# “The impact of firm characteristics, business competitiveness, and technology upgrade hurdles on R&D costs”


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# THE IMPACT OF FIRM CHARACTERISTICS, BUSINESS COMPETITIVENESS, AND TECHNOLOGY UPGRADE HURDLES ON R&D COSTS

## Abstract

The study explores factors influencing research and development (R&D) costs in developing economies. The findings may inform the decision-making process for firms keen on innovation-related expenditures. The paper examines 164 Kenyan firms using the World Bank Enterprise Survey (WBES) data for 2018. These factors are classified into three broad categories. These are firm characteristics (age, size, and ownership), business competitiveness (export orientation, innovation strategies, and informal competition), and technology upgrade challenges (skills availability, financial constraint, and technology incompatibility). The findings reveal that approximately 11% of firms incurring R&D costs export their products (services). Exportation, skilled labor availability, and degree of informal competition correlate positively and significantly to R&D expenditure. The largest ownership (%) has a marginal effect on the outcome variable. Moreover, firm size substantially influences R&D costs, with small to medium firms incurring lower costs than their larger counterparts. However, firm age, innovation strategy, financial constraint, and technology incompatibility weakly influence the outcome variable. The product innovation strategy's interaction effect with skills, firm age and informal competition substantially impacts R&D costs. Notably, firms' R&D spending must be in tandem with the domestic informal competition intensity, skills availability, and foreign market targeted. The study employs the Ordinary Least Squares (OLS) regression in examining the relationship between the predictors and the dependent variable.

**Keywords** innovation expenditure, informal competition, skilled labor, firm exportation

**JEL Classification** Q16, L25, L26

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## INTRODUCTION

The competitive nature of the business environment and the ever-changing consumer preferences force firms to improve their product offerings continuously. Existing literature suggests that large and small firms incur considerable costs in funding research and development (R&D) activities (Dougherty et al., 2007). Besides, whereas R&D spending aims to result in profitable outcomes, only some innovation projects succeed (Link & Wright, 2015). Moreover, substantial literature suggests that small to medium firms in these markets experience significant hurdles in accessing formal credit to finance innovation activities (Rahman et al., 2017).

By focusing on the Kenyan context, the study seeks to extend the literature on the determinants of R&D expenditure for enterprises in growing markets. Certain firms intensively engaged in innovation programs prefer R&D expatriates to locals (Akcali & Sismanoglu, 2015). Be that as it may, in developing economies with weak regula-



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tions, business practices by the informal enterprise may pose a real threat to formal firms. First, unregulated, or improper business practices result in informal competition with formal business operations. Such competition negatively influences the genuine firm's brand name (Wilke & Zaichkowsky, 1999). The rapid change or growth in technology renders existing production processes obsolete. Technology upgrades can result in different profitable innovations. In certain instances, existing and new technology may be incompatible. Such a scenario can have an undesirable effect on the firm's operations. The literature supports the agility of young and small to medium firms in implementing innovation activities more than their larger counterparts (Hansen, 1992; Huergo & Jaumandreu, 2004). However, it is a different subject whether these firms fund their innovation activities more or experience a higher success rate than their larger counterparts.

A survey by the Kenya National Bureau of Statistics (2016) commissioned by the country's central bank had revealing findings informing the present study. The study established that local firms engage in limited innovation activities while most do not; if they do, it is on a low scale. Most start-ups had a life expectancy of approximately four years, with size being a determinant. These firms cited hostility in the business environment, particularly access to formal credit. For instance, the country had interest controls from 2016 to 2019. Most firms cited increased financing hurdles during this period since formal credit providers shunned risky borrowers. The present study's period is within the same period. Firms in developing economies face informal competition and must develop survival and competitive strategies, like innovativeness. Innovation involvement is intertwined with R&D, which is an expensive investment for most enterprises. For instance, firms must develop products that are not easily copied while surveying the market for imitations. Still, firms not well-endowed financially find it extremely difficult to retain skilled and experienced human resources. Domestic firms cannot match the cutthroat competition witnessed among multinationals for highly skilled local labor. Can such a scenario influence innovation-related expenditures, not in the Kenyan economy but also other markets?

## 1. LITERATURE REVIEW AND HYPOTHESES

The dynamism of the business environment, like competition, forces firms to adopt appropriate strategies like innovation (Prajogo, 2016). Innovation activities to develop new products and processes require substantial resources, whether for the firm or the market. For instance, a firm may require an R&D department, whether in-house or external, based on cost and technical implications (Narula, 2001; Love & Roper, 2002). There are four types of innovation: product (services), process, organization, and marketing. Depending on the strategic objectives, an enterprise may pursue one or multiple innovation types. Based on a case for each firm, R&D-related technologies and processes may be expensive, requiring firms to adopt different financing models. Firms' intent on R&D investment can fund their operations through internal, external resources, or a combination of the two. Large established firms prefer internal funds for such investments and ensure this by managing their cash flow (Hall & Lerner, 2010).

Conversely, small enterprises prefer funding their R&D operations externally. Unfortunately, their inability to raise debt externally can be explained by their high ratio of intangible assets and the high-risk nature of their investments (Bougheas, 2004). Large firms invest more in R&D, but smaller firms are more efficient in using R&D allocations (Ayalew et al., 2020). The financial constraint impact on firms' R&D varies based on the activities implemented. This impact depends on whether the firm pursues routine or cutting-edge research and development programs. For instance, credit constraints limit the R&D spending of firms that devote a significant portion of their R&D to cutting-edge projects but not routine R&D investments (Czarnitzki & Hottenrott, 2011). Strategic cash holding may assist businesses in managing better the risks associated with cash flow uncertainty. Due to cash flow uncertainty, R&D investment decisions are more conservative and cautious. Firms experiencing higher uncertain cash flow are more cautious in their R&D investment (Beladi et al., 2021).

Nevertheless, R&D investments are intended to result in profitable innovation outcomes. However, the literature details the failure of such projects due to different reasons (van der Panne et al., 2003). The sunken costs associated with R&D affect firms differently, but the cost implications are higher for more prominent firms due to the resources allocated (Máñez et al., 2009). A firm may pursue four main types of innovation: product (or service), process, organization, and marketing. Product innovation may vary from new products and line extensions to product improvements and style changes. Businesses must understand the entire spectrum of product innovation to compete effectively in the marketplace (Heany, 1983). Process innovation is adopting technologically new or significantly improved production methods. Process innovation aims to boost businesses' competitiveness by lowering production costs and increasing the flexibility of their manufacturing mechanism (Medda, 2020). Fritsch and Meschede (2001) examined 1,800 German manufacturing firms from three regions. The study sought to establish whether larger firms apportion a significant proportion of their R&D expenditure on process innovation than smaller enterprises. They conclude that based on the firm size, there is a meaningful association between process innovation and R&D costs while statistically non-significant in the case of product. For product innovation, any incentives like tax subsidies stimulate enhanced R&D expenditure. Regarding firm size, there exists a strong correlation between process innovation and R&D (Reichstein & Salter, 2006).

Moreover, firms have unique characteristics that may inform their involvement in innovation activities. The study interrogates three firm characteristics: size, age, and ownership. The size may influence its growth over time and access to requisite innovation resources. Specific R&D projects could be beyond the financial ability of an enterprise, forcing them to seek the necessary resources externally. For example, firm size is a significant determinant of access to formal credit (Cenni et al., 2015). R&D spending grows higher than firm size (Wakasugi & Koyata, 1997). In their study, larger manufacturing firms pursued innovation programs more aggressively than smaller ones. Likewise, firm size is a critical determinant of enterprises' heterogeneous R&D activities. Large firms enjoyed innovative advantages over smaller firms through enhanced research and development expenditure (Choi & Lee, 2018).

Further, Mallinguh et al. (2020b) suggest that the age of an enterprise may influence its operations and management decisions. For example, smaller but more mature enterprises are associated with higher R&D costs and sales growth than their younger but larger counterparts (Spescha, 2019). In addition, a negative correlation exists between firm age and R&D intensity or expenditure (Balasubramanian & Lee, 2008).

The shrinking domestic markets and competition forces firms to explore markets beyond their boundaries. There is a positive association between exporting, R&D expenditure, and firm productivity (Aw et al., 2011). As Mallinguh et al. (2020a) demonstrate, a positive, powerful affiliation exists between the firm's budgets allocated for technology acquisition (R&D costs). Be that as it may, increased R&D spending and market size impact the comparative advantage distribution. For instance, a one-percentage-point increase in R&D expenditures results in a three-percentage-point increase in high-technology exports, whereas the market size is insignificant. Still, research indicates that the probability of becoming an exporter is influenced positively by the size of a firm (Braunerhjelm & Thulin, 2008). Nonetheless, Suri and Banerji (2016) find no meaningful correlation between exports and R&D costs, whether capital or recurrent.

Moreover, a firm that invests in R&D and employee training is expected to be successful at innovating. For smaller businesses, investing in workers' skills enhances innovation even in the absence of R&D. Meanwhile, on-the-job training in large enterprises may primarily serve to reinforce the effects of R&D. The increased absorptive capacity through the higher ability of qualified staff leads to improved innovation performance (González et al., 2016). The firm's R&D skill endowment substantially relates to innovation-related investments and expenditures. The employees performing innovation-related activities accumulate experience, while new or inexperienced acquire job training skills (Piva & Vivarelli, 2009). Differently, skill intensity substantially influences innovation activities (Freel, 2005; Gallié & Legros, 2012).


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Product or process technology is changing rapidly, and firms must maintain the pace to be competitive. Enterprises must find technology that fits that in use during an upgrade. Technology incompatibility may result in undesirable effects on R&D innovation. Technological possibilities that encourage anti-competitive behavior, while impeding potential rivals' entry, foster R&D-based welfare, and growth (Grossmann & Steger, 2008). Informal businesses are typical in developing economies for various reasons. Since informal businesses do not follow the rules, informal competition may stem from practices like unauthorized products or process imitation. The impact of informal business practices on formal enterprises depends on certain factors. With a significant economic impact, credit-constrained enterprises face more intense competition from the informal sector. In other words, financial constraint is the primary reason firms endure informal competition. Other essential factors include firm size, corruption, and poorly designed labor market regulations (Friesen & Wacker, 2013).

Informal competition substantially adversely affects firm performance (Ramadani et al., 2019). That notwithstanding, this competition decreases with firm size becoming more insignificant for larger enterprises. Human capital is most important in determining the probability of young firms innovating (Ayalew et al., 2020).

Based on the literature review, the purpose of the study is to establish factors that influence research and development (R&D) costs in developing economies. Thus, the study elaborates on the following hypotheses:

*H1: Firm characteristics (age, size, and ownership) have no impact on R&D expenditure; however, if the converse holds, the relationship is significantly inverse.*

*H2: The competitiveness in the business environment (export orientation, innovation strategies, and informal competition) has a substantial effect on R&D costs.*

*H3: Technology upgrade challenges (skills availability, financial constraint, and technology incompatibility) have no meaningful correlation with R&D spending.*

## 2. METHODOLOGY

The study employs the World Bank Enterprise Survey (2018) dataset, recent now on the Kenyan economy. The enterprise survey (ES) is executed by the World Bank as critical diagnostic tool for the private sector, measuring firms' day-to-day experiences. These surveys produce comparable data across time and economies using a consistent global methodology. In addition, the aggregate indicators derived from raw, firm-level data enable policymakers to compare countries. As a result, the enterprise survey data serve as a critical diagnostic tool for the private sector development agenda (The World Bank, 2021; Hamed & Bohari, 2022).

WBES is a valuable data source since it has no common method variance problems (Mohammad & Husted, 2021). In 2018, the ES surveyed 1,001 Kenyan firms spread across the country. The firms are of different sizes and categorized as manufacturing, retail, or others. The study explores certain factors considered by firms in allocating their R&D budget. The study utilizes the World Banks Enterprise Survey (ES) data (2018), the latest information. The data set contains information on 1,001 enterprises. With R&D expenditure as the main criterion for inclusion in the study, 164 firms are considered. The ES examines businesses across the country, focusing on three business segments: manufacturing, retail, and others.

The dependent variable is evidence that a firm had set aside a budget specifically for R&D. Based on the criteria, only 164 firms were included in the analysis. To investigate the involvement in innovation activities, the surveyed enterprises stated whether they introduced a new or significantly improved product or process as required by the survey tool. However, the study opted to consider only those firms that incurred R&D-related costs as proof of involvement in innovation activities. Such a consideration acted as a second filtration layer with the costs expressed in the local currency. The R&D cost and firm age are log-transformed to make the data pattern more interpretable and fulfill the assumptions of the inferential statistics. The use of R&D expenditure as the outcome variable or its determinants and quantification is well documented (Wakelin, 2001). The predictor varia-

bles are broadly placed in three groups: firm characteristics, business competitiveness, and technological upgrade hurdles.

The first group is firm characteristics, namely age, size, and ownership. Firm size is based on the number of employees, thus, small, medium, and large. Age is the difference between when the business commenced operations (not when it was registered) and the survey year (2018). The firm age variable is log-transformed. On ownership, the focus is on the interest of the largest shareholder in the business. The variable is the proportion held by the most prominent investor to total ownership (0-100%). Business competitiveness consists of exportation, innovation strategy, and informal competition. With the increasing competition, businesses are forced to venture beyond their traditional markets. Foreign markets offer domestic firms a chance to reach more customers through exportation. The export performance is the proportion of firm sales generated outside the local market (0-100%). Like R&D and firm age, the export variable is log-transformed. The inclusion of this variable in the analysis is premised on existing empirical literature (Ganotakis & Love, 2011; Vynogradova et al., 2020). The other predictor variable is engagement in innovation activities (strategy).

Further, unregulated business practices may result in informal competition for legalized enterprises' operations. The informal competition effects vary across firms and sectors. To calibrate the degree of the informal competition, firms self-evaluated. These firms responded, "To what degree are the practices of competitors in the informal sector an obstacle to the current operations of this establishment?" The self-assessment is premised on a seven-level Likert scale: 0 = No Obstacle, 1 = Minor Obstacle, 2 = Moderate Obstacle, 3 = Major Obstacle, 4 = Very Severe Obstacle, 5 = Do Not Know and 6 = Not Applicable. For this current study, firms whose responses included the last two scales were omitted from the analysis.

The Oslo manual on innovation defines it as a new or improved product, process, or a combination of both which is significantly different from the firm's past products or processes and is available to potential customers (product) or already in (process). For innovation, the survey tool focused on product and process innovation through "Yes" (1) or "No" (0) responses. In addition, the firms responded to the question of whether "over the last three years, they introduced a new or significantly improved product or service." The new or improved process focuses on producing goods or providing services, logistics, delivery, distribution methods for inputs, goods, or services, or process support activities.

Moreover, technological upgrade hurdles include scarce skilled labor, financial constraints, and incompatibility between existing and new technology. Like with informal competition, firms made a self-assessment based on a seven-level Likert scale. The firms self-assessed, "to what degree is the (lack of skilled manpower, financial constraint, and technological incompatibility) an obstacle to the technological upgrading of this establishment"? Businesses with 'Do Not Know (5) and Not Applicable (6)' responses were dropped from the analysis. Table 1 presents a summary of the variable description and quantification.

Table 2, part (a), presents the distribution of the firms by size based on the number of workers. Different economies have varying employee bands to ascertain the size of an enterprise. The WBES is guided by the government classification in the Kenyan case. According to the data collection tool, small firms employ 5-19 workers, medium – 20-99, while large – above 100. The variable is dummy coded as small (d1), medium (d2), and large (d3). In general terms, there is a fair distribution of three sizes. Part (b) is the distribution of the firms through the innovation strategy (activities) implemented. Based on the responses, we developed four categories: product, process, and product and process (for those implementing both simultaneously) and others. In the 'others' category, an assumption is made that these firms' product/process projects were still in progress, unsuccessful, or focused on different innovation types (like organization and marketing). Therefore, the categories are dummied: product (d4), process (d5), product & process (d6), and others (d7). The continuation in the dummy variables numbering is for convenience purposes.


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**Table 1.** Description and measurement of variables

| Outcome variable | Measurement |
|---|---|
| R&D Costs | The total costs incurred for research and development. The programs may be in-house or contracted with other establishments. |
| **Predictors** | |
| Exports | The proportion of sales composed of exports (foreign market sales) |
| Firm Size | Based on the declared number of employees. Small >=5 and <=19, Medium >=20 and <=99, Large >=100. Dummied (d1), (d2), and (d3), respectively. |
| Skilled Labor | The degree to which human resources were an obstacle to the technological upgrading of this establishment. Scaled: 0 = No Obstacle, 1 = Minor Obstacle, 2 = Moderate Obstacle, 3 = Major Obstacle and, 4 = Very Severe Obstacle, 5= Do Not Know and 6 = Does Not Apply. |
| Financial Constraint | The degree to which financial constraint was an obstacle to the technological upgrading of this establishment. A similar scale to skilled labor was used. |
| Technological Incompatibility | The degree to which incompatibility with existing technology was an obstacle to the technological upgrading of this establishment. Scaled like for skilled labor and financial constraint. |
| Innovation | A. Product: The establishment stated whether it introduced new or improved products or services over the last three years – binary response (Yes/No). If yes, coded (1).<br>B. Process: Checked whether the establishment introduced any new or improved processes over the last three years. The process relates to manufacturing products or offering services; logistics, delivery, or distribution methods for inputs, products, or services; or supporting activities for processes. Binary response (1 = Yes, 2 = No). If yes, coded (2).<br>C. Product & Process: The firm introduced both product and process based on the first two responses (Yes/No). If yes, coded (3).<br>d. Others: Neither introduced product nor process innovation, coded (0).<br>The coding 0-3 is for input analysis purposes while dummies (d4), (d5), (d6), and (d7) for output comparison, denote product, process, product & process, and, and no or other innovations (not captured by the questionnaire like organization or marketing), respectively. |
| Informal Competition | The extent to which practices of competitors in the informal sector are obstacles to legalized firms' current operations.<br>Scaled: 0 = No Obstacle, 1 = Minor Obstacle, 2 = Moderate Obstacle, 3 = Major Obstacle, 4 = Very Severe Obstacle, 5= Do Not Know and 6 = Does Not Apply. |
| Largest SH | The proportion of the firm held by the single largest shareholder. |
| Firm Age | It is quantified as the difference between the survey year (2018) and the year the establishment began its operations. |

**Table 2.** Firm distribution by size and innovation strategy

| Firm size indicator | N = 164 | Proportion | Cumulative |
|---|---|---|---|
| **a. No. of employees** | | | |
| Small-sized *(d1)* 5-19 | 53 | 32.32% | 0.32 |
| Medium-sized *(d2)* 20-49 | 65 | 39.63% | 0.72 |
| Large-sized *(d3)* 100+ | 46 | 28.05% | 1.00 |
| **b. Innovation strategy** | | | |
| Firms implementing product innovation only *(d4)* | 54 | 32.93% | 0.33 |
| Firms implementing process innovation only *(d5)* | 29 | 17.68% | 0.51 |
| Firms implementing both product & process *(d6)* | 15 | 9.15% | 0.60 |
| Firms neither implementing process nor process (others) *d7* | 66 | 40.24% | 1.00 |

*Note*: The large-sized (d3) and others (d7) are the referent group for the firm size and innovation strategy, respectively. The referent group selection is based on previous studies.

## 2.1. Model specification

Three equations express the relationship between the predictors and the R&D costs. Equations 1 and 2 are general and specific, respectively. However, they do not factor in the interaction effect crystallized by equation 3. Put differently, equation 3 introduces the interaction effect in equation 2. The study opines that the innovation strategy adopted may interact with firm size, available skills, and informal competition to influence R&D costs. The three factors could inform the innovation strategy implemented.

$$\begin{aligned} &R\,\&\,D\ Costs\left(log\right)= \\ &=\beta_0+\beta_i Firm\,Characteristics+ \\ &+\beta_j Business\,Competitiveness+ \\ &+\beta_k Technological\,Upgrade\,Hurdles+\varepsilon_1\left(i\right), \end{aligned} \tag{1}$$

$$R\&D\ Costs\left(log\right)=\beta_0+\beta_1 Size+\beta_2 Age+ \\ +\beta_3 LargOwn+\beta_4 Informal\ Comp+ \\ +\beta_5 Exports+\beta_6 Innovation\ strat+\beta_7 Skills+ \\ +\beta_8 Financial\ Const+\beta_7 Tech\ Incomp+\varepsilon_1\left(ii\right), \quad (2)$$

$$R\&D\ Costs\left(log\right)=\beta_0+\beta_1 Size+\beta_2 Age+ \\ +\beta_3 LargOwn+\beta_4 Informal\ Comp+ \\ +\beta_5 Exports+\beta_6 Innovation\ strat+ \\ +\beta_7 Skills+\beta_8 Financial\ Const+ \\ +\beta_7 Tech\ Incomp+\beta_i Size\cdot InnovationStrat+ \\ +\beta_j Skills\cdot InnovationStrat+ \\ +\beta_k Informal\ Compet\cdot Innovation\ Strat+\varepsilon_2\left(iii\right). \quad (3)$$

The terms $\beta_0$, $\beta_{1...n}$, and $\varepsilon_1$, $\varepsilon_2$ represent the constant, regression coefficients, and the error term, respectively. $\beta_i$, $\beta_j$, $\beta_k$ are the interaction coefficients of innovation and firm size, skills, and informal competition.

## 3. RESULTS

Table 3 summarizes the study variables, while Table 4 shows their correlation matrix. The results show that, on average, the total sales comprise approximately 11% of exports. Financial constraint as an obstacle to technology upgrade is experienced more than a lack of relevant workforce and technological incompatibility. Domestic firms generate the most revenue by focusing more on the domestic market. The concentration on the domestic market may be attributed to various factors, for example, uncompetitive production activities or regulatory framework. Besides, the largest shareholder had about 66% of the firm's ownership on average.

Table 4 is the correlation matrix of the study variables. Based on the results in Tables 3 and 4, specific ordinary least square assumptions are met.

Table 5 presents the ordinary least squares (OLS) results of the determinants of R&D expenditure. The equation constant is statistically significant at 0.1% (6.1030, p-value = 2e-16). Both the export market performance sales-wise (1.2310, p-value = 0.0072) and skilled labor availability (0.4512, p-value = 0.0037) positively correlate with R&D expenditure at a 1% SL. Likewise, a significant positive and linear association exists between informal business practices (0.3088, p-value = 0.029) and R&D spending at 5%. Conversely, firm age,

**Table 3.** Variable summary statistics

| Variable | Obs | Mean | Std Dev | Min Stat | Max Stat |
|---|---|---|---|---|---|
| R&D Costs (log) | 164 | 5.4832 | 1.0356 | 3.3 | 9 |
| Firm Size (No. of employees) | 164 | 1.95 | 0.774 | 1 | 3 |
| Firm Age (log) | 164 | 1.2239 | 0.3701 | 0 | 1.95 |
| Largest Own (% shares) | 164 | 0.6647 | 0.2662 | 0 | 100 |
| Export (% of sales) | 164 | 0.1085 | 0.167 | 0 | 100 |
| Skilled Labor (lack of) | 164 | 1.45 | 1.21 | 0 | 4 |
| Financial Constraint | 164 | 2.23 | 1.137 | 0 | 4 |
| Technological Incompatibility | 164 | 1.16 | 1.205 | 0 | 4 |
| Innovation Strategy | 164 | 1.72 | 1.17 | 0 | 3 |
| Informal Competition | 164 | 1.65 | 1.237 | 0 | 4 |

**Table 4.** Correlation matrix

| Variable | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
|---|---|---|---|---|---|---|---|---|---|---|
| (1) R&D Costs (log) | 1.00 | | | | | | | | | |
| (2) Firm Size | 0.45 | 1.00 | | | | | | | | |
| (3) Largest Ownership (%) | –0.24 | –0.19 | 1.00 | | | | | | | |
| (4) Firm Age (log) | 0.05 | 0.22 | 0.00 | 1.00 | | | | | | |
| (5) Exports (% of sales) | 0.30 | 0.28 | –0.17 | 0.03 | 1.00 | | | | | |
| (6) Innovation Strategy | 0.04 | 0.07 | –0.13 | –0.15 | 0.05 | 1.00 | | | | |
| (7) Skills (Lack of) | 0.05 | 0.10 | 0.05 | –0.05 | 0.00 | 0.15 | 1.00 | | | |
| (8) Informal Competition | –0.01 | –0.04 | –0.07 | –0.05 | –0.14 | 0.08 | 0.14 | 1.00 | | |
| (9) Financial Constraints | –0.05 | 0.00 | –0.02 | –0.10 | –0.03 | 0.11 | 0.42 | 0.20 | 1.00 | |
| (10) Techn Incompatibility | –0.05 | 0.02 | 0.09 | 0.05 | –0.05 | 0.04 | 0.55 | 0.16 | 0.35 | 1.00 |


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largest shareholding, and technical incompatibility correlate negatively to the dependent variable. While these three factors reduce firm R&D expenses, their effect is weak. Likewise, financial access weakly enhances R & D expenditure as technological incompatibility has an inverse effect.

Moreover, the results indicate a significant correlation between firm size and R&D budget. There is a negative correlation between small-sized firms (–2.4132, p-value = 3.66e-05) and medium-sized enterprises (–1.9089, p-value = 0.0002). The size difference (d1/d2) effect is statistically significant at 0.1%. On the other hand, the three innovation strategies of the product (d4), process (d5), and product & process (d7) have a weaker relationship with what enterprises spend on R&D than the others (d7) category. The other category is assumed to focus on organization and marketing innovations. Besides, product innovation correlates positively with R&D, while the opposite holds for process and product & process. Be that as it may, these three innovation strategies are not substantially different from the others in the category.

Table 6 is a continuation of the findings in Table 5. It presents the results of the innovation strategy's interaction with firm size, skilled labor availability, and informal competition. First, the study explores the effect of such an interaction with firm size on R&D spending. For small-sized enterprises, the product (1.4654, p-value = 0.0242) and product & process (1.3393, p-value = 0.0361) innovation strategies positively relate to R&D costs. These two strategies' influence on the dependent variable is substantially greater than for large-sized firms.

On the contrary, process innovation strategy has no notable influence. For medium-sized businesses, the product innovation strategy effect mirrors that observed in small-sized firms. Whereas the process strategy does not affect R&D costs, the product & process approach has a marginal influence. These two factors are not significant determinants of R&D costs for medium firms.

Second, it examines the interaction effect of innovation strategy and skilled labor availability. The interaction results in lower R&D expenditure which is strong for product innovation (–0.675, p-value = 0.0006) and product & process (–0.4837, p-value = 0.0073). Lastly, the study investigates the effect of such an interaction on the informal competition. Like firm size and skilled labor availability, the product innovation strategy significantly influences the outcome variable, albeit negatively.

Finally, the product strategy is the most substantial determinant of all innovation strategies' R&D costs. The strategy's interaction with firm size, skilled labor availability, and informal competition has a statistically significant effect on R&D expenditure. The results support hypotheses one and two, but hypothesis three is rejected. To wrap

**Table 5.** OLS regression results of the determinants of R&D costs

| Variable | Coeff | Std Error | *p*–Value |
|---|---|---|---|
| Constant | 6.1030 | 0.4233 | < 2e–16 *** |
| Firm Age | –0.0538 | 0.1495 | –0.3600 |
| Largest Own (%) | –0.559 | 0.3057 | 0.0694 + |
| Export (%) | 1.2310 | 0.4513 | 0.0072 ** |
| Skilled Labor Available | 0.4512 | 0.1528 | 0.0037 ** |
| Financial Constraint | 0.0089 | 0.0723 | 0.9028 |
| Technological Incompact | –0.0928 | 0.0728 | 0.2046 |
| Informal Competition | 0.3088 | 0.1400 | 0.0290 * |
| **Firm Size** | | | |
| Small *(d1)* | –2.4132 | 0.5662 | 3.66e–05 *** |
| Medium *(d2)* | –1.9089 | 0.4866 | 0.0002 *** |
| **Innovation Strategy** | | | |
| Product *(d4)* | 0.0069 | 0.5081 | 0.9892 |
| Process *(d5)* | –0.2463 | 1.1208 | 0.8264 |
| Product & Process *(d6)* | –0.0273 | 0.5224 | 0.9584 |

*Note*: Large-sized firms (d3) and others (d7) – innovation strategies are the referent groups for the two variables. ***, **, *, and '+' represent 0.1%, 1%, 5%, and 10% significance levels (SL) respectively.

**Table 6.** Innovation strategy interaction's effect on R&D costs

| Firm Size | Innovation Strategy | Coeff | Std Error | *p*–Value |
|---|---|---|---|---|
| Small *(d1)* × | Product *(d4)* | 1.4654 | 0.6430 | 0.0242 * |
| | Process *(d5)* | 1.4859 | 1.0996 | 0.1787 |
| | Product & Process *(d6)* | 1.3393 | 0.6331 | 0.0361 * |
| Medium *(d2)* × | Product *(d4)* | 1.7937 | 0.5652 | 0.0019** |
| | Process *(d5)* | 1.0470 | 1.1108 | 0.3475 |
| | Product & Process *(d6)* | 0.9507 | 0.5572 | 0.0901 + |
| **Skilled Labor** | **Innovation Strategy** | **Coeff** | **Std Error** | ***p*–Value** |
| Skills × | Product *(d4)* | –0.6750 | 0.1919 | 0.0006 *** |
| | Process *(d5)* | –0.4356 | 0.2682 | 0.1066 |
| | Product & Process *(d6)* | –0.4837 | 0.1776 | 0.0073 ** |
| **Informal Business Practices** | **Innovation Strategy** | **Coeff** | **Std Error** | ***p*–Value** |
| Informal competition × | Product *(d4)* | –0.4080 | 0.1755 | 0.0215 * |
| | Process *(d5)* | –0.3212 | 0.2566 | 0.2127 |
| | Product & Process *(d6)* | –0.2592 | 0.1684 | 0.1259 |
| | $R^2$ = | 0.5931 | | |

*Note*: Large-sized firms (d3) and others (d7) – innovation strategies are the referent groups for the two variables. *** = 0.001, ** = 0.01, * = 0.05, and '+' = 0.1 significance levels. '×' = the interaction.

up, the explanatory factors and interactions account for approximately 59% ($R^2$ = 59.31) of the R&D spending change.

## 3.1. Robustness test

A robustness check is performed to validate the OLS results, as shown in Table 7. The robustness weight statistics indicate that all observations were included in the analysis. The findings of the robustness check confirm the OLS regression results. Be that as it may, specific changes are notable. For instance, the SL for the export changes from 0.1% to 0.5%, while there is an improvement in skilled labor availability (0.1% to 0.01%). The marginal effect of the largest shareholding is wiped out in the robust test. The robust test shows that the interaction between process innovation strategy and lack of skills results in R&D expenditure reduction, unlike in the previous results. Put differently, strategies (of product, process, or a combination) interaction with limited skills available to the firm is statistically different from the 'others' innovation strategies. Nonetheless, the robustness check results closely mirror the OLS findings, validating this model.

**Table 7.** Robustness check of the determinants of the R&D cost model

| Antecedent | Variable | Coeff | Std Error | *t*–Value |
|---|---|---|---|---|
| | Constant | 6.4756 | 0.3596 | 18.009*** |
| | Firm Age | –0.1125 | 0.1056 | –1.0650 |
| | Largest Own (%) | –0.3748 | 0.3135 | –1.1950 |
| | Export Market | 1.0609 | 0.4970 | 2.135* |
| | Technical Incompact | –0.0999 | 0.0832 | –1.2000 |
| | Access to finance | 0.0025 | 0.0729 | 0.0350 |
| | Skills Availability | 0.5038 | 0.1437 | 3.505*** |
| | Informal competition | 0.3182 | 0.1438 | 2.212* |
| Firm Size | Small *(d1)* | –2.3633 | 0.5836 | 4.049*** |
| | Medium *(d2)* | –1.8354 | 0.4268 | 4.300*** |
| Innovation Strategy | Product *(d4)* | –0.0232 | 0.4132 | –0.0560 |
| | Process *(d5)* | 0.0489 | 0.4911 | 0.1000 |
| | Product & Process *(d6)* | 0.1685 | 0.4830 | 0.3490 |
| **Interacting factor** | **Variable/Strategy** | **Product** | **Process** | **Product & Process** |
| Innovation Strategy | Small-Sized firms | 1.58 (0.69)* | 1.32 (0.63)* | 1.20 (0.69)+ |
| | Medium-Sized firms | 1.95 (0.58)*** | 0.80 (0.61) | 0.79 (0.56) |
| | Skills Availability | –0.68 (0.16)*** | –0.45 (0.19)* | –0.79 (0.56)** |
| | Informal competition | –0.44(0.17)* | –0.40 (0.19)* | –0.28 (0.19)* |

*Note*: *** p < 0.001, ** p < 0.01, * p < 0.05 and, + p < 0.1; '×' = the interaction; values in parenthesis represent related standard errors.


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## 4. DISCUSSION

The study aimed to determine factors impacting R&D expenditure for businesses operating in developing economies. Three broad hypotheses were developed relating to firm characteristics (size, age, and ownership) and non-firm-related attributes (exports, innovation, skills availability, and informal competition). The results supported the first two hypotheses but not the third. The findings suggest that firm size significantly affects R&D expenditure. For small and medium firms, size negatively influences such spending compared to large enterprises. Larger firms invest more in R&D than their smaller and medium-sized counterparts. Shefer and Frenkel (2005) draw a similar conclusion. The insufficient internally generated funds and limited external options explain why small to medium enterprises' R&D budgets are lower than their larger counterparts. Decision-makers should formulate policies to enhance innovation-related expenditure by SMEs.

Further, the results revealed a negative correlation between the proportion held by the largest shareholder and R&D expenditure. The inverse relationship between concentrated ownership and R&D spending suggests that local investors may be risk-averse. Traditional credit providers may be unwilling to lend to a firm where risk is concentrated in such an ownership structure. Chen and Hsu (2009) had the same conclusion that as firms age, they allocate fewer financial resources to research and innovation. Nevertheless, the effect of age on such allocation is statistically significant. As firms age, they probably establish a good market for their products and services, necessitating lesser R&D expenditure. Should substantial changes affect the business environment, enterprises channel more funds into innovation strategies. Hansen (1992) confirms that firm size and age negatively affect R&D spending.

Moreover, there is a substantial correlation between export market performance and R&D expenditure. The regulations in the export market like on product quality or competition may affect innovation expenses incurred. These results resonate with Neves et al. (2016), who established a complementarity between exports and R&D. The implication is that implementing R&D activities enhances the probability of executing export activities. Notably, these firms must budget sufficiently for their R&D programs. Besides, their study focused on product and process innovations at the center of the present study. Therefore, R&D spending boosts productivity, allowing domestic enterprises to tap into the foreign market (Vogel & Wagner, 2021).

That notwithstanding, results establish a positive relationship between skills availability and R&D spending. It is pointless for an enterprise to set aside scarce financial resources when the skills required to implement innovation-related projects are lacking. The test results concur with other previous studies. For instance, high technical skills complement product or process innovation and R&D collaboration. Skilled human capital is an enabling element in profitable innovation. Firms benefit less from innovation without sufficient skills due to a lack of the requisite absorptive capacity or complementary capabilities. Incompatibility between existing and new technology negatively influences R&D programs. However, the effect does not substantially hurt innovation activities (Piva & Vivarelli, 2009).

In addition, legalized businesses encounter both formal and informal competition in developing economies. Informal business practices may include product imitation with undesirable effects on formal firms' goods or services. Such situations require affected enterprises to devise mechanisms for dealing with the competition. The results indicate a positive link between R&D costs and domestic firms facing informal competition incurring higher R&D costs. Probably, these costs relate to improving product quality or the complexity of copying. The findings amplify other previous studies (Dwibedy, 2022). Surprisingly, financial constraint is a weak hindrance to technological upgrade.

Nonetheless, the overall importance of financial resources in R&D innovation cannot be overemphasized. R&D projects are more likely to be suspended or discontinued in a financially constrained R&D-intensive firm. Moreover, the risk of R&D-intensive firms grows with their financial constraints. Conversely, the risk of constrained firms rises in proportion to their R&D intensity (Li, 2011).

The innovation strategy adopted interacts with the firm size, skills availability, and informal competition to influence R&D costs. The product strategy significantly interacts with the three factors. Regarding firm size, such interaction increases innovation spending for SMEs more than larger firms. Small to medium firms would allocate more money to R&D when implementing product innovation activities. The spending is partly due to the absence of bureaucracy observed in larger firms when undertaking innovation.

Conversely, with skilled staff availability and informal competition, the interaction leads to a decline in innovation-related spending. Firms minimize their R&D costs when the R&D department is insufficiently staffed, and informal business practices do not threaten formal businesses' operations. Where the findings illustrated above differ from existing literature may be due to specific factors. These may include but are not limited to economic status, funding availability, skilled staff or technology, and proper regulation of the business environment.

## CONCLUSION

The study sought to explore certain factors influencing R&D costs incurred by firms in emerging markets like Kenya. The study informed that other than mature and larger firms with sufficient resources to make informed decisions, other categories of firms may be incurring R&D costs arbitrarily. Therefore, the current study attempts to assist firms experiencing challenges on elements that might influence their innovation-related expenditures. To answer the question, the study used the WBES data on the Kenyan economy for 2018. Notably, the innovation strategy served two purposes; its effect on R&D costs separately and when interacting with firm size, skill labor availability, and informal competition. In addition, a robust test was performed to validate the results obtained – approximately 11% of the firms were exporting their product or services.

The results show that the degree of informal competition, requisite skills availability, and exportation positively influence R&D expenditure. Conversely, there is an inverse relationship proportion of firm ownership held by the largest investor and the outcome variable. On firm size, small and medium enterprises incur lower R&D costs than their larger counterparts. However, firm age has a weak negative influence on the outcome variable. Likewise, the impact of the product and process innovation strategy has no meaningful difference from the 'others' category of organization and marketing. The interaction of firm size and innovation strategy reveals a substantial difference between small to medium firms and larger enterprises. The difference holds for the product and a combination of the product and process strategies. As explained next, the positive effects do not imply that these two categories of firms spend more than the larger firms. A similar outcome to the innovation strategy's interaction with the informal competition; however, this is for product only. The interaction of the product innovation strategy and firm size, skills, and informal competition is definitively different from zero. The findings are a pointer to the significance of the strategy adopted.

Further, the findings concur with the existing literature that larger firms incur significantly higher innovation-related costs than small and medium ones. Be that as it may, firm size (small and medium) interaction with innovation strategy (product and product & process) results in a more substantial increase in R&D expenditure than large, well-established firms. Likewise, skilled staff's interaction with the product and product & process strategy significantly influences the dependent variable.

Interestingly, compared to firms incurring R&D expenses, few firms export their products or services. The situation should stir conversation among the industry players about the reasons for such low involvement in the export market by local R&D businesses. For example, is it linked to regulatory restrictions or firm-specific attributes linked to R&D or innovation activities? Future studies could explore these areas in-depth.


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In summary, specific conclusions are drawn based on the test results. Firms must adjust their R&D budgets according to the informal competition intensity in their domestic markets, availability of requisite skills, and target markets, especially international ones. They should also be cognizant of the innovation strategy to be implemented, whether about the product, process, or combination. Besides, enterprises should refrain from pegging their R&D expenditure on their life-cycle phase. This explains why some new firms aggressively implementing innovation programs are gazelles beating mature and larger ones.

## AUTHOR CONTRIBUTIONS

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