Impacts of R&D Expenditures On Firms' Innovation and Financial Performance: A Panel Data Evidence from Ethiopian Firms

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Research

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Impacts of R&D Expenditures on Firms' Innovation and Financial Performance: A Panel Data Evidence from Ethiopian Firms

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Abstract

In the era of the rapid development of knowledge economy and science, all countries have thought highly of technical innovation and greatly increased investment in R&D from time to time. The vast literature indicates that the relationship between R&D and firms' performance is highly complex while evidences suggest that R&D positively influences firms' performance, yet the process how R&D activities influence firms' performance is still mixing. This paper explores the impacts of investment in R&D on firms' performance from 476 firms in Ethiopia by employing a combination of the fixed-effect, PSM and ETE estimation methods. The findings of this study support the existence of a strong interaction between R&D activities and firms' performance. The empirical results reveal that investment in R&D positively influences both innovation and long-term financial performance, while it negatively impacts shorter-term financial performance. Moreover, results show that the impacts of R&D activities vary significantly along the different category of firms confirming that heterogeneity is possible issue among firms considered. The results also indicate that availability of credit is more important moderating factor for the relationship between R&D investment and firms' performance than legal system. The results from the current study have important implications for firms especially those from developing countries like Ethiopia with growing R&D operations. We propose that Ethiopian firms should invest more on R&D activities, such as the production of fundamental research and applied research to have better performance and enhance their competitiveness in the future.

Keywords: R&D investment; Firm performance; Impact evaluation; Panel data; Ethiopia
JEL Classification Codes: D21; D92; L25; O32; M10

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1. Introduction

In the current era of the rapid economic development and expansions of knowledge transfer and science, nations have thought highly of technical innovation and greatly increased investments in research and development (hereafter R&D) targeting to bring required levels of growth. In the late 1980s the endogenous growth theories emphasized on the importance of human capital, R&D and innovation in economic growth process (Aghion et al., 1998; Aghion and Howitt, 1992; Grossman and Helpman, 1991a, 1991b; Romer,1986, 1990; Lucas, 1988). Investment in R&D can enhance innovation and thus improving and sustaining long-run economic growth (Jones and Williams, 2000; Mansfield, 1991), and rising R&D spending leads to an increase in innovation and total productivity of the economy. In regions like the European Union (EU), one of the crucial priorities of economic growth and jobs strategy is the trends of investment in R&D and knowledge transfer (European Commission, 2010; Trajtenberg, 1990) and this strategy is at the heart of growth policy in the region. The R&D related investment is used as a foundation of competitive advantage, long-term economic growth and technological advancement that results in improved firm performance (James and McGuire, 2016; Ruiqi et al., 2017; Patel et al., 2018).

Contextually, the R&D spending and its related outcomes have long been studied by economists in empirical studies (Mansfield, 1962). R&D is also one of the most important approach to increase firm's performance via improved productivity and technological innovation (Guo et al., 2018; Shin et al., 2009), thus becoming a central driver of a country's social welfare and economic growth (Alam et al., 2019a; Chen, 2017) in which, most countries investing more in R&D are growing faster and achieve higher levels of social welfare in general. In line with these facts, many nations are trying to gain a competitive advantage in the global innovation context (Atkinson, 2013; Chen et al., 2018; Mikalef and Pateli, 2017; Scuotto et al., 2017; D'Ippolito et al., 2019) and emphasizing on innovation technology to accelerate growth and competitiveness (Acs, et al., 2017; Shen et al., 2017) where there is an increased global competition which accelerates the life cycle of products and technology transfers.

The effect of R&D expenditure on performances of firm has attracted the interests of researchers and policy makers for more than five decades in the past with a general consent that R&D investments have a favorable effect on a firm's capability to innovate which in turn leads to greater productivity (Mansfield, 1962; 1980; 1986; Griliches, 1986; Lööf and Heshmati, 2006; Lööf et al., 2003; Coad and Rao, 2008; Aboody and Lev, 2000). Since the late 1970s, there has been a surge in a research sector that focus on the importance and possible impacts of R&D on aggregate welfare as international firms have ever more expanded their R&D activities world-wide (Chen et al., 2012; Kafouros et al., 2020; Martinez-Roman et al., 2019), and due to this fact last few decades have witnessed a remarkable growth in R&D investment globally.

A vast literature also indicate that R&D activities improve the innovation process and encourages R&D based absorptive capacity by enabling the imitation of the existing innovation (Islam, 2009). Any form of investment in R&D plays a crucial role for a firm to be more innovative and the cumulative effects to the country, thus R&D activity is necessary for the advance of new innovative outputs in general (Wei et al, 2001). It is also true that due to the existence of shared agglomeration externalities and knowledge spillovers, the effects of R&D can easily be observed on firms' performance levels, where firms sharing the same environmental conditions are more similar in their innovation performance than firms that do not share the same environment. Building successful R&D relationships is based on knowledge sharing and the context in which the firm is located. It is very vibrant for firms to engage in knowledge sharing relationships with other firms, and also with organizations from other sectors of the economy (Cooke and Morgan, 1998; Carayannis and Campbell, 2009; Carayannis and Rakhmatullin, 2014). Again, alliances of firms from knowledge sharing perspective can be heavily motivated by the extent to which partner firms potentially can learn from each other (Cowan, 2005; Wersching, 2010), the issue of technological fit, and a firm's level of innovativeness can effectively influence its decision to cooperate or not.

From the vast literature, it is observed that R&D activities have favorable effects on firm's performance in general and R&D investment could be considered as a key driving factor towards firm performance. However, a continuous increase in R&D investment typically leads to a surge in revenues when R&D implementation produces successful outcomes (Liao and Lin, 2017; Xu and Sim, 2018). Consequently, it is crucial to determine whether more investment in R&D leads to improved firm performance and to affirm whether more and continuous increase in R&D investment are a worthwhile activity (Lee et al., 2019). Moreover, managers in technology-based firms face with three core challenges that need to be answered in relation to investment in R&D. These are: "(1) Have we invested enough in R&D expenses? (2) Have we allocated enough resources to the commercialization of the firm's technology assets? (3) Do our investments in R&D and commercialization really pay off in terms of bottom-line finance performance?" (Lin et al., 2006, p.1).

Apart from this, the relationship between R&D and innovation is highly complex in its context and nature (Edquist, 2011; Holgersson and Kekezi 2018). There is also a large and extensive body of literature on the relationship between R&D expenditures and firm's performance and there seems to be a general consensus in the literature that R&D has a positive effect on firm performance. Despite this extensive research, the evidence shows that the impact of R&D expense on firm performance appears in mixed trends (VanderPal, 2015). The results of some others study also highlighted even conflicting results (e.g., Fosfuri andTribó, 2008; Kim et al., 2019; Morikawa, 2004; Eberhart et al., 2004; Ike and Kingsley; 2010; Porter and Stern, 2000; Furman and Hayes, 2004; Xu and Sim, 2018) found positive impact, while (Hsu and Boggs, 2003; Majocchi and Zucchella, 2003; Vithessonthi and Racela, 2016; Lu and Wand, 2011) have reported negative effect. Moreover, some previous studies (e.g., Yeh et al., 2010) found that there may a positive association, but the positive effect of R&D expenditures on firm performance continues, to a certain extent.

Despite extensive research on the impact of investment in R&D on firms' performance, quite lots of these studies focused on firms' innovation or financial performance separately. In measuring firms' level of efficiency, financial performance measures are crucial, yet they are not enough to define a firm's overall performance (Latifi et al., 2021; Murphy et al., 1996). Only a study by Leung and Sharma (2021) recently has approached both topics closer, but the study targets to investigate the mediating role of innovation performance in the effects of R&D on firm performance. Although there has been a contentious debate as to whether R&D investment contributes to firm performance, in our current study we argue that R&D investment may influence firm performance differently under various conditions and the timely effects may also vary with the timing of the investment as those factors need time to show intended results since R&D investment is viewed as an ongoing activity. This topic thus, deserves further research in order to fully understand those complex yet important relationships. Despite its significance, the literature on R&D spending and firms' operation indicates that too narrow focus is given to the relationship and less is known about the simultaneous impacts of R&D expenditure on firms' innovativeness and firms' performances. In addition to these facts, there is substantial heterogeneity in the impacts of R&D across different types of firms (Hall et al., 2009; Ortega-Argile´s et al., 2010). So, here we will try to explore the impacts by disaggregating firms based on their size and location.

Another gap in the vast literature that we observed is from measurement sides. From the sides of the current study's argument, the impact of R&D on a firm's bottom line is undeniable. It is also often argued that R&D is appraised as a driving factor for innovation through the accumulation of different technological strength and capacity that fuel a firm's growth (Lee et al., 2019). Technological innovation through investment in R&D can potentially drive firms to develop new and more products to raise market value and growth. However, little is known about how the impacts of R&D vary when different performance measures are used. This condition casts doubt on R&D effects on firms' innovativeness and performance. Though quite lots of previous studies on this topic have supported the notion that R&D has a positive effect on firm performance, there may still be different perspectives in which change in measurement may have different effect over the considered outcomes.

Despite the growing number of studies on this the topic under study, to the best of our knowledge none of study has specifically captured the issue of performance measurements carefully both in the short and long-term context in developing countries like Ethiopia and only few have done in advanced countries case. This is because the R&D activity requires large investment costs. Therefore, R&D activities are not really appreciated in developing countries. Most R&D research in developing countries is mainly focused on China (Tung & Binh, 2021). Thus, the current study addresses the above observed research gaps in the literature by exploring the differences in the impact of R&D expenses on firms' short-term, annual sales and profits, and long-term, Total Q and Tobin's Q, financial performance; and on firms' innovativeness using introduction of new or improved products or services, and new or improved marketing practice at firm level using a panel data in Ethiopian.

The final novel contribution of the study is that it applies a panel data to account for the dynamic aspect of the issue in which dozens of previous studies have focused on cross-sectional or time series data, while quite few studies have employed panel data. Based on a two rounds of the World Bank's Enterprise Survey panel database of 2011 and 2015, this study makes important contributions to the literature.

2. Theoretical Background and Hypotheses Formulation

From previous studies we note that R&D expenditures are related to different types of firms' performance. The contributions of R&D investment to firms' performance are discussed widely in the literature (see Roberts, 1999; Cho & Pucik, 2005; Hua & Wemmerlov, 2006; Homburg et al., 2017; Hsieh et al., 2003; Morbey, 1989). Studies also evidenced that R&D investment can help firms gain new technologies and products, and can improve firm's productivity in order to respond quickly to change in market demands, which can positively affect firms' profits (Alam et al., 2020; Jung & wak, 2018; Xu & Sim, 2018). It is also important for firm managers to understand the relationship between R&D investment and firm's performance and value (Tubbs, 2007). Investment in R&D is also one key strategic factor to frequently progress the product and services in today's business world based on new technology innovation. So, based on those previous studies in the field we developed the following hypotheses and Fig.1 below explains this conceptual model:

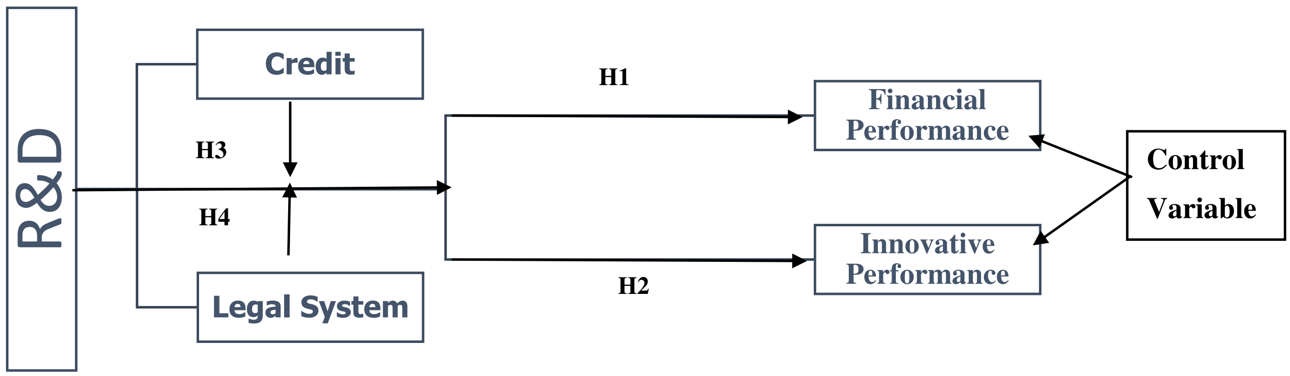

Figure 1. The conceptual framework of this study, Source: Own presentation.

R&D investment decisions are determined by available resources of firms as well as future returns. A large number of studies are conducted to examine the impact of R&D investment on firms' performance. Most of the studies indicate the positive effect of R&D on firms' performance (Kim et al., 2019; Ike & Kingsley; 2010; Furman & Hayes, 2004; Xu & Sim, 2018; Chan et al., 2001; Yeh et al., 2010; Eberhart et al., 2004). Alam et al., 2020 argue that there could be a positive relationship between the current year's R&D /previous year's R&D and future performance/ and current performance, but the relationship could be stronger in the presence of some factors like investor protection in the country.

Some other groups of studies have also found that current year's R&D investment reduces current year's profits but may influence positively on future firm performance (Knecht (2013). Furthermore, others have found that spending on R&D affects negatively profit for the year of the investment while there may be a strong positive relationship after some years (Parcharidis & Varsakelis, 2007; Natasha & Hutagaol, 2009). Moreover, a study by Yeh et al. (2010) found that there may a positive association, but the positive effect of R&D expenditures on firms' performance continues, to a certain extent. Therefore, spending on R&D above a certain rate results a negative effect on profitability. In other similar studies, for instance a study by Wang (2009) revealed that the relation between R&D investment and firms' performance has a reversed s-curve while Yang et al. (2014) explained that there is an s-curve association between R&D investment and firms' performance. Thus, based on this vast mixed literature in the field, in our case the R&D spending and financial performance are associated negatively in the short run and positively in the long run. Thus, based on the above deep consultation of the literature, we hypothesize that:

H1a. *R&D Investment activities negatively affects* concurrent *financial performance.*

H1b. Previous year's *R&D Investment activities positively affects* current *financial performance.*

Several studies have found that the relationship between investment in R&D and innovation performance is positive (Belussi et al., 2010; Faems, 2005), while the impact dependent on the firm's structure and on the type of knowledge developed. Some other prior studies have also found that R&D expenditure positively impacts innovation performances (Jensen, 1987; Scherer, 1965; Pakes & Griliches, 2007; Crépon et al., 1980; Iwasa & Odagiri, 2004; Penner-Hahn & Shaver. 2005). Other groups of studies have also explored the association between R&D activity and innovation performances and found that the former has a positive impact on the latter (Belluci & Pennacchio, 2016; Barra & Zotti, 2018; Hagedoorn & Duysters, 2002; Peeters & de la Potterie, 2007). Leung and Sharma (2021) argues that firms use spending on R&D to advance their innovation performance by rising and introduction new and innovative products and services to achieve high returns. In general, the positive relationship between the R&D investments and innovation performance is quite well established in the literature, such that firms that increase spending in R&D are expected to be more likely to positively progress and launch new products and technologies, and increase competitiveness (Artz et al., 2010; Su et al., 2020). So, based on the above facts, the following hypothesis is postulated:

H2. *R&D Investment activities positively affects innovation performance.*

In a related study, Pindado et al. (2015) have shown that country-level factors moderate the relationship between R&D and firm performance. Chan et al. (2001) also found evidence that external corporate governance helps to improve the relationship between R&D and firms' performance. For example, Hillier et al. (2011) and Pindado et al. (2015) highlighted the role of investor protection, financial development and control mechanism. Other studies argue that although market stimulus is a major source of innovation continuity, sole reliance on it may not always produce sufficient incentives for innovation (Bin, 2005; Fang, 2010). Private investors are usually concerned about obtaining quick and safe returns on their investments (Henk & Guus, 1994), and the high R&D costs and risks involved in both basic and applied research keep many investors away.

Studies also examine that in any economic system government policy and wide variety of incentive instruments regarding financial incentives is considered to be a crucial element in firms' development and promote innovation (Zhang & Guan, 2018; Guan & Yam 2015). A study by Saha and Shaw (2018) shows that the Korean government often giving several types of incentives such as tax credits and exemptions to stimulate R&D activities for high-tech enterprises. This means that the government provides such types of incentives to encourage firm's investment and varies activities in R&D area. Moreover, some type of incentive like tax incentives are provided aiming to stimulate firms that are more interested investing in R&D (Czarnitzki et al., 2011). Moreover, it has been argued that firms' choice of investment in R&D is driven by the institutional arrangements challenging managers, together with industry circumstances and firm-specific resources (Peng, 2008) while better governance ensures greater disclosure and accountability, which in turn facilitates the availability of external financing for R&D (Hillier et al.,2011).

In sum, the current study investigates how government incentives such as credit availability/loan and policies or legal system like business licensing, and permits and tax administration mechanisms moderate the relation between R&D, and firm's financial and innovation performance, and pose the following hypotheses:

H3. *Availability of credit or loan positively moderates the relationship between R&D, and firms' performance*

H4. *Poor legal system negatively moderates the relationship between R&D and firms' performance*

3. Methodology

3.1 Sample and Data

The data used in this paper comes from the World Bank's Enterprise Survey (WBES) panel database of 2011 and 2015[2] for privately-owned firms listed in Ethiopia. In the data collection, a sample survey was conducted using stratified random sampling by industry, establishment size, and location(region). The survey covers 644 and 848 firms in 2011 and 2015, respectively, including micro, small, medium, and large firms summing to 1,492 firms. About 744 firms appeared in both years. After dropping the outliers, adjusting and accounting for missing variables and values, the overall sample consists of 476 firm year observations in our study.

The survey covers firms operating in five major geographical regions in the country -- Addis Ababa, Oromia, Amhara, SNNP and Tigray. Firm-level data were drawn from WBES, including engagement in R&D activities, values of annual sales and profits, product and marketing innovation, employment level, and other aspects of enterprises. The World Bank considered similar questionnaires in the successive surveys, which could make easy to pool the data at the different surveys. Among the 744 privately-owned firms, we select those firms which provide required information over the period 2011 and 2015. Our final sample includes an unbalanced panel of 476 firms. According to Hillier et al. (2011) in any appropriate study unbalanced panel data helps to moderate the survivorship bias problem. In addition, Arellano (2003) also argues that estimations constructed from unbalanced panel data are as good as studies based on balanced panel data and almost equally reliable.

3.2 Measurement of Major variables

3.2.1 Outcome Variable: *Firms' Performance*

In the current study, we have used two measures of firms' performance; financial and innovative performance.

Financial performance: Financial performance lies at the heart of firms' performance (Latifi et al., 2021). In our study we have collected financial information to measure both short and long-term financial performance. The short-term financial performance is measured through *annual sale and profit levels both divided to '100000' to reduce large values and adjust outliers*. We also used two measures for long-term financial performance, the *Tobin's Q,* the ratio of market value to book value of tangible assets (Bebchuck et al., 2011); and, *Total Q*, the ratio of market value to book value of both tangible and intangible assets (Du & Osmonbekov, 2020) to reflect the authentic effect of R&D activities. The application of the Total *Q* in addition to *Tobin's Q* gives us the advantages of accounting for the firms' intangible investment opportunities better than other Tobin's Q proxies (Du & Osmonbekov, 2020).

The use of Tobin's Q, rather than the frequently used measures like returns on assets (ROA) or returns on sales (ROS), etc., enables us to explore the long-term impacts of R&D as the Tobin's Q is regarded as a forward-looking measure of firms' performance (e.g., Leung & Sharma, 2021; Anderson et al., 2004), and one of the good proxies for firms' competitive advantage (Hung &

[2] The author would like to thank the World Bank Enterprise Survey team for granting him access to the Data, especially Prof. **Joshua Wimpey** and Prof. **Akash Pradhan**

Chou, 2013; Leung & Sharma, 2021; Wernerfelt & Montgomery, 1988). Studies also specify that a Tobin's Q greater than 1.0 indicates investors have a positive outlook for the firm's growth opportunities (Dushnitsky & Lenox, 2006).

Innovation performance: Innovation performance is the second outcome variable used in the current study. We measured a firm's innovation performance in terms of the introduction of new or improved products or services, and new or improved marketing methods in firm's activities. Product (service) innovation is a dummy variable that takes the value 1 if a firm reports having introduced new or significantly improved products (services) in the current or previous two years, and otherwise 0; and the same coding follows for marketing innovation.

3.2.2 Treatment variable: *Investment in R&D*[3]

Investment in R&D, the key treatment indicator variable in the current study, is measured as a dummy variable that takes the value 1 if a firm has expenditures on R&D activities, and 0 otherwise following Leung and Sharma (2021) who employed a dummy variable for *R&D Internationalization*, Un and Rodríguez (2018) who use a bivariate variable for R&D collaboration, and Penner-Hahn and Shaver (2005) who employ a dummy variable for international R&D activity.

3.2.3 Moderators and control variables

Next, we measured our possible mediators, access to credit or a loan, a dummy variable coded as 1 if a firm has credit service (credit or a loan from a financial institution) in the last three years, and 0 otherwise and legal system, measured by business licensing, and permits and tax administration, coded 1 if the tax administration, and the business licensing and permits is an obstacle to firms' operation, and otherwise 0.

On the other hands, the control variables are those that may influence a firm's decision on whether or not to engage in R&D activities at a particular time, and are reported as follows. The current study uses several firm level control variables, including firm size and type of establishment dummy to control the establishment effect, etc., (see Table 1 for detail discussion of variables used in the study). *Firm size* is measured as the natural logarithm of the number of employees, which influences firms' performance (Tung & Binh 2021; Zouaghi et al., 2018; Bayona et al., 2013). Most of the recent studies find a positive impact of firm size on firms' performance, such that larger firms generate greater performance than smaller firms (Alam et al., 2020; Majumdar, 1997; Penrose, 1959). Consequently, a positive relationship is expected between firm size and firm performance. Furthermore, we also included size of the participating firms as control factor defined as a dummy variable: *micro-dummy* if employment is less than 5, *small-dummy* if employment is between 5 to 19 employees, *medium-dummy* if employment is between 20 to 99 employees, and finally *large-dummy* if a firm had more than 99 employees.

Firm age represents the number of years since the firm was established. *Firm age is also measured as a* binary variable coded 1 when a firm's age is below the industry median of firm age and 0 otherwise as proposed by Leung and Sharma (2021). We may expect that older firms may have accumulated valuable production and business experience that gives them a likely market gain (Carboni, 2017). *Productivity* is defined as the natural logarithm for firm sales divided by the total

[3] **Note:** Investment in R&D, expenditure on R&D, R&D expenses and R&D spending are interchangeably used in this study just to represent the same term, R&D activities.

number of employees in the firm. For the *geographical location (region)*, we create a location dummy for each of the five **r**egions. The comparison among the different regions of the country can give a clear picture in the difference in terms of the firms' performance, economic as well as institutional factors. We also include female CEO, *gender*, *work experience* and *education level* variables to examine whether these factors have the power to affect R&D activities of those firms.

3.3 The Econometric Framework and Model Specification

Investment in R&D are not randomly assigned to firms, but rather determined by the firm's decision which implies that firms have a strong self-selection to invest in R&D or not to do so. This issue poses the problem of selection bias. Common econometric approaches for dealing with the selection bias include propensity score matching (PSM), generalized propensity score (GPS) matching methods, endogenous switching regression (ESR), treatment effects models (TE) of different types, sample-selection models (eg., Heckman two-step), instrumental variable (IV) approaches, correlated random effects (CRE), fixed-effects (FE) models, the difference-in-difference (DID) method, economic surplus, and double hurdle. For instance, Boeing (2016) and Guo et al. (2016) state that PSM and the Heckman two-step approach are the two widely used methods in empirical studies to address the selection bias.

Similarly, in the context of the current study reverse causality may be another concern since R&D investment has an impact on firm performance (Ehie & Olibe, 2010), and/or firms' performance may also impact R&D investment, as a more powerful and larger firms may encourage managers to commence new R&D activities (Pindado et al., 2015). In other words, this is to mean that investment in R&D may improve firm performance, but high-performance firms are also more likely to have resources to spend on R&D more easily. The presence of this simultaneity bias or reverse causality signals that those techniques like the OLS regressions results may be unreliable (Frijns et al., 2014).

The other important issue in program/impact evaluation is the question of how firms decide to invest in R&D. A rational firm will invest in R&D only if the benefit is higher when a firm is engaged in R&D than without participation in R&D, i.e., $(T^* = \pi_1 - \pi_0 > 0)$. In this case π_1 and π_0 are the benefits with R&D investment and with no R&D activities, respectively. However, the two benefits are unobservable as non-experimental data do not contain sample counterparts; thus, they can be expressed as a function of observable components in the latent variable model as:

$$T_{it}^* = \beta\psi_{it} + u_{it}, with \;\; T_i = \begin{cases} 1 & if \; T_i^* > 0 \\ 0 & otherwise \end{cases} \tag{1}$$

Eq. (1) is called the selection or treatment equation of R&D spending; it shows what factors determine firms' decision to invest or not. *T* is a binary variable (treatment indicator) for investing in R&D; *T*=1 if a firm invests in R&D and *T* = 0 otherwise. β is a vector of the parameters to be estimated, ψ is a vector that represents firm-related characteristics, t is time (year dummy), and u is the random error term with mean zero and constant variance.

For estimation purpose, due to the above stated possible selection problems, we prefer to use three different estimation techniques. The first empirical modeling approach that this study adopts is the two-way fixed-effects (2FE) error component structure method which is a flexible approach that allows us to estimate treatment effects considering differing R&D spending times. We use the FE model to eliminate the effects of observable and unobserved household heterogeneity. However, the FE error structure only incorporates the potential influence of time-invariant unobservable, i.e it can solve the problem partly. To address some limitations of the FE approach, we complemented the analysis by employing PSM and endogenous treatment effects (ETE) models that take into account the selection bias both from observable and unobserved factors.

The two-way fixed-effects error component structure is given by:

$$\pi_{it} = \alpha_0 + \beta X_{it} + \varphi T_{it} + \alpha_i + \varepsilon_t + \mu_{it} \tag{2}$$

where y_{it} is the outcome variable (firms' performance in this case) for firm i in the treatment category at time t, T is the treatment indicator variable as defined in eq. (1). α_i are firm fixed-effects, ε_t are the year effects or wave fixed-effects, and μ_{it} is the random error term. X_{it} is a vector matrix including a set of firm-related covariates, and φ is the impact of interest in our case, or a factor that captures the average treatment effects.

In the second estimation technique, following Cameron and Trivedi (2005); Greene (2012); Heckman (1976, 1978); Maddala (1983); and Wooldridge (2010) we specify the ETE model as:

$$\pi_{it} = \alpha_{it} + \delta T_{it} + \beta X_{it} + \varepsilon_{it} \tag{3}$$

$$\text{where } T_{it}^{*} = \beta \psi_{it} + u_{it}$$

where ψ_{it} are the covariates used for modeling the treatment assignment (R&D spending) and the error terms u_{it} and ε_{it} from eq. (1) and (3) are bivariate normal with mean zero and the covariance matrix is given as:

$$cov(\varepsilon_{it}, u_{it}) = \begin{bmatrix} \sigma^2 & \rho\sigma \\ \rho\sigma & 1 \end{bmatrix}$$

It should be noted that the covariates X_{it} and ψ_{it} are unrelated to the error terms (they are exogenous). Thus, this is termed as a constrained model because the variance and correlation parameters are identical across the treatment and control groups. σ^2 is the variance of the disturbance term (ε) in the main outcome regression eq. (3), the variance of the error term (u) in the selection or treatment equation*;* and $\rho\sigma$ is the covariance of ε and u. The maximum likelihood estimates provide us consistent and asymptotically efficient results. Using the maximum likelihood estimation technique, we estimate the ETE model with different options.

Eq. (3) can be generalized to a potential-outcome model with separate variance and correlation parameters for the treatment and control groups as follows:

$$\pi_{i0} = \beta_0 X_{i0} + \varepsilon_{i0} \tag{4}$$

$$\pi_{i1} = \beta_1 X_{i1} + \varepsilon_{i1}$$

The likelihood function for this model is discussed in Maddala (1983) and Greene (2000) and it presents the standard method of reducing a bivariate normal to a function of a univariate normal and the correlation ρ. The log likelihood function for Eq. (1) and (3) for firm i is expressed as:

$$lnL_i = \begin{cases} ln\Phi\left\{\frac{\beta\psi_{it} + (\pi_i - \beta x_{it} - \delta)\,\rho/\sigma}{\sqrt{1-\rho^2}}\right\} - \frac{1}{2}\left(\frac{\pi_i - \beta x_{it} - \delta}{\sigma}\right)^2 - ln\left(\sqrt{2\eta\sigma}\right) & T_i = 1 \\ ln\Phi\left\{\frac{-\beta\psi_{it} - (\pi_i - \beta x_{it})\,\rho/\sigma}{\sqrt{1-\rho^2}}\right\} - \frac{1}{2}\left(\frac{\pi_i - \beta x_{it}}{\sigma}\right)^2 - ln\left(\sqrt{2\eta\sigma}\right) & T_i = 0 \end{cases}$$

where $\Phi(\cdot)$ is the cumulative distribution function of the standard normal distribution. In the maximum likelihood estimation method σ and ρ are not directly estimated, instead $ln\,\sigma$ and $atanh\,\rho$ are directly estimated where they are expressed as $atanh\,\rho = \frac{1}{2}\,ln\left(\frac{1+\rho}{1-\rho}\right)$.The standard error of $\lambda = \rho\sigma$ is simply approximated through the delta method, which can be expressed by the functional form: $Var(\lambda) \approx \mathbf{D}\,\mathbf{Var}\{(atanh\,\rho\ ln\sigma)\}\mathbf{D}'$ where $\mathbf{D}$ is the Jacobian of λ with respect to $atanh\,\rho$ and $ln\sigma$.

The third method that this study uses is the non-parametric regression method, PSM to assess the robustness of the results and compares the outcomes of treated observations with the outcomes of comparable non-treated observations**.** Matching is one of the widely used method in program evaluation (e.g., Heckman et al., 1998; Heckman & Navarro-Lozano, 2004; Smith & Todd, 2005). PSM is a two-step procedure. First, a probability model for investing in R&D is estimated to calculate the probability (or propensity score) of investing for each observation. In the second step, each treated (those who invest) is matched to a control group with similar propensity score values for estimating the average treatment effects on the treated (ATT). It is defined as the conditional probability of receiving treatment given pre-treatment characteristics as:

$$P(X) \equiv Pr\{T_i = 1|X\} = E\{T_i|X\} \tag{5}$$

Rosenbaum and Rubin (1983) show that if the exposure to a treatment (investing in R&D) is random within cells defined by *X*, it is also random within cells defined by the values of the mono-dimensional variable $P(X)$. Thus, given a population of units denoted by i, if the propensity score $P(X_i)$ is known, ATT can be estimated as:

$$\begin{aligned} ATT &= E\{\pi_{1t} - \pi_{0t}|T = 1\} = E(\pi_{1t}|T = 1) - E(\pi_{0t}|T = 1) \\ &= E(\pi_{1t}|T = 1, P(X) - E(\pi_{0t}|T = 1, P(X)\big) \end{aligned} \tag{6}$$

Few previous studies have used PSM in technology related researches (Carboni, 2011, 2017; Scandura, 2016; Bai et al., 2019). However, PSM only controls for biases emanating from observed heterogeneity. That is why we complemented the analysis with other methods (FE and ETE) as the application of PSM alone cannot control unobservable biases.

4. Results and Discussion

4.1 Results of descriptive analyses

Table 1 reports the descriptive statistics for the variables employed throughout this study. First, we compared the basic firm level characteristics between subsamples of firms with and without R&D investment and results are presented in Table 1. We recognized that only 132 (28%) firms in our sample are with R&D investment. We found significant differences in terms of all outcomes between the two subsamples. This descriptive analysis also shows that firms with R&D investment activities have higher value in terms of all outcome variables.

For example, investing firms have higher annual sales and profit values per '00000' Birr. Those firms also have larger productivity values, have more access to credit service, own large number of male workers, large firm size and age and have more work experience, while non- investing firms in R&D are more likely to be located around Addis Ababa, have more female CEO top managers, enterprise types are dominated by medium size firms and most non-investing firms engage in rental services as compared to firms that invest in R&D.

In Table 1, we also found significant differences in terms of the long-term financial performance (Tobin's Q and Total Q) between the two subsamples wherein the firms with R&D activities have higher value in both measures. In this descriptive analysis, we included values such as the mean and standard deviation for the variables included in the empirical analysis. The mean values of some continuous outcomes such as annual sales, profit values, Tobin's Q and Total Q reveal that, on average, firms with R&D activity are effectively using their assets, equity and sales to generate better performance. Moreover, the mean values of some control variables like productivity and firm's size show investing firms are at a relatively high level of productivity and have bigger firm sizes as compared to their counterfactuals.

A close look at of the standard deviation values indicate that, except for the innovation performance outcomes, the values of all other outcome variables significantly vary across firms over time. Moreover, the high standard deviations of the annual sales, profit and productivity variables confirm variation in asset accumulation and firm observations. In general, the two subsample firms are significantly distinguishable in terms of gender of respondents, productivity levels, firm size, level of education, purchase of fixed assets, etc.

Table 1: A Description of outcome, treatment and explanatory variables used for estimating the Models.

Variables	Description	Full sample (N=476)	Invest in R&D (N=132)	Don't Invest in R&D (N=344)
Outcome variables:				
Annual Sales ***	Values of Annual Sales (in '00000' Birr)	985.29 (3930.97)[♣]	1735.89 (3384.28)	697.27 (4089.62)
Profit***	Values of firms' annual Profit (in '00000' Birr)	937.21 (3854.74)	1624.34 (3234.03)	637.55 (4041.21)
Tobin's Q***	The ratio of market value to book value of tangible assets	1.01 (3.17)	1.72 (4.79)	0.52 (0.77)
Total Q***	The ratio of market value to book value of both tangible and intangible assets	1.27 (3.97)	2.15 (5.99)	0.65 (0.96)
Products Innovation ***	In the last three years, has this establishment introduced new products or services? (1 = yes)	0.47 (0.50)	0.68 (0.47)	0.39 (0.49)
Marketing Innovation ***	Has this establishment introduced new or significantly improved marketing methods in the last three years? (1 = yes)	0.34 (0.49)	0.62 (0.48)	0.29 (0.46)
Treatment Indicator Variable:				
Investment in R&D	A firm has expenditures on R&D activities (1 = yes)	0.28	1.00	0.00
Moderator Variables:				
Credit ***	A firm has line of credit or loan from a financial institution (1 = yes)	0.42 (0.49)	0.55 (0.50)	0.36 (0.48)
Tax Administrations	Is the tax administration an obstacle to firms' operation? (1 = yes)	0.64 (0.48)	0.66 (0.47)	0.63 (0.48)
Business Licensing	Is the business licensing and permits an obstacle to firms' operation? (1 = yes)	0.27 (0.44)	0.30 (0.46)	0.26 (0.43)
Explanatory Variables:				
work_experience	Working experience of the top manager in this sector (years)	9.09(6.35)	9.50(6.78)	8.94(6.19)
Gender**	Gender of the main respondent (1= male)	0.85(0.36)	0.90(0.30)	0.83(0.38)
Productivity***	The natural logarithm of firm's sales divided by the total number of employees in the firm (in '0000' Birr)	106.22 (433.75)	205.60 (712.59)	68.07 (247.68)
female_CEO	Is The Top Manager Female? (1 = yes)	0.09(0.29)	0.08(0.28)	0.10(0.30)
Firm_size***	The natural logarithm of the number of employees	3.42(1.51)	4.15(1.60)	3.14(1.37)

Firm size_dummy***	A firm's size (natural logarithm of the number of employees) is below the industry median of firm size (1 = yes)	0.50 (0.50)	0.35 (0.48)	0.56 (0.50)
Firm age	The number of years since the firm was established	17.95(12.91)	18.39(12.12)	17.78(13.21)
Firm age_Dummy	A firm's age is below the industry median age value (1 = yes)	0.46(0.49)	0.49(0.50)	0.45(0.49)
Level of Education***	Full Time Workers Completed High School (1 = yes)	0.37(0.48)	0.62(0.49)	0.27(0.44)
Fixed_Assets ***	A firm has purchased any Fixed Assets in Last Fiscal year (1 = yes)	0.449(0.49)	0.621(0.49)	0.384(0.49)
Enterprise Type				
Micro_dummy	The Enterprise Type is Micro (1 = yes)	0.013(0.11)	0.015(0.12)	0.012(0.12)
Small_dummy **	The Enterprise Type is small (1 = yes)	0.328(0.47)	0.257(0.44)	0.355(0.48)
Medium_dummy	The Enterprise Type is medium (1 = yes)	0.380(0.49)	0.356(0.48)	0.389(0.49)
Large_dummy ** (cf.)	The Enterprise Type is large (1 = yes)	0.279(0.45)	0.371(0.48)	0.244(0.43)
Sampling Region				
Addis_dummy	Sampling Region is Addis Ababa (1 = yes)	0.727(0.45)	0.697(0.46)	0.738(0.44)
Amhara_dummy	Sampling Region is Amhara (1 = yes)	0.057(0.23)	0.053(0.22)	0.058(0.23)
Oromia_dummy	Sampling Region is Oromia (1 = yes)	0.097(0.29)	0.098(0.30)	0.096(0.29)
SNNPR_dummy	Sampling Region is SNNPR (1 = yes)	0.038(0.19)	0.053(0.22)	0.031(0.18)
Tigray_dummy (cf.)	Sampling Region is Tigray (1 = yes)	0.082(0.27)	0.098(0.29)	0.075(0.26)
Establishment Type				
Manufacturing *** (cf.)	The establishment is manufacturing type (1 = yes)	0.357(0.48)	0.447(0.49)	0.323(0.47)
Retail Services **	The establishment is Retail Services type (1 = yes)	0.105(0.47)	0.242(0.43)	0.343(0.48)
Non-retail Services	The establishment is Non-retail Services type (1 = yes)	0.328(0.47)	0.311(46)	0.334(0.47)

Note: *** p < .01, ** p < .05, * p < .10. ♣Standard Deviations

Source: Author's calculations using WBES panel database of 2011 and 2015.

4.2 Results of Empirical Analyses

This section reports and discusses results obtained from the three methods: FE regression, PSM approach and ETE technique. First, the study employed the fixed effect regression approach as it can control for unobservable firm factors. Fixed effect regression models can also effectively rude out omitted variable bias.

According to the estimated results from the fixed effect model of Table 2, the R&D variable has a positive and statistically significant effect on innovation performance measured by both product and marketing innovation. The findings for both indicators show that current year's R&D investment and current year's innovation performance have a positive relationship. For the first outcome variable, product innovation, R&D investment led to a rise in the likelihood (probability) of participation in product innovation by about 14.70 percentage points while firms' participation in marketing innovation has been increased by about 13.50% due to the investment in R&D. The findings of the study are in line with the studies of Belussi et al., 2010; Belluci & Pennacchio, 2016; Barra & Zotti, 2018.Thus, the findings strongly support *Hypothesis H2.* R&D expenditure can rise firm's innovativeness in two different ways. One, firms could create progressive innovation at a lower cost, and two, R&D expenditure benefits firms to create new products/service, which could be improved with a better quality of new technologies.

Concerning the impacts of R&D investment on shorter-term financial performance, results of Table 2 suggest that current year's R&D investment has negative impact on current year's firm performance measured by sales and profit values. This implies that R&D activities take time to show returns on the investment, confirming the general view that engagement in R&D activity does not necessarily create an immediate benefit in the same period. These results are consistent with previous studies (Alam et al., 2020; Leung & Sharma, 2021) and show that current year's R&D investment could reduce firms' operating performance, because if R&D spending is taken as an expense in the year in which it is incurred, the firms' earnings will be decreased. However, these results are not statistically significant and thus, *Hypothesis H1a* is partially supported. A closer reading of the coefficients of R&D investment on both sales and profit values shows that in this case it exerts relatively weaker effect on the shorter-term financial performance. The estimated coefficient of R&D activity for the shorter-term financial performance model implies that other things being constant, firms' engagement in R&D will lead to a decrease on average 518 and 546 million Birr in the firm's annual sales and profit, respectively.

On the opposite, interestingly the long-term financial performance show that the previous year's R&D investment has positive relationship with both indicators, Total Q and Tobin's Q, and results are statistically significant. The positive relationship indicates that previous year's R&D investment will mature in subsequent year in form of introduction of new technologies and method of production and process, which increase firms' returns and capital formation (Usman et al., 2017). Such increase in firms' performance gives positive signal to investors, which subsequently create value for the investing firms in terms of profitability and capital holding. As R&D investment is long term in nature and takes time to affect firms' performance, it is expected that R&D has a positive impact on firms' future performance. Thus, as expected, the results show that previous year's R&D investment has a positive and significant impact on Total Q and Tobin's Q (see last two column of Table 2). Consequently, *Hypothesis H1b* is strongly supported, and the results suggest that firm level R&D investment are significant factor to improve firms' long-term financial performance and in creating value.

The results of Table 2 also show the influences of major control variables, and findings reveal that those variables are mostly statistically significant in the expected directions. Firm size impacts negatively on innovation performance (the likelihood of introducing both product and marketing innovation) and positively on both short and long-run firms' financial performance, indicating the persistent performance of the firm in terms of financial measures. In this case, some previous studies (for example Alam et al., 2020) argue that larger firm size in most cases represents a more asset holding, higher capacity, higher investment and greater human capital, which help to employ more resources and obtain greater returns. The result is also consistent with the common logic that bigger firms are more likely to own more capitals than smaller firms do and thus, larger firms would enjoy the benefits of large-scale investment.

Among the other variables, gender has significant negative effects on both innovation and long-term financial performance. Hence, the negative effects of gender seem to be stronger in the case of innovation and long-term financial performance, but not for the case of short-term financial performance. In contrast, firm's age has no significant effect on innovation and short-term financial performance, but has a negative and significant effect on long-term financial performance, which suggests that older firms with greater investment in R&D may not be able to benefit from engagement in the investment activities in the long-run as newer firms do. This implies that older firms underperform in terms of long-term financial performance than newer firms do, and the results contradict with the findings of Tung & Binh (2021) and Alam et al. (2020).

The female CEO variable shows a negative relationship with all outcomes, but it is statistically significant in impacting long-term financial performance. This result suggests that if the firm is managed by a male CEOs, it would have higher long-term financial performance than firm managed by female CEOs. On the other hands, none of the enterprise dummies have clear effects on all the outcome variables consistently, however small dummy and medium dummy positively and significantly affect short-term financial performance implying that smaller and medium sized enterprises performed better in the short-run as compared to larger firms. Concerning the geographical location, only the coefficient of the SNNPR dummy is positive and significant in the short-term financial performance(sales), while the other location coefficients are negative and insignificant for most of the regions including the capital, Addis Ababa.

As expected, firm productivity has a positive and significant effect on all performance indicators. The findings suggest that more productive firms investing in R&D strongly expand knowledge, skills and abilities, and the investment provides them with new technologies which in turn improves products /services, and increases firms' performance. Level of education has also significant positive effects on innovation performance, but was not significantly associated with shorter-term financial performance. However, it was omitted from the long-run model due to collinearity problem. Among other variables, owning fixed assets has a significant positive effect on innovation and short-term financial performance, but no effect on long-run financial performance indicators.

All the remaining control variables have mixed effects on all the outcome variables; hence these are not discussed in detail, but can be interpreted in a similar fashion.

Table 2. FE results: For all Outcome variables

Variables	Outcome Variables					
	Innovation Performance		Short-term Financial Performance		Long-term Financial Performance	
	Product/service Innovation	Marketing Innovation	Annual Sales	Profit	Total Q	Tobin's Q
R&D	0.147***	0.135***	-518.393	-545.568	1.994***	1.595***
Firm_size	-0.026	-0.042**	403.729**	699.523***	0.055	0.044
female_CEO	-0.044	-0.009	-427.951	-605.661	-1.862*	-1.489*
Fixed_Assets	0.256***	0.140***	482.372	654.782**	-0.395	-0.316
work_experience	0.003	-0.003	-25.055	-6.873	0.035	0.028
Gender	-0.107*	-0.001*	38.869	190.419	-1.526*	-1.221*
Level_of_Education	0.236***	0.458***	-99.438	50.486		
Firm_age	-0.000	0.001	-2.290	2.596	-0.054**	-0.043**
Dummy_2015	0.106**	-0.117***	140.777	699.316**	-0.385	-0.308
Poductivity	0.009	0.033***	0.000***	0.000***	0.000**	0.000**
Micro_dummy	0.092	-0.003	-234.998	-510.134	6.117	4.894
Small_dummy	-0.096*	0.036	800.855*	984.123**	-0.176	-0.141
Medium_dummy	-0.062	-0.030	947.439**	1,024.575***	-1.078	-0.862
Addis_dummy			-29.888	-253.257	-2.779	-2.223
Amhara_dummy			-163.198	-213.453	-0.826	-0.661
Oromia_dummy			177.552	-342.392	-2.366	-1.893
SNNPR_dummy			1,145.531*	746.044	-1.206	-0.965
Retail Services	0.025	0.011***	429.559***	268.317**	-0.770***	-0.616***
Non-retail Services					-0.281	-0.225
Constant	0.246	-0.153	-7,603.437***	-2,465.401***	10.868**	8.695**
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	476	476	476	476	168	168

Note: *** $p < .01$, ** $p < .05$, * $p < .10$

Source: Author's calculations using WBES panel database of 2011 and 2015.

Furthermore, we evaluate the robustness of the models and study hypotheses by using two other estimation methods, PSM and ETE approaches since the fixed-effects error structure only incorporates the potential influence of time-invariant unobservable. Before discussing the causal effects of R&D on firms' performance, the matching methods were checked and they passed different quality checking tests. We find that there is a considerable overlap in common support as Fig. B1-B6 in the Appendix show. A visual inspection of the density distributions of the estimated propensity scores for the two group of firms (who invest and don't invest in R&D) indicates that the common support condition is satisfied for all outcome variables which means that there is substantial and considerable overlap in the distribution of the propensity scores of both groups. The bottom half of the figures show the propensity scores' distribution for those who don't invest and the upper half is for who invest in R&D; the densities of the scores are on the y-axis.

The second tests employed is the covariate balancing tests before and after matching as reported in Table A1 in the Appendix. The standardized mean difference for overall covariates used in the propensity score for all outcome variable (around 18-29% before matching) is reduced to around 3-6% after matching. The p-values of the likelihood ratio tests showed that the joint significance of the covariates was always rejected after matching, whereas it is never rejected before matching. The pseudo R^2 also dropped significantly from around 12-17% before matching to about 0.6-2.6% after matching under all outcomes considered. The likelihood ratio test was also statistically significant before matching for all cases, but it becomes insignificant after matching. Thus, the low pseudo R^2, high bias reduction, and the insignificant p-values of the likelihood ratio test after matching suggest that the proposed specification of the propensity score is successful in terms of balancing the distribution of covariates between the two subsamples.

After checking the matching quality of PSM method, Table 3 reports the results of R&D impact on all outcome variables. The PSM results are reported using three matching methods NNM, KM and RM; while in the ETE approach we used estimation techniques including inverse-probability weighted (IPW), inverse-probability weighted regression adjustment (IPWRA), and linear regression with endogenous treatment effects (LRETE). Almost similar results were obtained using PSM and ETE methods with different estimation options except we see inconsistent results in the long-run financial performance from ETE approach.

According to Table 3, the R&D variable has a positive and statistically significant impact on innovation and long-term financial Performance in the PSM regression results and the findings are consistent with the fixed effect results. The estimated influence of R&D on innovation performance implies that other things being unchanged, firms' spending in R&D will lead to an increase in the likelihood of engaging in product and marketing innovation by about 23 and 29%, respectively based on five neighbors of NNM method. These results remain consistent across other methods both in sign and magnitude. Regarding the impacts of R&D investment on shorter-term financial performance, findings indicate that current year's R&D investment has negative impact on current year's firm performance as both NNM and KM methods show, but it is only significant in the case of KM with band width of 0.03 matching type. Results from NNM based on a single neighbor and RM suggest that R&D activities positively influence shorter-term financial performance, however these results are not statistically significant. As we may expect, the long-term financial performance is positively associated with previous year's R&D investment, and results are statistically significant. All matching methods produced similar results, and thus *Hypothesis H1b* is accepted as it was the case in fixed effect method.

The magnitude of the R&D coefficient in the PSM model for both innovation and short-term financial performance is much higher than the coefficient in the fixed effect model which implies that that PSM method has efficiently removed the influence of time-invariant unobservable.

In Table 4, we introduced the ETE regressions, and findings show that the R&D variable is still positively and significantly impacts innovation performance as both IPW and IPWRA methods indicate while it negatively influences short-term financial performance, but results are statistically insignificant. In contrast, the results from LRETE regression produced a mixed outcome, especially the long-term financial performance is negatively impacted by R&D activities which is not consistent with both fixed effect and PSM approaches. This result is not surprising, given the fact that in some cases current R&D investment may need longer time to bring returns to the investing firms. This finding is partly consistent with the findings of Leung and Sharma (2021) who concluded that R&D intensity and R&D international negatively influence long-term financial performance in some cases, though results were statistically insignificant in their study.

Table 3. PSM[1] results: For all Outcome variables

Estimation method	Outcome variables					
	Innovation Performance		Short-term Financial Performance		Long-term Financial Performance	
	Product Innovation	Marketing Innovation	Annual Sales	Profit	Total Q	Tobin's Q
NNM[2]	0.225*** (3.67)	0.290*** (4.80)	-628.770 (1.15)	-672.392(1.25)	1.756** (2.10)	1.405** (2.17)
NNM[3]	0.321*** (4.03)	0.359*** (4.63)	106.389 (0.24)	101.569(0.24)	1.811** (2.15)	1.448** (2.18)
KM[4]	0.245*** (4.32)	0.311*** (5.37)	-582.235 (1.41)	-613.248(1.53)	1.753** (2.51)	1.403*** (2.73)
KM[5]	0.231*** (3.88)	0.322*** (5.49)	-1028.759** (2.47)	-1052.068** (2.60)	1.770** (2.12)	1.416** (2.04)
RM[6]	0.321*** (4.03)	0.359*** (4.63)	106.389 (0.24)	28.866(0.07)	1.812** (2.45)	1.449** (2.06)
Observations	476	476	476	476	168	168

Note: *** $p < .01$, ** $p < .05$. Absolute values of t-statistics in parenthesis.
Source: Author's calculations using WBES panel database of 2011 and 2015.

[1] The first stage of the propensity score estimates are not reported, but can be made available up on request.
[2] NNM based on five neighbors and common support.
[3] NNM based on a single neighbor and common support.
[4] Kernel-based matching with a band width of 0.06 and common support.
[5] Kernel-based matching with a band width of 0.03 and common support.
[6] Radius matching

Table 4. ETE[2] results: For all Outcome variables

Estimation method	Outcome variables					
	Innovation Performance		Short-term Financial Performance		Long-term Financial Performance	
	Product Innovation	Marketing Innovation	Annual Sales	Profit	Total Q	Tobin's Q
IPW	0.274*** (4.84)	0.322*** (5.80)	-354.008(0.40)	-383.149(0.44)		
IPWRA	0.274*** (4.85)	0.321*** (4.42)	-372.143(0.62)	-387.113(0.47)		
LRETE	0.203(0.64)	0.156(1.04)	507.724*** (14.47)	496.137*** (14.72)	-3.571*** (9.04)	-2.893*** (8.87)
Observations	476	476	476	476	168	168

Note: *** p < .01. Absolute values of z-statistics in parenthesis.
Inverse-probability weighted (IPW), inverse-probability weighted regression adjustment (IPWRA), linear regression with endogenous treatment effects (LRETE).
Source: Author's calculations using WBES panel database of 2011 and 2015.

Next, control variables and the two moderators were entered in the model and results are reported in Table 5 showing the moderating roles of credit and legal system on the relationship between R&D and firms' performance. In order to examine which parts of moderator variable drive the effect of R&D on firm performance, we estimate a separate model for each of the outcomes with varieties of options (under each estimation method 'a' represents estimation results without a moderator, 'b' with only credit, 'c' with legal system and finally 'd' for the combined effect of all moderators).

Applying the fixed effect method, original model for innovation performance shows that the R&D variable has a positive and statistically significant effect on innovation performance, and results are statistically significant. Again, when moderators are added the relationship is still positive and significant, for credit however the magnitude of the variation is not big except the case of marketing innovation, which implies that R&D more influences the probability of participation in marketing innovation positively when access to credit or financial sources are available to firms, but it partly reduces the participation rate in the case of product innovation. Looking at the role of legal system measured by business licensing, and permits and tax administration, the results show that both of them (business licensing and tax administration) negatively moderate the relationship between R&D and innovation performance. The likelihood of participation in product innovation reduces from 14.70% to 13.80% while participation in marketing innovation decreases from 13.50% to 13.3% due to the weak and unfavorable legal system. This implies that if the legal system is an obstacle to do a business, R&D negatively impacts firms' innovativeness. Consequently, *Hypotheses H3 and H4* are partly accepted.

Concerning the roles of those moderators on financial performance, as expected credit positively moderates the relationship while legal system negatively mediates the connection between R&D and financial performance. Credit is suggested to have a positive moderating effect on the relationship between R&D and firms' financial performance, indicating support for *Hypotheses H3*, and thus the findings reveal that credit moderates both the short and long-term financial performances positively. However, results are not statistically significant in the case of short-term

[2] The results of the ETE estimates are not reported to save space, but are available from the authors upon request.

financial performance implying that availability of credit service does not influence firm short-term financial performance or has not played a moderating role in this case. Similarly, the legal system moderates follow the same pattern, but in opposite direction implying that *Hypotheses H3 and H4* are partially supported. Last for fixed effect approach, results of the combined effect of both moderators reveal that the positive credit influence outweighs the negative moderating effect of legal system as the estimated coefficients of the financial performance indicates implying that availability of credit service for firms play a vital role in mediating the relationship between R&D and firms' financial performance.

When the PSM approach with different matching method is employed, the results remain robust and almost consistent with the fixed effect method. Like the case was in the fixed effect method, credit is suggested to have a positive moderating effect on all outcomes, but results of the short-term financial performance are not statistically significant indicating that credit can't moderate R&D and firms' short-term financial performance. For instance, in the case of NNM the base model results show that there is relative increment on both innovation and long-term financial performance due to the moderating effect of credit. On the other hands, using the NNM, legal system shows that results are mixing in the case of innovation performance while the negative moderating effect is clear in the case of long-term financial performance as the estimated coefficient decrease as legal system variable is added to the model (Total Q reduce from 1.756 to 1.677 and Tobin's Q from 1.403 to 1.369) which suggests that poor legal system negatively influence the connection between R&D and long-term financial performance. Similar to the fixed effect approach, the aggregate moderating effect show that the positive credit effect dominates the negative moderating effect of legal system under all outcomes suggesting that credit play a more critical role in moderating R&D and firms' performance.

Finally, the results from the ETE using the LRETE are reported on the last part of Table 5. However, results come in mixing type in this case and mostly they are inconsistent with both the fixed effect and PSM like it was for models without moderators. Lastly, no evidence has been found for the moderating role on innovation performance. To summarize the moderating part, though the results do not fully support *Hypotheses H3 and H4*, these results suggest that R&D activities can be supported with the presence of active credit service while poor and corrupted legal system negatively influences the effectiveness of firms even when they participate in R&D sectors.

Table 5. Moderating roles of credit and legal system: For all Outcomes and Estimation Methods

Estimation method	Outcome variables					
	Innovation Performance		Short-term Financial Performance		Long-term Financial Performance	
	Product Innovation	Marketing Innovation	Annual Sales	Profit	Total Q	Tobin's Q
FE a[1]	*0.147***(2.78)*	*0.135*** (2.84)*	*-518.393(1.32)*	*-545.568(1.42)*	*1.994*** (3.81)*	*1.595*** (3.97)*
FE b[2]	0.145***(2.73)	0.136***(2.89)	-514.179(1.31)	-541.579(1.40)	2.005***(3.85)	1.604***(3.74)
FE c[3]	0.138***(2.60)	0.133***(2.82)	-520.922(1.32)	-548.554(1.42)	1.992***(3.69)	1.953***(3.57)
FE d[4]	0.136***(2.57)	0.134***(2.81)	-509.858(1.29)	-539.075(1.39)	2.012***(3.46)	1.609***(3.69)

[1] No moderator
[2] Credit
[3] Legal system
[4] Both credit and legal system (***Note***: the order of a-d follows the same representation for all methods)

NNM a	*0.225***(3.67)*	*0.290***(4.80)*	*-628.770(1.15)*	*-672.392(1.25)*	*1.756**(2.10)*	*1.405**(2.17)*
NNM b	*0.275***(4.54)*	0.297***(5.38)	*-74.217(0.14)*	*-117.920(0.22)*	1.791**(2.15)	1.342**(2.17)
NNM c	*0.256***(4.16)*	0.290***(4.74)	*-886.859(1.70)*	*-930.659(1.82)*	1.677**(2.06)	1.369**(2.02)
NNM d	*0.293***(4.78)*	0.295***(4.83)	*-5.977(0.01)*	*44.231(0.08)*	1.773**(2.09)	1.418**(2.13)
KM a	*0.245***(4.32)*	*0.311***(5.37)*	*-582.235(1.41)*	*-613.248(1.53)*	*1.753**(2.51)*	*1.403***(2.73)*
KM b	0.242***(4.17)	0.294***(5.13)	*-357.999(0.81)*	*-380.627(0.89)*	1.760**(2.08)	1.403***(2.73)
KM c	0.240***(4.08)	0.269***(4.43)	*-828.121*(1.94)*	*-861.109(2.07)*	1.634**(2.01)	1.307***(2.08)
KM d	0.212***(3.50)	0.240***(4.01)	*-91.691(0.20)*	*-134.526(0.30)*	1.775**(2.09)	1.420**(2.12)
LRETE a	*0.203(0.64)*	*0.159(1.09)*	*507.724***(14.37)*	*496.137***(14.72)*	*-3.571***(9.04)*	*-2.893***(8.87)*
LRETE b	0.137(0.67)	0.160(1.09)	515.156***(14.50)	504.112***(14.74)	*-3.486***(8.99)*	*-2.789***(8.64)*
LRETE c	0.119(0.61)	0.156(1.04)	507.377***(14.40)	496.034***(14.65)	*-3.771***(8.91)*	*-2.856***(9.04)*
LRETE d	0.131(0.65)	0.156(1.06)	514.882***(14.43)	503.081***(14.67)	*-3.504***(8.47)*	*-2.788***(8.46)*
Observations	476	476	476	476	168	168

Note: *** p < .01, ** p < .05, * p < .10

Source: Author's calculations using WBES panel database of 2011 and 2015. Absolute values of t-statistics for FE & PSM and, z-statistics for ETE in parenthesis.

4.3 Heterogeneous Impacts

Differential firm-level impacts of R&D by firm size and location

Table 6 shows the deferential impacts of R&D on different firms based on their size and location of operation. Beyond the conventional impact assessment methods, this study employed a differential or distributional analysis to explore the heterogeneous impacts of R&D activities on selected firms' performance indicator, two short-term measures (product innovation and sales), and one long-term indicator (Tobin's Q). This is because R&D investment may have a possible differential impact across different segments of firms. For this purpose, two grouping factors are used; (1) firms are divided into quartiles based on their size, and (2) location they operate is also considered and the PSM stratification method is employed to estimate the impacts which also enables us to identify the heterogeneity of the impacts among the different parts of the firms.

Our study shows that, in general, R&D investment positively influence firms' performance under different categories. Concerning the influence of R&D on products innovation, among the other categories, 2nd and 3rd quartiles are strongly and positively impacted, however results are not statistically significant for 1st and 4th quartiles implying that the increase in the likelihood of participation in products innovation due to R&D investment is more powerful in the 2nd and 3rd quartile. This suggests that the influence of R&D investment on products innovation for firms who investment more is significantly higher if their size is average or the positive influence of R&D investment seem to be stronger for medium size firms. Regionally, R&D investment has significant positive effect on both Addis Ababa and Amhara regions. Results are still positive in the remaining regions but are not strong.

With respect to deferential impacts on annual sales, the results are positive but all are statistically significant across all quartiles supporting the aggregate level analysis. The finding shows that, in value terms, the gains are higher in the 2nd and 4th quartiles. In contrast, a regional level analysis shows that R&D expense has stronger influences on firms operating in Addis Ababa and Oromia regions. Hence, the positive sales effect of R&D investment seems to be stronger for central parts of the country. The possible reason could be the large market in these two regions and relatively better infrastructural set ups and location advantages for firms operating in these areas.

Results from Tobin's Q regressions further suggest that the impacts are largest among firms with the smaller (2nd quartile) and larger (4th quartile) firm size, however results are insignificant for the latter case, and the lowest and upper middle quartiles are the least affects ones in terms of the change in Tobin's Q values, while the highest impact regionally gained goes to firms located in Addis Ababa areas. In regions like SNNPR and Tigray, the estimated impacts are large, however they are not statistically significant, and results for other categories can be compared and interpreted in a similar fashion.

In general, this approach of disaggregating impacts by different segment of firms offers us a vibrant picture of the differential effects of R&D investment on firms' performance. The empirical findings revealed that the impacts of R&D spending vary significantly along the different categories considered in the study confirming that there is significant heterogeneity in differential impacts of the R&D activities.

Table 6: Heterogeneous / differential impacts on firms' performance based on firm's size and location

Outcome Variable	Category		Impacts of R&D
Products Innovation	Quartiles (based on firm's size)	Lowest	0.077(0.57)
		Lowest middle	0.662*** (8.17)
		Upper middle	0.252*** (2.51)
		Highest	0.152(1.67)
	Region (Location of the establishment)	Addis Ababa	0.317*** (5.52)
		Amhara	0.492** (2.34)
		Oromia	0.164(0.979)
		SNNPR	0.130(0.65)
		Tigray	0.112(0.62)
Annual Sales	Quartiles (based on firm's size)	Lowest	147.160(1.06)
		Lowest middle	649.1.09)
		Upper middle	278.542(1.07)
		Highest	465.091(0.37)
	Region (Location of the establishment)	Addis Ababa	966.681** (2.00)
		Amhara	442.800(1.56)
		Oromia	700.179** (2.25)
		SNNPR	550.834(1.47)
		Tigray	2,308.801(1.62)
Tobin's Q	Quartiles (based on firm's size)	Lowest	0.006(0.02)
		Lowest middle	1.783** (2.21)
		Upper middle	0.020(0.15)
		Highest	1.354(1.43)
	Region (Location of the establishment)	Addis Ababa	1.384* (1.80)
		Amhara	0.055(0.11)
		Oromia	0.409(0.82)
		SNNPR	1.659(0.51)
		Tigray	1.479(0.72)

Note: *** $p < .01$, ** $p < .05$, * $p < .10$

Source: Author's calculations using WBES panel database of 2011 and 2015. Absolute values of t-statistics in parenthesis.

5. Conclusion and Implications

Now a days, investment in R&D has been regarded as a critical approach to improve firms' performance and competitiveness. Evidences indicate that the relationship between R&D activities and firms' performance is highly complex in its context and nature, though extensive body of literature state that R&D positively influences firms' performance. However, the process how R&D activities influence firms' performance is still not clear. Thus, to fill these observed research gaps and contribute to the existing literature, this study explored the potential impact of R&D activity on firms' innovation and financial performance from Ethiopian firms. Using unbalanced panel data from 476 privately-owned firms listed in Ethiopia and employing a combination of the fixed-effect, PSM and ETE estimation methods, our study has found solid evidence that, R&D activity has a robust, substantial, and significant impact on firms' performance.

The descriptive statistics shows that about 28% of firms invest in R&D in the sample considered. The results also reveal that there is a significant difference in terms of all outcomes between the two subsamples suggesting that firms with R&D activities have higher value in terms of all outcome variables.

The empirical results using the FE method also suggest that investment in R&D has a positive and statistically significant effect on innovation performance which show that current year's R&D investment and current year's innovation performance have a positive relationship, while in the case of shorter-term financial performance, current year's R&D investment has negative impact on current year's firms' performance. Moreover, the current year's long-term financial performance is positively influenced by previous year's R&D investment which strongly supports hypotheses posed in the study. In addition, the study employs PSM and ETE to evaluate the robustness of the models, and almost similar results were obtained from both methods with different estimation options, except there is some inconsistent results in the long-run financial performance using ETE approach. In addition, results show the influences of major control variables, and findings reveal that those variables are mostly statistically significant in the expected directions.

Moreover, this research tried to examine the moderating roles of credit and legal system between R&D activity and firms' performance, and a separate model is estimated for each of the outcomes with several options. In general, the moderating effect estimations show that availability of credit service positively moderates the relationship between R&D investment and firms' performance while poor legal system negatively influence the connection between the two factors. The results also suggest that the positive credit effect dominates the negative moderating effect of legal system under all outcomes suggesting that credit play a more critical role in moderating R&D and firms' performance. The results also show that R&D investment generates higher benefits if firms have better access to credit or loan services and if the legal system related to business activity is comparatively in a good quality.

Lastly, the study employed a deferential impact analysis to see the heterogeneous impacts of R&D activities on different segment of firms. This practice provides us a better understanding of the relationship between R&D investment and firms' performance with inclusion of a disaggregated analysis by firm size and location factors. The findings reveal that the impacts of R&D activities vary significantly along the different category of firms confirming that there is significant heterogeneity in differential impacts of the R&D activities.

The results from the current study have three major implications: first, the results show that the R&D activity has a significant impact on both forms of firms' performance. This shows the need of strong support from both government and other stakeholders to further boost the returns from R&D activities. Firms can improve their profitability and competitiveness by increasing R&D investments where there is sufficient government supports, and results suggest that firm want to increase its performance must invest in R&D and wait for some periods to get performance benefits.

Second, our findings reveal that credit positively moderates the relationship between R&D investment and firms' performance while poor legal system negatively influence the connection which in turn implies that the effectiveness of R&D investment partly depends on the availability of credit services and at the same times poor and corrupted legal system discourages investors from making risky investments such as R&D. Thus, the condition needs strong and coordinated financial system that support investors activity and minimizes bureaucratic processes at all administration levels.

Third, the disaggregated analysis confirms that the R&D influences vary significantly along the different category of firms which implies that it is important to follow different policy options based of firm size, location and types of establishments.

5.1 Limitations and Future Research

As is usually the case when it comes to research, our study faced some limitations and these could suggest lines of future research. First, the study is based on only two rounds panel data sets. Thus, to fully captured the R&D dynamics and long-run effects of the activity, we recommend further researches in the area by using relatively longer panel datasets. Second, our study is confined only to Ethiopia which suggests that future researches need to be conducted in other developing regions, especially in Africa, and examine the generalizability of the current findings.

Declarations

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Appendix A. Supporting Tables

Table A1: Covariate balance indicators before and after matching: Quality test[1]

Outcome Variables	Pseudo R^2 Before matching	Pseudo R^2 After matching	LR χ 2 (p − value) Before matching	LR χ 2 (p − value) After matching	Mean standardized bias before matching	Mean standardized bias After matching
Short-Run						
Product Innovation	0.130	0.013	72.85(p=0.000)	4.90(p=0.987)	23.4	5.2
Marketing Innovation	0.159	0.006	89.42(p=0.000)	2.14(p=1.000)	28.6	3.1
Annual Sales	0.123	0.012	68.87(p=0.000)	4.42(p=0.986)	17.9	5.0
Profit	0.130	0.013	72.85(p=0.000)	4.90(p=0.987)	23.4	5.2
Long-run						
Total Q	0.120	0.008	26.90(p=0.030)	1.26(1.000)	18.1	4.2
Tobin's Q	0.172	0.026	38.61(p=0.001)	3.84(p=0.998)	19.2	6.3

Source: Author's calculations using WBES panel database of 2011 and 2015.

[1] The reported results are based on the nearest neighbor matching (NNM) method. Though not reported, these results are the same using the other matching methods. Similarly, the following tests are from the NNM method.

Appendix B. Propensity score distribution figures

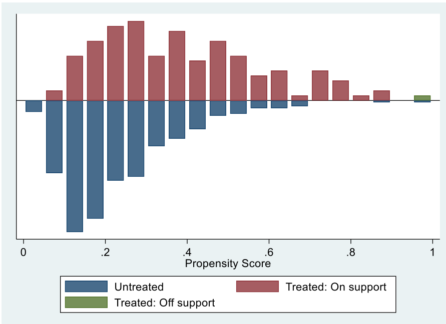

Figure B1. Propensity score distribution and common support for propensity score estimation of R&D: Outcome is Product Innovation

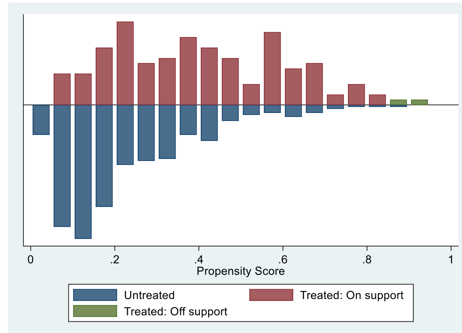

Figure B2. Propensity score distribution and common support for propensity score estimation of R&D: Outcome is Marketing Innovation

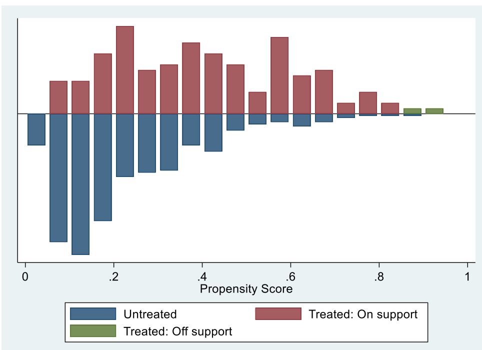

Figure B3. Propensity score distribution and common support for propensity score estimation of R&D: Outcome is Annual Sales

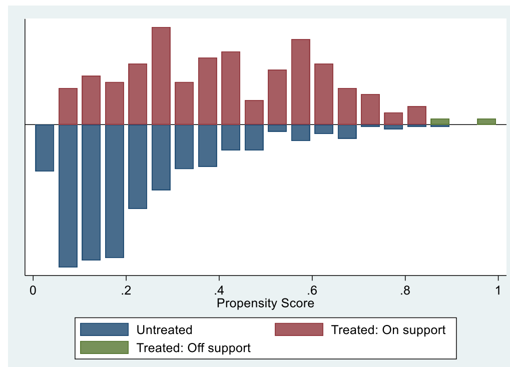

Figure B4. Propensity score distribution and common support for propensity score estimation of R&D: Outcome is Profits

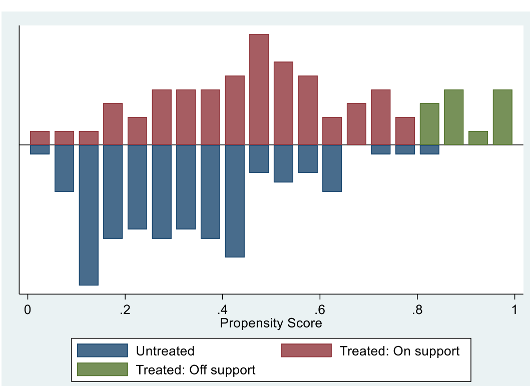

Figure B5. Propensity score distribution and common support for propensity score estimation of R&D: Outcome is Tobin's Q

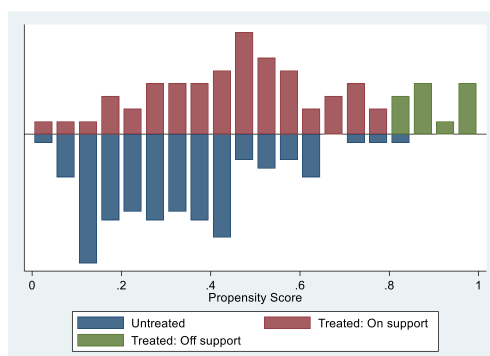

Figure B6. Propensity score distribution and common support for propensity score estimation of R&D: Outcome is Total Q