5.4 Robustness check

To assess the robustness of our results, we performed PSM using one-to-three NNM and RM (caliper = 0.1 of the standard deviation). We checked for the common support and balancing properties and found that they were satisfied [3]. Then, we proceeded to run NBR analysis. Table 8 presents the NBR results from NNM (8a) and RM (8b) procedures. Overall, this table shows that government RDI support positively and statistically significantly affects firms' product innovation. Firms receiving both types of support (S_{nff}) are more likely to launch new products than their counterparts without support. The results are similar for S_f and S_{nf}, suggesting that firms that received only financial support or only non-financial support are more likely to introduce product innovations than those that received no support. These results generally confirm those in Table 7. Therefore, it can be argued that the effects of government RDI support are robust across different matching methods.

6. Discussion

6.1 The mechanics of government research, development and innovation support for product innovation

6.1.1 Financial support and product innovation. The finding that S_f positively affects firms' product innovation (IRR = 2.15, $p < 0.01$) is consistent with the capital market failure theory, which posits that private capital markets tend to underfinance firms' innovative activities (Arrow, 1972; Nelson, 1959). In Thailand's context, where specialized capital markets to finance innovative businesses are lacking (Wonglimpiyarat, 2014), public funding appears to fill a critical void. The relatively large effect size of S_f (more than doubling the expected count of new products) implies that financial constraints are a considerable barrier for Thai firms. Additionally, aligned with the OL perspective (March, 1991), the private financial cost of exploratory search for new knowledge is reduced by government financial support. With financial support, firms can explore new technological solutions, resulting in superior innovation performance (Chapman and Hewitt-Dundas, 2018; Chundakkadan and Sasidharan, 2020). Moreover, the AC theory (Cohen and Levinthal, 1990) suggests that firms that invest in R&D can effectively utilize newly acquired knowledge. Based on the information in Table 1, the Thai government's financial support programs primarily fund firms' R&D projects. Therefore, it can be argued that these programs may strengthen firms' R&D investment, thereby increasing their AC and innovation performance.

6.1.2 Non-financial support and product innovation. The positive and statistically significant effect of S_{nf} (IRR = 1.92, $p < 0.05$) suggests that non-financial support is essential for strengthening firms' product innovation. Some mechanisms may explain this result. First, according to human capital theory, firms with a knowledgeable, highly skilled workforce tend to utilize knowledge more efficiently. It is likely that non-financial support can enhance firms' knowledge and skills through training, consultation and information services, thereby increasing their ability to acquire and utilize new knowledge. Moreover, given that Thai firms generally have a low baseline AC (Rakthin *et al.*, 2024), support programs that strengthen their knowledge base through capacity-building and consultation services, and thereby upgrading their AC, may exert a strong impact on their innovation performance. Second, from a RBV, the diverse knowledge and skills held by a firm's managers and employees are strategic assets that can be combined to generate innovation (Hadjimanolis, 2000). Government non-financial support through training, consultation and information services can enrich this internal pool of expertise and upgrade firms' human capital, thereby strengthening their ability to introduce product innovation.

6.1.3 Combined support and product innovation. The finding that the effect of combined support (S_{nff}) is positive and statistically significant (IRR = 2.16, $p < 0.01$) suggests a

Table 8. NBR results based on NNM and RM

Variable	S_{nff} sample				S_f sample				S_{nf} sample			
	Coef.	Robust SE	[95% conf. interval]		Coef.	Robust SE	[95% conf. interval]		Coef.	Robust SE	[95% Conf. Interval]	
a: NNM												
Constant	−0.887	0.633	−2.127	0.353	−2.957**	0.658	−4.247	−1.666	−0.169	0.656	−1.454	1.117
S_{nff}	0.763**	0.275	0.224	1.302								
S_f					1.092**	0.262	0.577	1.606				
S_{nf}									0.729**	0.367	0.010	1.448
Age	0.158	0.158	−0.152	0.469	0.454**	0.143	0.174	0.734	−0.022	0.296	−0.602	0.559
Size	0.016	0.082	−0.145	0.177	0.410**	0.099	0.216	0.603	0.093	0.173	−0.246	0.431
Hcap	−0.141	0.543	−1.205	0.923	0.321	0.514	−0.686	1.328	−1.585*	0.774	−3.103	−0.068
R&D	0.115**	0.019	0.078	0.153	0.071**	0.019	0.034	0.107	0.097**	0.033	0.032	0.161
HiTech	−0.904**	0.276	−1.446	−0.363	−0.897**	0.267	−1.421	−0.374	−0.386	0.337	−1.046	0.274
BMR	0.410	0.276	−0.131	0.951	0.187	0.285	−0.372	0.746	0.457	0.452	−0.429	1.343
Export	0.195	0.270	−0.334	0.724	−0.266	0.275	−0.805	0.273	0.228	0.350	−0.459	0.915
Alpha	1.635**	0.326	1.106	2.417	1.152**	0.260	0.740	1.792	2.268**	0.486	1.490	3.452
Wald chi2			81.720**				68.280**				32.430**	
Pseudo R^2			0.097				0.123				0.058	
N			146				113				108	
b: RM												
Constant	−0.460	0.612	−1.659	0.740	−1.352	0.731	−2.786	0.081	0.048	0.595	−1.118	1.214
S_{nff}	0.589*	0.295	0.010	1.168								
S_f					0.814**	0.257	0.310	1.317				
S_{nf}									0.718**	0.307	0.117	1.319
Age	0.039	0.154	−0.263	0.340	0.055	0.153	−0.245	0.355	−0.238	0.243	−0.714	0.238
Size	0.035	0.077	−0.116	0.187	0.339**	0.102	0.140	0.538	0.176	0.148	−0.114	0.465
Hcap	−0.225	0.582	−1.365	0.915	−0.414	0.571	−1.532	0.705	−1.976**	0.644	−3.239	−0.713
R&D	0.114**	0.018	0.078	0.149	0.062**	0.016	0.030	0.095	0.089**	0.027	0.036	0.142
HiTech	−0.824**	0.283	−1.378	−0.270	−0.662**	0.259	−1.169	−0.154	−0.408	0.293	−0.983	0.166
BMR	0.295	0.288	−0.270	0.861	0.505	0.284	−0.051	1.061	0.681	0.364	−0.033	1.395
Export	0.371	0.265	−0.149	0.891	0.043	0.265	−0.476	0.562	0.391	0.283	−0.164	0.946
Alpha	2.033**	0.406	1.374	3.007	1.731**	0.377	1.129	2.652	2.238**	0.456	1.501	3.337
Wald chi2			79.070**				74.010**				38.300**	
Pseudo R^2			0.073				0.084				0.054	
N			344				328				320	

Note(s): * and ** denote statistical significance levels at $p < 0.05$ and $p < 0.01$
Source(s): Authors' own work

powerful synergistic relationship between financial and non-financial support, enhancing firms' innovative performance. There are some theoretical mechanisms that explain this result. First, from the AC perspective, financial and non-financial support programs jointly enhance firms' AC. While financial support enables firms to undertake more exploratory research and add novel knowledge to their existing knowledge base (Gao *et al.*, 2021), non-financial support strengthens firms' human capital, increasing their ability to utilize knowledge more effectively (Vega-Jurado *et al.*, 2008). As a result, this combined effect leads firms that receive both support to perform better than those that receive neither. Second, while financial support augments firms' knowledge base by adding novel insights generated mainly by their research activities, non-financial support enlarges firms' skill sets through various capacity-building activities. Both of these support provide firms with the tangible and intangible resources necessary for innovation, which is consistent with the RBV. Consequently, this combined support exerts a strong effect on firms' product innovation.

6.2 Theoretical implications

The findings of this study have some implications for theoretical and empirical literature on the government's role in promoting firms' innovation. First, the impacts of different types of RDI support on firms' innovation are positive but vary in their magnitude. Existing literature has not examined this issue sufficiently. Most previous studies investigate the effects of a particular type of government support (either financial or non-financial) without exploring and comparing their individual and combined effects. Thus, little is known about whether (and to what extent) different forms of support are crucial for upgrading corporate innovative capabilities.

Second, financial and non-financial support have distinct theoretical foundations. Financial support is primarily drawn on the market failure logic, especially the private markets' inability (or unwillingness) to provide monetary capital for innovative activities. These activities are subject to imperfect information and, thus, considered too risky by private financial institutions (Zúñiga-Vicente *et al.*, 2014). Therefore, public finance is necessary to provide firms with sufficient financial resources and reduce their financial burdens, enabling them to invest in innovative activities (Czarnitzki *et al.*, 2009; Gao *et al.*, 2021; Wu *et al.*, 2022). On the other hand, non-financial support is primarily drawn on the logic of human capital accumulation, which mainly aims to upgrade firms' human resources and managerial capabilities. This support modality is generally given through training, consultation or technical assistance, which can help enhance firms' absorptive capacity by strengthening their human capital (Gyamfi *et al.*, 2024; Widodo and Mahi, 2022). The effects of these two support types may differ in either direction or magnitude. Therefore, in a particular context, analyzing how effective government RDI support programs are in promoting corporate innovation should also consider the differential effects across types of support. In the current study, the findings support both the capital market failure perspective and human capital theory.

Third, we contribute to the extant literature on government RDI support by taking Thailand, which is characterized as a less advanced innovation system, as a case study. The finding that financial support is significant suggests that capital market imperfection is perhaps a serious issue in the Thai context. This finding aligns with some prior studies highlighting the weakness of the Thai capital market for innovative activities (Wonglimpiyarat, 2014; WIPO, 2023) and the resulting inability of SMEs (more than 99% of Thai firms) to overcome financial constraints and invest in R&D (Chaminade *et al.*, 2012; Intarakumnerd *et al.*, 2002). The finding that non-financial support is essential for promoting

innovation indicates that the knowledge and skills of Thai firms are limited and need upgrading, and that government assistance is deemed important.

6.3 Practical implications

The finding that both financial and non-financial support are vital to promoting firms' product innovation underscores the importance of government RDI programs in fostering corporate innovation. Therefore, it is necessary to increase the accessibility of the programs and broaden their coverage to reach a larger number of beneficiaries. However, based on the survey conducted for this study, we found that approximately 70% of the sample firms did not recognize any of the government's RDI support programs listed in Table 1. Many indicated that they wanted to upgrade their technological capabilities but could not access financial support. This is consistent with the NXPO's survey of industrial RDI activities, which found that, on average, less than 10% of surveyed firms recognized the existence of public RDI support programs (NXPO, 2019). Interestingly, our survey shows that firms that received support (on average, 4% of the sample for each program in Table 1) perceived support as essential to technological improvement and the commercial success of innovations. This information highlights the importance of increasing access to the programs.

7. Conclusion, limitation and further research

The objective of this study is to examine the effect of the government's RDI support on firms' innovation performance. We contribute to the extant literature on innovation by analyzing the impact of different types of support (financial, non-financial and combined support), a distinction that differs from most studies that focus on either type. Additionally, we focus on Thailand, a typical developing economy characterized by a weak innovation system. This study differs from most studies that draw on experience from developed countries.

We analyze the survey data of 423 manufacturing firms. Our data set contains beneficiary firms of financial and non-financial support programs. We use the PSM method to control for selection bias, whereby firms with particular characteristics are more likely than others to be supported by the programs. Then, we use the NBR to analyze the effects of support on firms' new product counts, based on the propensity score-matched data.

The analysis results reveal that financial, non-financial and combined support all have positive effects on firms' product innovation, but differ only in their effect size. This finding implies that it is necessary to distinguish between different types of RDI support when examining their effects on firms' innovation performance. The finding of a positive effect of financial support aligns with the market failure thesis, highlighting the crucial role of public subsidies in addressing market failures and promoting corporate innovative activities. It is also consistent with the AC and OL theories, as government financial subsidies enable firms to pursue exploratory research and seek novel insights beyond their existing knowledge base. The positive effect of non-financial support highlights the importance of upgrading the knowledge and skills of firms' human resources through various means, including training, consultation and information services. This result supports RBV and human capital perspectives.

We acknowledge some limitations in this study and highlight them for further research. First, our study covers only 20 RDI programs, mainly offered by public agencies under the Ministry of Higher Education, Science, Research and Innovation. Some programs implemented by different ministries (e.g. the Ministry of Industry and the Ministry of Commerce) may contribute directly or indirectly to firms' technological upgrading and are not covered by our study. Thus, the findings of this study may be limited in their generalizability. Despite this limitation, our focus on the financial and non-financial aspects

of RDI support proffers substantial theoretical and policy implications. Future studies may increase the degree of generalization by broadening the coverage to include all programs implemented by all relevant agencies.

Second, this study's results can only reveal whether financial and non-financial RDI support is significant for firms' innovation performance. However, it cannot show how and under what circumstances each type of support may deliver innovative outcomes. Future research may adopt a detailed qualitative analysis based on case studies of financial and non-financial programs to investigate these issues.

Notes

[1.] Thailand's gross R&D expenditure was only 1.3% of GDP, far below the OECD average of 2.7%. Its patents by origin per GDP were only 0.5, and intellectual property receipts were only 0.1% of total trade (WIPO, 2024).

[2.] Due to the unavailability of the data, we cannot include foreign ownership, which is used in many studies, in the analysis. However, as foreign-owned firms in Thailand tend to be export-oriented, it is likely that the variable "export orientation" to some extent captures foreign-owned firms (Jongwanich and Kohpaiboon, 2008; Nidhiprabha, 2017).

[3.] The results are not presented here to save space, but are available upon request.

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