

# The finance of innovation in Africa

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## Abstract

**Purpose** – The purpose of this paper is to investigate how firms in developing countries finance innovation. Notably, the study seeks to investigate whether innovative firms exhibit financing patterns different from those of non-innovative ones. It also examines the effect of financing sources on firm's probability to innovate.

**Design/methodology/approach** – The study utilizes firm-level data from the World Bank Enterprise Survey. From 28 African countries, 11,173 firms have been included in the sample. A statistical *t*-test is used for two independent samples and logistic regression models.

**Findings** – The results show that innovative firms, specifically innovative small- and medium-size firms exhibit financing patterns different from non-innovative peers. Further analysis indicates that there is no statistically significant difference between the financing patterns of innovative and non-innovative large firms. In Africa, innovation is mostly financed using internal sources and bank finance. Equity finance and bank finance have shown a higher effect followed by internal finance, finance from non-bank financial institutions and trade credit finance on firms' probability to innovate.

**Practical implications** – The management of innovative firms should reduce dependency on short-term and retained earning financing and increase the use of long-term instruments improve innovation performance.

**Social implications** – A pending policy task for African leaders is to design and evaluate reforms to create a strong financial sector that willing to support the innovation process.

**Originality/value** – This study contributes to the existent literature on finance of innovation by examining how firms finance innovation activities in developing countries. This study provides evidence on how innovative firms exhibit financing patterns different from non-innovative ones from developing countries.

**Keywords** Africa, Innovation, Financing sources, Innovation financing, Innovative firms

**Paper type** Research paper

## 1. Introduction

The literature shows that achieving sustained long-term productivity and economic growth is intrinsically linked to research and development (R&D) and innovation investment (Cainelli *et al.*, 2005; Coe *et al.*, 2009). At the micro-level, innovation has an impact on corporate performances (Gorodnichenko and Schnitzer, 2010; Chatzoglou and Chatzoudes, 2018) and survival of firms (Varis and Littunen, 2010). Developing countries have become increasingly aware of the vital role that innovation and efficiency play in driving economic growth and development (Barasa *et al.*, 2018). However, particularly in developing regions, the companies desire to innovate and their innovation performance severely challenged by financial difficulties.

Since the analysis of Schumpeter (1934) finance has been seen as a vital part of the innovation processes. Following Schumpeter analysis, a large body of theoretical literature indicates the lack of sources of finance stands out as the primary factor preventing potentially disruptive and radical innovations (Hall, 1992, 2002; Hall and Lerner, 2010). Generally, theories justify at least four main reasons why financing investment in innovation is different from financing ordinary investment. Investment in innovation is a bet on the future (Mazzucato, 2013), the returns are long-term and uncertain and most attempts fail (Silva and Carreira, 2010).

The question of how investment in R&D and innovative activities can be financed, especially in developing countries is open for discussion and gain much attention from researchers and policymakers. Indeed, a considerable body of empirical literature has been conducted in developed countries. These empirical papers indicate the presence of difficulties in raising funds for innovative activities, and this difficulties are regarded as a persistent barrier to innovate (Hajivassiliou and Savignac, 2008; Savignac, 2008; Hottenrott and Peters, 2012; Gorodnichenko and Schnitzer, 2010; Brown, Degryse, Höwer and Penas, 2012;



Efthyvoulou and Vahter, 2012; Hummel *et al.*, 2013; Mazzucato, 2013; Cincera and Santos, 2015; Agénor and Canuto, 2017). Few empirical works conducted in developing and emerging economies show that financing constraints are more severe, and are binding constraints for firm's growth in developing countries, particularly for innovative firms (Beck *et al.*, 2004, 2008).

The African countries are severely disadvantaged from financial development, and financing constraint is the most binding constraint for firms' innovation activities. Latest available data from firms in the African countries show that the growth barrier most frequently experienced is the unavailability of funds and high costs associated with innovation (Ayalew and Xianzhi, 2018). Financing constraint in the region is twice higher than non-African countries, and only about 23 percent of firms use bank loans (Otchere *et al.*, 2017), and is more binding than other constraints such as corruption or infrastructure (Ayyagari *et al.*, 2011).

However, the empirical literature does not provide concrete evidence on the question "to what extent firm's preference of a particular source of finance over the other sources has advantage or disadvantage in their probability to innovate?" Moreover, whether the innovative firms exhibit different financing patterns particularly in Africa, is still not empirically addressed. In addition, most empirical studies on the financial structure of innovative firms do not consider the difference in financing patterns of innovative firms separately to working capital and investment finance (see for instance Bartoloni, 2013; Bozkaya and De La Potterie, 2008; Hummel *et al.*, 2013; Planes *et al.*, 2001; Serrasqueiro *et al.*, 2011; Serrasqueiro *et al.*, 2016). However, there is a difference in the financing choice for working finance and investment finance in a given firm. Therefore, it might be more informative if the financing patterns of innovative firms specifically addressed distinguishing working capital and investment finance. Finally, the empirical literature on the financing of innovation that addresses cross-country evidence is scanty as most of the existing empirical papers discuss a single economy (Hummel *et al.*, 2013; Schäfer *et al.*, 2004; Casson *et al.*, 2008; Winston, 2011; Serrasqueiro *et al.*, 2011; Aghion *et al.*, 2004; Bozkaya and De La Potterie, 2008). A good cross-country empirical evidence is provided by Fernandez (2017) who studied the financing of innovation in ten Latin American countries. Recently, Grilli *et al.* (2017) strongly pointed out the need to research and assess the quantitative and qualitative evolution of financing dedicated to industrial R&D and innovation.

This study particularly seeks to investigate whether the innovative firms exhibit financing patterns different from those of non-innovative ones. It further investigates the effect of financing sources on firms' probability to engage in innovative activities. Therefore, the following three crucial research questions are addressed:

- RQ1. What is the source of the required capital that innovative firms use for their cost-intensive innovation activities?
- RQ2. Do innovative firms exhibit financing patterns different from non-innovative ones?
- RQ3. What is the effect of firms' choice of financing sources on their probability to innovate?

Data obtained from the various source are used to achieve the objectives mentioned above. The firm-level information source is the World Bank's Enterprise Survey (WBES) from 2013 to 2016. Information about country-level variables is obtained from the World Development Indicators (WDI), the doing business (DB) and the Global Financial Development Database (GFDD).

This study contributes to the existing pool of knowledge in the area as follows. First, the theoretical argument on whether innovative firms' exhibit unique financial structure is not well-developed but rather is still growing. This study will contribute to this growing theory by providing additional empirical evidence from developing countries perspective. Second, the current study will fill at least the following main gaps in the empirical literature.

The study is the first of its kind conducted on the continent of Africa. The study addresses 28 countries and as a result, will have contributed to the scant cross-country empirical evidence. All the sampled countries are mainly developing economies; hence, it will fill the gap that many empirical studies bypassed, as they concentrated in a developed economy. Third, methodologically, this study will have many contributions. In investigating whether innovative firms exhibit financing patterns different from non-innovative firms, we investigate separately for working capital and investment finance which is the first in its approach. The previous studies on the financial structure of innovative firms mainly used regression analysis while the present study additionally incorporated a parametric test (*t*-test for two independent samples). Finally, in doing the analysis, we first investigate the financing patterns of innovative firms and then we examine the effect of each financing sources on a firm's probability to innovate, i.e., the approach not seen in previous studies.

The structure of the rest of the paper is as follows: Section 2 refers to the literature review and hypothesis. Section 3 presents the data, econometric specification and methodology. Section 4 presents the results and discussion. Finally, Section 5 provides the conclusion.

## 2. The review of literature and hypothesis

### 2.1 *The unique characteristics of innovation financing*

From the perspective of investment theory, investment in innovative activities has unique features that make it different from ordinary investment. Finance and economic theories also show that unique features make it challenging to finance innovation. These unique characteristics are intangibility, uncertain return, moral hazard and asymmetric information. First, the firms engaged in innovation have a high percentage of intangible assets, including the human capital, such as scientist and engineers (Kerr and Nanda, 2015; Agénor and Canuto, 2017). Second, the investment in innovation is a bet on the future, the returns are long-term and uncertain and most attempts fail (Silva and Carreira, 2010; Mazzucato, 2013; Kerr and Nanda, 2015). Although the uncertainty tends to be greatest at the beginning and gradually decrease (Hall and Lerner, 2010), from a financier's perspective, in any stage, it is harder to certainly evaluate potential innovative projects that may require funding (Kerr and Nanda, 2015).

Third, the uncertain return from investment in innovative activities leads to the problem of moral hazard. In modern firms, there is a separation of ownership and management. This separation may cause a principal-agent problem when the goals of the two conflicts. Managers tend to spend on activities that benefit them, but also are reluctant to invest in uncertain innovation projects (Hall, 2002). The lemons premium for innovative projects will be higher than that for ordinary investment because the investor has more difficulty distinguishing good projects from bad projects (Hall, 2002; Stiglitz and Weiss, 1981; Ughetto, 2008).

The above literature generally indicates that innovative firms are faced with unique difficulties to raise the fund required to finance innovative activities. In the case of Africa, where financial markets are underdeveloped and highly imperfect, these difficulties are bound to be severe. Thus, innovative firms would have a unique financing strategy that would affect their financing pattern. Accordingly, the following hypothesis can be posited as:

*H1.* The financing patterns of innovative firms are basically different from non-innovative firms.

Firms usually finance working capital using internal sources and short-term credit including bank overdraft and trade credit. In contrast, most investment projects require a relatively long time to complete and a massive commitment of capital. Therefore, unlike working capital, the investment should be financed using the long-term and the medium-

term debt, and external equity finance. As a result, it is reasonable to assume that there will be a difference in the financial patterns of innovative and non-innovative firms specifically for working capital and investment finance. Hence, we construct two hypotheses which are a sub-division of the first hypothesis as follows:

- H1a.* The working capital financing pattern of innovative firms is basically different from non-innovative firms.
- H1b.* The investment financing pattern of innovative firms is basically different from non-innovative firms.

## 2.2 *The financing patterns of innovative firms*

The classical and neoclassical theories of capital structure tend not to focus directly on innovation characteristics but suggest reasons why innovative firms may favor particular sources of finance (Aghion *et al.*, 2004). Hall and Lerner (2010) proposed four reasons why these theories, especially Modigliani and Miller theory, of capital structure might fail in practice. First, uncertainty coupled with incomplete markets may make real options approach the innovation investment decision more appropriate. Second, the cost of capital may differ by source of funds for non-tax reasons. Third, the cost of capital may vary by source of funds for tax reasons. Fourth, the cost of capital may also change across types of investments (tangible and intangible) for both tax and other purposes. However, subsequent economic and finance theories advanced our understanding and raised a plethora of reasons why financial structure matter for innovative firms. Therefore, the pecking order theory and the financial growth cycle model is selected.

The rationale for the selection of these theories is given as follows. First, in the innovation setting, the validity of these theories should be improved. The Pecking Order Theory can be seen as a well-developed capital structure theory; however, its validity, particularly in the case of innovative firms, is still in the process of improvement. Similarly, the Financial Growth Cycle model is currently in the improvement stage. Second, both of Pecking Order theory and Financial Growth Cycle model assume the information asymmetry between principal and agents. Therefore, they are more relevant to the African situation where the problem of information asymmetry is high. Finally, the Financial Growth Cycle is explicitly modeled for small- and medium-sized enterprises (SMEs), whereas the Pecking Order Theory is more related to subjects matters related to management behavior of large or listed companies. Regardless of their specific advantage for SME and large firms, in practice, can be applied for all size of firms. Therefore, the use of these two theories together provides a more comprehensive understanding of the financial structure of innovative firms.

*2.2.1 Pecking order theory.* The pecking order theory is designed based on information asymmetry assumptions and argued that the choice of the firm's financial structure signals to outside investors the information of insiders. When the amount of internally generated funds is not enough, and external resources are required, firms prefer debt financing, which is less costly; equity will only be used as a last resort. Myers (1984) refers to this as a "pecking order" theory of financing. This model's style of financing help innovative firms to avoid the relatively high dilution costs and preserving control rights (Myers, 1984).

The Pecking order theory gains much acceptability in the empirical test of the model for innovative companies. Using unquoted 103 Belgian technology-based small firms, Bozkaya and De La Potterie (2008) examined the capital structure of start-up companies during their consecutive development stage. Their finding confirms the implications of the pecking order theory. Serrasqueiro *et al.* (2011) also investigated the financing sources of R&D for Portuguese SME. The result obtained from two-step estimation confirms the financing choice of Portuguese SMEs is in line with the pecking order theory.

Moreover, based on a self-developed measure of degrees of innovation, Hummel *et al.* (2013) examined the financing structure of 171 innovative SMEs in Germany. Their result validates the conformity of the pecking order theory. Finally, Serrasqueiro *et al.* (2016) analyzed the capital structure decisions of high-tech SMEs and non-high-tech SMEs. The results indicate that the capital structure decisions of high-tech SMEs are closer to the Pecking Order Theory.

The financial sector in Africa is mainly dominated by the banking sector (Otchere *et al.*, 2017) and more than 75 percent of the firms' external loan is from banks (Fowowe, 2017). Moreover, due to weak investors' protection and institutional qualities, raising funds by issuing external equity share is difficult in the region. As a result, to test the validity of pecking order style of financing in Africa, the following hypothesis is proposed:

H2. With respect to the hierarchy of financing instruments in innovative companies, internal funds have the highest importance, followed by debt finance (short, middle and long) and finally external equity.

*2.2.2 Financial growth cycle.* Based on an analogy between evolutionary biology and the business world (Berger and Udell, 1995) developed a model called the financial growth cycle. The model is essential in studying the financing structure of informationally opaque firms, such as small and young firms. These firms must finance themselves at first through diverse internal financial resources (such as those deriving from family, friends and fools), trade credit and business angels (Hummel *et al.*, 2013). In the course of the company growth, the access to other sources, such as venture capital and medium-term loan improves (Hummel *et al.*, 2013). In the latest phase, the firm acquires more experience and transparency, and at this stage of growth, the use of public equity and long-term loan capital are finally available.

The empirical test of this model is limited to few papers, such as Bozkaya and De La Potterie (2008) in Belgian technology-based small firms, Serrasqueiro *et al.* (2011) for Portuguese SMEs, and (Hummel *et al.*, 2013) for Germany small innovative firms. However, because our sample contains firms of different size group (small, medium and large) and different age groups (young and mature), the model may be relevant. Accordingly, in line with the financial growth cycle model and the work of Hummel *et al.* (2013), the following hypothesis is proposed as:

H3. Innovative firms take advantage of growth potential; as a result, there is a corresponding gain in the importance of internal funding, external equity, trade credits and other credit substitutes than non-innovative firms. At the same time medium to long-term bank financing loses its importance.

### *2.3 The effect of firms' financing preferences on the probability to innovate*

The sources of finance for investment in innovation can be broadly classified as internal and external sources. In perfect capital markets, external finance is a perfect substitute for internal finance (Modigliani and Miller, 1958). In practice, capital markets are imperfect, especially for innovative companies. Firms' financing choice influences the rate and direction of innovation (Mazzucato, 2013). Besides, young, high-tech, publicly-traded firms finance their R&D investment almost entirely through internal cash flow and external equity markets (Brown *et al.*, 2009). Schäfer *et al.* (2004) found that firms use more equity financing to exhibit better innovation performance. In practice, banks face greater liquidity constraints than other lenders; hence, they usually prefer borrowers' that have adequate collateral, transparent evaluation system and other low-risk sectors (Winton and Yerramilli, 2008). As a result, banks are either reluctant to finance innovative projects or demand higher interest than in the case of investments in physical assets (Hall, 2002; Hall and Lerner, 2010; Winston, 2011; Agénor and Canuto, 2017). The available empirical studies tend to the finding that innovative firms are less likely to use bank finance (Aghion *et al.*, 2004;

Cosh *et al.*, 2009; Ajagbe *et al.*, 2012; Brown, Degryse, Höwer and Penas, 2012). Planes *et al.* (2001) shown that compared to their useful contribution to total turnover, the innovative firms share a lower proportion of bank loans than the non-innovative ones.

The motive of the use of trade credit is more than bank financing when firms suffer negative cash flows or temporary liquidity shock and weaker banking relationship (Lin and Chou, 2015). Many empirical studies show that in the undeveloped financial markets or when the relationships between banks and firms are weak firms tend to use more trade credit (Garmaise and Moskowitz, 2003; Niskanen and Niskanen, 2006; Fisman and Love, 2003; Lin and Chou, 2015). Petersen and Rajan (1997) found that firms which are less likely to be bank credit constrained tend to rely less on trade credit.

Studies show that firms received government financial support grow faster (Lerner, 2000) and invest more in innovative activities (Aerts and Schmidt, 2008; Czarnitzki and Lopes-Bento, 2013; Görg and Strobl, 2007; Bloom *et al.*, 2002; Bérubé and Mohnen, 2009; Garcia and Mohnen, 2010). Furthermore, a large body of literature indicates that venture capitalist stimulates innovation, promote the emergence of start-ups and the development of industrial clusters (Dobloug, 2008; Hirukawa and Ueda, 2011; Peneder, 2014). Finally, innovation is also financed using credit from relatives, families and intra-group financing.

The median value is used to differentiate firms that have better internal financing capacity and external finance (see section 4.4 about the detail and reasons of using median value); hence, the final hypothesis is proposed as follows:

- H4.* Firms that have internal financing capacity and access to external finance, such as bank finance, finance from non-bank financial institutions, trade credit and other sources above the median value are more likely to innovate.

### 3. Data, econometric specification and variable definition

#### 3.1 Data

The data set used in this paper combines firm and country-level data from various sources. The firm-level data come from the WBESs Indicator Database, [www.enterprisesurveys.org](http://www.enterprisesurveys.org). The WBES is a rich database that has an advantage for this study. WBES collects direct measures of innovation and financing sources so that we do not have to rely on indirect proxies for the key variables in our analysis. The data set is also supplemented with country-level data from diverse sources, such as the WDI, the GFDD and the DB database. Enterprise survey conducted before the year 2011, for African countries, does not include innovation-related questions. Our sample is determined based on the survey conducted between the years 2011–2016. During this time frame, 29 African countries have surveyed by Enterprise survey group. Due to data inconsistency and the sake of cross-sectional analysis, we dropped the earlier survey (Rwanda) from our sample and begun the 2013 survey. The final sample includes 11,173 firms; of which 5,550 (49.67 percent) from 2013 survey, 3,465 (31 percent) from 2014 and the remaining 2,158 (19.33 percent) from 2016 survey. The details of the composition of the actual sample are presented in Table I. The details of specific countries and the number of the sample are presented in Table II.

#### 3.2 Econometric specification

In order to investigate whether innovative firms exhibit financing patterns different from non-innovative firms, the study will use a parametric *t*-test for two independent samples. The study employs binary logistics regressions to examine the effect of financing sources on the firm's probability to engage in innovative activities.

Broadly, there are two inferential statistical procedures: parametric and non-parametric. Depending on the level of the data (e.g. nominal, ordinal and continuous) and distribution of



**Table I.**  
Composition of the  
sample

Classifications	Frequency	Percentage from 11,173 total sample
Manufacturing	5,460	48.87
Service	3,969	35.52
Foreign-owned	1,541	13.79
Government-owned	303	2.71
Exporter	1,531	13.70
Micro-size firms (up to 10 permanent employees)	4,823	43.17
Small-size (11 to 49 permanent employees)	4,342	38.87
Medium-sized (50 to 200 permanent employees)	1,444	12.92
Large (200 and more)	563	5.04
Young (1-5 years)	2,022	18.10
Matured (6-15 years)	4,612	41.28
Old (more than 15 years)	4,539	40.62

Country	No. obs.	% of sample	R&D expenditure > 0	Improved product in the last 3 years	Improved process in the last 3 years	Innovation: broad-base	Innovation: narrow base
<i>Survey 2013</i>							
Djibouti	139	1.24	30.99	33.8	32.39	49.29	23.94
DRC	345	3.09	26.87	43.21	33.52	54.84	29.09
Egypt	2,118	18.96	11.82	19.7	9.803	31.19	13.56
Ghana	516	4.62	37.64	50.75	35.77	63.48	23.41
Kenya	529	4.73	52.3	70.74	54.08	83.15	43.09
Morocco	264	2.36	37.5	26.1	28.31	48.89	15.44
Tanzania	258	2.31	52.27	59.85	26.89	71.98	40.53
Tunisia	483	4.32	18.95	25.98	23.44	40.23	16.6
Uganda	365	3.27	42.14	64.34	45.89	75.81	46.63
Zambia	533	4.77	43.01	51.72	36.48	73.68	34.3
Sub-total	5,550	49.67	35.35	44.62	32.66	59.25	28.66
<i>Survey 2014</i>							
Burundi	126	1.13	11.85	44.44	45.93	59.25	31.85
Malawi	264	2.36	40.89	49.83	38.14	68.38	28.18
Mauritania	81	0.72	19.54	58.62	59.77	71.26	39.08
Namibia	245	2.19	64.63	73.98	56.1	86.17	64.23
Nigeria	1,533	13.72	46.31	54.99	43.84	71.38	36.53
Senegal	301	2.69	2.932	49.51	34.53	57.65	32.9
South Sudan	565	5.06	33.28	50.34	26.21	69.63	26.03
Sudan	350	3.13	20.45	60.23	23.86	63.63	48.01
Sub-total	3,465	31	29.99	55.24	41.05	68.42	38.35
<i>Survey 2016</i>							
Benin	112	1	14.16	29.2	15.04	38.05	18.58
Cameroon	182	1.63	8.612	37.8	12.44	46.15	24.88
Cotedivior	212	1.9	7.306	35.62	15.53	42.00	20.55
Ethiopia	686	6.14	5.587	36.96	20.49	43.69	26.65
Guinea	154	1.38	11.54	29.49	16.67	35.89	21.79
Lesotho	46	0.41	6.0	4.0	4.0	10	4.0
Mali	102	0.91	13.51	27.93	27.93	40.54	23.42
Swaziland	74	0.66	19.23	19.23	6.41	33.33	12.82
Togo	114	1.02	16.94	33.87	15.32	43.54	24.19
Zimbabwe	476	4.26	14.17	26.15	14.37	35.32	15.97
Sub-total	2,158	19.33	11.71	28.02	14.82	36.85	19.29
Total	11,173	100	25.37	41.73	28.68	54.94	28.08

**Table II.**  
Innovative indicators  
in African countries

data (normal or non-normal) a particular statistical approach should be followed. Parametric tests rely on the assumption that the data resemble a normal or “bell-shaped” distribution. In order to conduct a parametric test, the dependent variable should be on a continuous scale. Furthermore, the decision to use a parametric or non-parametric test also depends on whether the mean or median more represent the distribution of the data sets.

For the mathematical expression of a *t*-test, let us consider two independent random samples  $X_1, X_2, \dots, X_m$ , and  $y_1, y_2, \dots, y_m$ , are from two populations. For comparison, the mean value is used and the statistical hypothesis developed as follows:

$$H_0 : \mu_1 = \mu_2 \text{ vs } H_1 : \mu_1 \neq \mu_2,$$

where  $\mu_1$  and  $\mu_2$  indicates the mean value of the first population and the mean value of the second population, respectively. When the two population distributions are normal, but the population variances for the two samples ( $\sigma_1^2$  and  $\sigma_2^2$ ) are unknown but equal, according to (Tanis, 2008) the test, statistics is:

$$T = \frac{X - Y - (\mu_1 - \mu_2)}{S_P \sqrt{\frac{1}{m} + \frac{1}{n}}},$$

where:

$$S_P = \sqrt{\frac{(m-1)S_1^2 + (n-1)S_2^2}{m+n-2}}. \tag{1a}$$

*T* has a *t*-distribution with  $m + n - 2$  degree of freedom (df). However, if the population variance is unknown and unequal, following Reinard (2006), the test statistics will be computed as:

$$T = \frac{X - Y - (\mu_1 - \mu_2)}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}},$$

where:

$$X = \frac{\sum_{i=1}^m X_i}{m}, Y = \frac{\sum_{i=1}^n Y_i}{n}, S_1^2 = \frac{\sum_{i=1}^m (x_i - X)^2}{m-1}, S_2^2 = \frac{\sum_{i=1}^n (y_i - Y)^2}{n-1}, \tag{1b}$$

*T* has a *t*-distribution with a degree of freedom:

$$df = \frac{(A+B)^2}{\frac{A^2}{m-1} + \frac{B^2}{n-1}},$$

where:

$$A = \frac{S_1^2}{m} \text{ and } B = \frac{S_2^2}{n}. \tag{1c}$$

In order to investigate the effect of financing sources, the study will use logistics regression, which is derived based on the latent regression of the form:

$$y^* = X'\beta + \varepsilon, \tag{2a}$$



where  $y^*$  is an unobservable index variable,  $x$  is a vector of explanatory variables,  $\beta$  is a vector of parameters and  $\varepsilon$  is an error term. For case,  $y^* = 1$  (i.e. innovative firms) if  $y^* > 0$ , and  $y = 0$  (non-innovative firm). For the logit model with a set of variables  $x$  and an additional (any) variable of interest, the odds in favor of response of one is given as:

$$\frac{p}{1-p} = \frac{1 + e^{x'\beta}}{1 + e^{-x'\beta}} = e^{x'\beta}. \quad (2b)$$

The odds ratio presents the probability of success or having an event,  $p$ , to the likelihood of failure or not having an event,  $(1-p)$ . By taking the natural logarithm of both sides of Equation (2b), one obtains the logistics regression model:

$$\text{Ln} \left( \frac{p}{1-p} \right) = x'\beta = \beta_1 + \beta_2 X_2 + \dots + \beta_K X_K. \quad (2c)$$

Therefore, to estimate the effect of each financing sources on the probability to be an innovative firm, controlling both firm-level and country-level variables with the inclusion of fixed-effects (industry and country) is given as follows:

$$\begin{aligned} \text{Innov}_{ij} = & \beta_1 + \beta_2 \text{FinSource}_{ij} + \beta_3 \text{FirmSpecifConVars}_{ij} + \beta_3 \text{CountryLevConVars}_{ij} \\ & + \beta_4 \text{InduFE}_{ij} + \beta_5 \text{CountryFE}_{ij} + \beta_6 \text{Timedummy}_{ij} + \varepsilon_{ij}, \end{aligned} \quad (2d)$$

where,  $\text{Innov}_{ij}$  is the probability for firm  $i$  in country  $j$  to be innovative,  $\text{FinSource}_{ij}$  is a vector of main independent variables.  $\text{FirmSpecifConVars}_{ij}$  is a vector of firm-specific control variables, such as firm size, firm age, sales growth, ownership, exportation, the gender of a top manager, management experience, business group affiliation, auditing practices of a firm.  $\text{InduFE}_{ij}$  is a vector of industry-fixed and  $\text{CountryFE}_{ij}$  represent country fixed-effects. The next section presents the definition and measurement of variables.

### 3.3 Variable definition and measurement

**3.3.1 Indicators and measurements of innovation.** Broadly, there are two indicators of innovation: input and output indicators. Input indicators comprise, for example, the R&D expenditures or the percentage of the R&D employees to all other employees. Output indicators comprise mostly the number of patents as well as the number of product and process innovations. The measurement of these two innovation indicators usually takes two approaches, i.e., the objective and subjective approaches. The objective approach measures innovation using directly measurable indicators, such as the number of patents a company registers. The subjective approach measures innovation based on the self-assessment of the company as to its innovation activities.

Our firm-level data set: WBES allows us to use both innovation indicators (input and out) which are measured using a subjective approach. Broadly (innovation: broad-based), we defined innovative firms that satisfy at least one of the following three criteria: a firm that spent a non-zero amount on R&D activities, a firm that introduced new or significantly improved products in the last three years and a firm that launched a new/significantly improved process for producing/supplying products in the previous three years. The classification of firms as innovative and non-innovative based on these criteria has many advantages. Besides, expenditure on R&D does not necessarily mean that the company is innovative. For instance, in our sample, 3,160 firms reported R&D expenditure greater than zero, but among them, only 1,831 (57.94 percent) firms introduce a new process, and only 2,217 (70.15 percent) firms introduce new product/service.

Moreover, R&D spending is likely to have a distinct sectorial bias (Lee *et al.*, 2015). In this regard, our sample indicates that among 3,160 firms with non-zero R&D expenditure more than half (51.1 percent) are manufacturing firms. Finally, R&D is an input measure that cannot indicate innovation output. However, this approach is not free of limitations. For instance, the method includes firms who adopt innovation from elsewhere; as a result, it becomes less helpful in differentiating real-innovative firms from adaptive ones. In another world, the approach does not separate incremental innovator from a radical innovator. Nevertheless, these two forms of innovation may have different implications in the financing of innovation.

Therefore, based on the scope of our data source, we try to separate the incremental innovator from the radical innovator. In line with Lee *et al.* (2015), we differentiate the radical innovation from incremental innovation based on whether a firm that introduced a new product in the last three years were new to the market not just new to the firm. Therefore, throughout this paper, firms are classified as innovative and non-innovative based on the two concepts: innovation: broad-based and innovation: narrow-based. In the case of innovation: broad-based, innovative firms are those firms which spend a non-zero amount in R&D or introduced a new or significantly improved product or process during the last three years, otherwise, categorized as non-innovative firm. In the case of innovation: narrow-based, firms are considered as innovative if a new or significantly improved product were new to the market/industry, otherwise, categorized as non-innovative firm. Therefore, in the logistics regression, the dependent variable “innovation” is included as a dummy variable taking value = 1 if the firm is innovative, zero, otherwise.

Table II presents innovation indicators based on the above contexts. Innovation measures indicate that there is a substantial difference in the level of innovation among countries in Africa. The average percent of firms with R&D expenditure greater than zero is 25.3 percent. On average, 41.7 percent of the firms introduced new or significantly improved product during the last three years. On average 28 percent of firms introduced new or significantly enhanced process during the previous three years. The information presented in Table II, generally shows that there is a substantial difference in innovation input and output across countries in Africa. On average 28 percent of firms failed in the innovative category when innovation is measured based on innovation: narrow-base and approximately 55 percent of firms failed in the same group when innovativeness is measured based on innovation: broad-base.

*3.3.2 Measurement and treatment of financing sources.* In this study, financing sources are used as a dependent and independent variable for different purposes. First, they treated as the dependent variable to investigate whether innovative firms exhibit financing patterns different from non-innovative peers. Accordingly, financing sources are measured based on their proportional share from the total finance of a firm hence treated as continues variable in the *t*-test for two independent samples. The measurement and classification of financing instruments are based on their presentation in the WBES. The WBES section *K* exhaustively address the sources of finance for enterprises. We construct the data for financing sources based on the responses to the survey question *k3*; the proportion of financing sources for working capital (working capital finance), and *k5*; the proportion of financing sources for purchase of fixed assets (investment finance). According to the alternatives in *k3* and *k5*, there are six sources of finance. These are: internal/retained earnings; owners' contribution or new equity finance; bank finance; financed from non-bank financial institutions which include microfinance institutions, credit cooperatives, credit unions or finance companies; trade credit which represent credit due to purchases on credit from suppliers and advances from customers; other sources which include moneylenders, friends, relatives and bonds. The detail description of these variables is presented in Table III.

Variable name	Measurement and definition	Data source
<i>Innovation measures</i>		
Innovative firm (innovation: narrow-base)	Dummy variable equal to 1 if a firm is innovative; an innovative firm is the one that introduced new/significantly improved products new to the market in the last three years, 0 otherwise (non-innovative)	WBES
Innovative firm (innovation: broad-base)	Dummy variable equal to 1 if a firm is innovative; an innovative firm is the one that spends a non-zero amount in R&D, or introduced a new or significantly improved product or process during the last three years, take value = 0, otherwise (non-innovative)	–
<i>Financing sources</i>		
Internal/retained earnings	The proportion of working capital and investment financed using internal/retained earning	
Equity finance	The proportion of working capital and investment financed from owners' contribution or issued new equity shares	
Bank finance	The proportion of working capital and investment financed borrowed from the bank	
Finance from non-bank financial institutions	The proportion of working capital and investment financed borrowed from non-bank financial institutions, which include microfinance institutions, credit cooperatives, credit unions, or finance companies	
Trade credit finance	The proportion of working capital and investment financed using credit from suppliers and advances from customers	
Other sources of finance	The proportion of working capital and investment financed using others, moneylenders, friends, relatives, bonds, etc.	
<i>Firm-level control variables</i>		
Firm size	Log of the number of permanent full-time employees	
Firm age	Log of Age of the firms	
Sales growth	The difference between the current year sales and the sales three years before the survey year divided by the current year sales	
Foreign-owned	Dummy variable that takes on the value 1 if any foreign company or individual has a financial stake in the ownership of the firm, zero otherwise	
Government-owned	Dummy variable that takes on the value 1 if any government agency or state body has a financial stake in the ownership of the firm, zero otherwise	
Part of a large firm	Dummy variable equals to 1 if the firm is part of a larger firm, 0 otherwise	
Exporter	Dummy variable that takes on the value one if a firm directly exports goods or services, zero otherwise	
Audited	Dummy variable equals to 1 if the firm has its annual financial statement checked and certified by an external auditor	
Female-manager	Dummy variable that takes on the value 1 if the manager is female 0 otherwise	
Log (experience)	Log of experience in this sector that the top manager has	
Micro & small (MSEs)	A firm has 1–49 permanent employees	
Medium-firm	A firm has 50–199 permanent employees	
Large firm	A firm has more than 200 permanent employees	
Young	1–5 years	
Mature	6–15 years	
Old	more than 15 years	

**Table III.**  
Variable description  
and data source

(continued)

Table III.

Variable name	Measurement and definition	Data source
<i>Country-level control variable</i>		
The depth of credit information	The depth of credit information index is a measure of the coverage, scope and accessibility of credit information available through either a public credit registry or private credit bureau (0–10)	DB
Bank Competition	The value of the Boone indicator	GFDD
GDP per capita	Log of GDP per capita (Constant USD)	WDI
Financial system development	Domestic credit provided by the financial sector (% of GDP)	GFDD

**Note:** In the binary logistics regression each financing sources are included as a dummy variable equal to 1 if the financing source percentage (for working capital and investment financing) of a particular firm is greater than the median across all sampled firms of a given country

**3.3.3 Control variables.** Firm size. Larger firms are assumed to be more innovative than smaller ones, either as a result of capital market imperfections which leave small firms with insufficient internal resources to fund innovative activities (Schumpeter, 1942) or due to the higher level of output which renders larger firms able to produce more output (Cohen and Klepper, 1996). Empirically, the firm’s size effect is not universal, some find evidence that supports positive effect (Abdu and Jibir, 2017; Hajivassiliou and Savignac, 2008; Protogerou *et al.*, 2017), whereas others, for example, Álvarez and Crespi (2011) and Zemplerová and Hromádková (2012) produced adverse effect.

Firm age. Young firms are vital sources of novel and technologically superior products and processes (Schumpeter, 1934). In contrast, Cohen and Klepper (1996) argued that older firms are more innovative due to non-negligible learning-by-doing effects which materialize over time. Over time processes become more efficient, routinized and cost-efficient (Cohen and Levinthal, 2000).

Firm ownership status is decisive for its ability to pursue innovative efforts and financing sources. In particular, owing to easier access to knowledge, human resources and internal funds paired with more efficient and widespread risk-diversification strategies, innovative efforts may be higher among firms that are both parts of a group and foreign-owned (Leitner and Stehrer, 2016). To control the effect of ownership and business affiliation, we include foreign-owned, government-owned and parts of a group as dummy variables. Foreign-owned firms enjoy access to external technical know-how, managerial and organizational skills and finance that affects their innovation performance (Leitner and Stehrer, 2016; Gonzalez *et al.*, 2017). In Africa, government-owned firms are favored to obtain a loan from state-owned banks and are less likely to be financially constrained (Ayalew and Xianzhi, 2018); however, in terms of innovativeness they usually consider as less innovative. As a part of a growth strategy, especially small and younger firms perform business affiliation (be a part of a group) with large and well-establish firms. As a result, they can acquire the necessary resources and knowledge to pursue innovative activities (Leitner and Stehrer, 2016). Empirical studies conducted in Africa such as Goedhuys (2007) in Tanzania, El Elj (2012) in Tunisia, Dotun (2015) in Nigeria find the evidence supports the above relationships.

Exporting firms also benefited from their exposure to international technology and the ensuing technology transfers that may take place. Exporters have better access to information about the availability of as well as better access to foreign embodied and disembodied technology that provide the opportunity to innovate (Abdu and Jibir, 2017; El Elj, 2012).

Innovation performance and the firm’s access to finance is also affected by the gender and experience of the top manager of the firm. Management experience increases the efficiency of human capital, decreases uncertainty about the value of opportunities and provide access to diverse types of information required for opportunity identification, and also help to acquire

resources including financial resources (Protogerou *et al.*, 2017). Aterido *et al.* (2013) provided three main reasons how gender bias in the credit market happens. First, taste discrimination in the sense that the financial system is dominated by men and the barriers to accessing financial services are consequently higher for women than men. Second, statistical discrimination due to the lower degree of educational attainment and little involvement in the former market economy might be a barrier for women to access formal financial services. Third, the traditional role of females, i.e., women focused on household activities and men focused on market economies might be reflected in the use of formal financial services. Therefore, a firm with a top manager-female would have less access to external finance. Ayalew and Xianzhi (2018) find evidence that audited firms have better access to external finance in Africa.

Moreover, country-level variables correlated with innovation and access to finance, such as per capita GDP, financial system development, bank competition and depth of credit information are controlled in the regression analysis. A large body of literature documented the positive role of these variables on firm's access to finance (Beck, 2012; Beck *et al.*, 2007, 2008; Carbo-Valverde *et al.*, 2009; de Guevara and Maudos, 2011). To capture unobservable characteristics shared by firms in the same sector and differences between countries, industry-fixed effect, country fixed-effects and time-dummies are included in the estimation. The measurement and data source of the above control variable is presented in Table III. The summary statistics for the variable are presented in Table IV. The correlation between variables is given in Tables V–VII, respectively. All external sources of finance are negatively correlated with internal/retained earnings finance; indicating an increase in the use of one followed by the decrease to the other (see Table IV). Generally, the correlation between the independent variables is very low.

Variable	Obs.	Mean	SD	Min.	Max.
<i>Innovativeness indicators</i>					
Innovative firm's: broad-base	11,173	0.5444	0.4980	0	1
Innovative firm's: narrow-base	11,173	0.2726	0.4453	0	1
<i>Main variables: Financing sources</i>					
Retained/internal	11,173	0.4993	0.2722	0	1
Owner con./new equity	11,173	0.0071	0.0604	0	1
Bank finance	11,173	0.0679	0.1713	0	1
Finance form non-bank financial institutions	11,173	0.0136	0.0634	0	1
Trade credit	11,173	0.0540	0.1108	0	1
Other financing sources	11,173	0.0273	0.0978	0	1
<i>Firm-specific control variables</i>					
Firm size	11,173	63.30	413.97	1	30,000
Firm age	11,173	16.879	14.380	1	166
Sales growth	11,173	0.0259	0.2821	-1.899	3.175
Foreign-owned	11,173	0.1379	0.3448	0	1
Government-owned	11,173	0.0271	0.1624	0	1
Part of large group	11,173	0.1859	0.3891	0	1
Export	11,173	0.1370	0.3439	0	1
Management experience	11,173	17.313	21.738	1	68
Manager-female	11,173	0.1097	0.3125	0	1
Audited	11,173	0.5466	0.4978	0	1
<i>Country-level control variables</i>					
GDP per capita	11,173	1,777	1,164	219.60	5,625.12
Financial system development	11,173	0.4073	0.2613	0.0162	1.112
Bank competition	11,173	0.0003	0.0020	-0.0025	0.0052
Depth of credit information	11,173	3.204	3.1666	0	8

**Table IV.**  
Summary statistics

#### 4. Results

The suitability of the *t*-test for two independent samples is tested. First, the *t*-test is based on the assumption of normally distributed data; hence, the normality of the data is tested using the histogram. The histogram confirms the data are fairly normally distributed. Second, the *t*-test to be effective requires a large sample ( $n > 30$ ). In this regard, our sample is large enough to run the *t*-test. Third, the *t*-test for two independent samples have two options: either to assume equal variance or unequal variance. We conduct a variance ratio test, but we did not find any significant evidence that supports the presence of unequal variance. The literature shows that if the sample size of the two groups is unequal, it would be more likely to have unequal variance. As a result, we conduct the *t*-test assuming equal variance and unequal variance separately, but we did not find a significant difference in the results. Thus, a *t*-test for two independent samples is suitable for this study.

##### 4.1 Sources of finance for innovation

Table VIII presents the financing patterns of innovative and non-innovative firms for the overall financing (working capital and investment finance). Among 11,173 sample firms, only 3,707 firms purchased a fixed asset (invested in innovation) during the last three years hence our observation decrease to 3,707 of which 1,433 firms are identified as innovative using innovation: narrow-based approach. Innovative firms mostly finance innovation with internal/retained earnings (66.22 percent, total mean) followed by bank finance (18 percent, total mean). On average, 8 and 4 percent of fund used by innovative firms raised from trade credit and other sources (includes moneylenders, friends, relatives and bonds), respectively. Finance from owner's contribution/new equity finance and non-bank financial institutions (microfinance institutions, credit cooperatives, credit unions or finance companies) together contribute less than 6 percent of the total finance of innovative firms (see Table VIII). Generally, the above financing preferences of innovative firms' are the same to finance working capital (see Table IX) and investment (see Table X). However, the proportion of working capital financed using internal/retained earnings (70.63 percent, total mean) and trade credit (10.28 percent, total mean) is slightly higher than the overall finance (see Tables VIII and IX for comparison). Innovative firms used more bank finance (approximately 19 percent, at the mean) to finance investment than to fund working capital (see Tables IX and X).

##### 4.2 The financing patterns of innovative firms

Table VIII also indicates whether there is a difference in the financing patterns of innovative and non-innovative firms. To quantify the differences in financing sources according to firm type, we use a *t*-test for the independence of two samples (innovative and non-innovative). The *p*-value of the *t*-test indicates the null hypothesis the two samples have an equal mean ( $H_0$ : innovative = non-innovative) is rejected at 5 percent significance level for all financing

Sources of finance	Internal/ retained earning	New equity finance	Bank finance	Finance from non-bank financial institutions	Trade credit	Other sources
Internal/retained earning	1					
New equity finance	-0.0503	1				
Bank finance	-0.3594	0.0099	1			
Finance from non-bank financial institutions	-0.1687	0.0834	0.0284	1		
Trade credit	-0.3396	0.0373	0.0136	0.0461	1	
Other sources finance	-0.3031	0.1194	-0.0567	0.0407	0.0106	1

**Table V.**  
Correlation between  
financing sources



**Table VI.**  
Correlation between  
financing sources and  
firm-level control  
variables

No.	Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Internal/retained earning	1															
2	New equity finance	-0.050	1														
3	Bank finance	-0.359	0.0099	1													
4	Finance from non-bank fin. Ins.	-0.168	0.0834	0.0284	1												
5	Trade credit	-0.339	0.0373	0.0136	0.0461	1											
6	Other sources finance	-0.303	0.1194	-0.056	0.0407	0.0106	1										
7	Log (size)	0.0484	-0.0249	0.1596	-0.0216	0.0462	-0.0632	1									
8	Log age	-0.066	0.0157	0.0682	0.0203	0.0904	-0.0169	0.2855	1								
9	Log (experience)	-0.028	-0.0534	0.057	0.017	0.0836	-0.0743	0.2288	0.5223	1							
10	Sales growth	-0.036	0.09	0.0111	0.059	0.0138	0.0654	-0.014	-0.013	-0.034	1						
11	Foreign-owned	0.0225	0.0627	0.0606	0.053	0.0314	0.0551	0.1645	-0.049	-0.033	0.0181	1					
12	Government-owned	-0.081	0.251	0.1109	0.1987	0.1094	0.202	0.0643	0.0471	-0.02	0.1121	0.2113	1				
13	Export	-0.054	0.1338	0.206	0.1466	0.1341	0.0910	0.3102	0.1284	0.0992	0.0532	0.1961	0.2091	1			
14	Manager-female	-0.016	-0.0032	0.0162	0.0115	-0.013	0.0279	-0.097	-0.031	-0.087	0.0119	-0.023	-0.015	-0.034	1		
15	Audited	-0.016	-0.0481	0.1922	-0.0153	0.0627	-0.0749	0.3324	0.1466	0.1784	-0.041	0.0893	-0.015	0.1011	-0.032	1	
16	Part of large group	0.008	0.0446	0.036	-0.0041	0.017	0.0331	0.1912	0.1344	0.047	0.0089	0.0944	0.0599	0.0561	-0.007	0.0984	1

No.	Sources of finance	1	2	3	4	5	6	7	8	9	10
1	Internal/retained earning	1									
2	New equity finance	-0.0503	1								
3	Bank finance	-0.3594	0.0099	1							
4	Finance from non-bank fin. I	-0.1687	0.0834	0.0284	1						
5	Trade credit	-0.3396	0.0373	0.0136	0.0461	1					
6	Other sources	-0.3031	0.1194	-0.056	0.0407	0.0106	1				
7	Financial system development (FSD)	-0.0786	-0.083	0.0573	-0.007	0.0519	-0.07	1			
8	Banking competition	-0.0397	0.2752	-0.084	0.078	0.0018	0.179	-0.339	1		
9	Log (GDP per capital)	-0.1331	0.0878	0.0432	0.0591	0.0884	0.06	0.5591	0.1586	1	
10	Depth of credit information	-0.0572	-0.006	-0.035	-0.033	0.016	0.028	0.6929	-0.111	0.709	1

**Table VII.**  
Correlation between  
financing sources and  
country-level control  
variables

**Table VIII.**  
Financing patterns of  
innovative firms:  
overall finance

Source of finance	Innovative		Non-innovative		Combined		t-value (diff. mean)
	Mean (SE)	SD	Mean (SE)	SD	Mean (SE)	SD	
Internal/retained earning	0.6622 (0.0092)	0.3469	0.7476 (0.0064)	0.3062	0.7146 (0.0053)	0.3251	-7.8473 (-0.085)***
Owners cont./new equity	0.0288 (0.0032)	0.1204	0.0168 (0.0019)	0.0909	0.0214 (0.0017)	0.1034	3.4524 (0.012)***
Bank finance	0.1808 (0.0079)	0.2978	0.1172 (0.0046)	0.2198	0.1418 (0.0042)	0.2546	7.4569 (0.0636)***
Finance from non-bank financial institutions	0.0252 (0.0024)	0.0899	0.0275 (0.0021)	0.0997	0.0266 (0.0016)	0.096	-0.7112 (-0.002)
Trade credit	0.0769 (0.0037)	0.139	0.0678 (0.0028)	0.1326	0.0714 (0.0022)	0.1352	1.9904 (0.0091)**
Other sources	0.0405 (0.0034)	0.1301	0.0315 (0.0024)	0.1166	0.035 (0.002)	0.1221	2.1989 (0.009)**
No obs.	1,433		2,274		3,707		

**Notes:** The classification of firms as to innovative and non-innovative is based on innovation: a narrow-based approach where an innovative firm is the one that introduced new/significantly improved products new to the market/industry in the last three years. The mean value is reported, and standard errors are presented in parentheses. The t-value of t-test for two samples is reported along with the difference in mean values (presented in parenthesis) of innovative and non-innovative firms. Equal variance is assumed in the t-test for two samples. Financing sources are measured based on their average proportion of working capital and investment financing. \*\*\*, \*\*, \* Significant at 5 and 1 percent levels, respectively

Source of finance	Innovative		Non-innovative		Combined		t-value (diff. Mean)
	Mean (SE)	SD	Mean (SE)	SD	Mean (SE)	SD	
Internal/retained earning	0.7063 (0.0063)	0.3495	0.775 (0.0035)	0.3142	0.7563 (0.0031)	0.3256	-9.9683 (-0.068)***
Bank finance	0.1252 (0.0047)	0.2592	0.0742 (0.0742)	0.189	0.0881 (0.0881)	0.2117	11.3981 (0.051)***
Finance from non-bank financial institutions	0.0223 (0.0016)	0.0886	0.015 (0.0008)	0.076	0.017 (0.0008)	0.0797	4.3034 (0.0073)***
Trade credit	0.1028 (0.0035)	0.1933	0.0914 (0.0021)	0.1903	0.0945 (0.0018)	0.1912	2.7946 (0.0114)***
Other sources	0.0434 (0.0027)	0.1484	0.0443 (0.0018)	0.1612	0.0441 (0.0015)	0.1578	-0.2883 (-0.001)
No. obs.	3,046		8,127		11,173		

**Notes:** The classification of firms as to innovative and non-innovative is based on innovation: a narrow-based approach where an innovative firm is the one that introduced new/significantly improved products new to the market/industry in the last three years. The mean value is reported, and standard errors are presented in parentheses. The t-value of t-test for two samples is reported along with the difference in mean values (presented in parenthesis) of innovative and non-innovative firms. Equal variance is assumed in the t-test for two samples. Financing sources are measured based on their average proportion of working capital financing. \*\*\*, \*\*\*, \*\*\*: Significant at 5 and 1 percent levels, respectively

**Table IX.**  
Financing patterns of  
innovative firms:  
working capital  
finance

**Table X.**  
Financing patterns of  
innovative firms:  
investment finance

Source of finance	Innovative		Non-innovative		Combined		t-value (Diff. mean)
	Mean (SE)	SD	Mean (SE)	SD	Mean (SE)	SD	
Internal/retained earning	0.6722 (0.0105)	0.3972	0.7677 (0.0076)	0.3613	0.7308 (0.0062)	0.3784	-7.5394 (-0.096)***
Owners cont./new equity finance	0.0288 (0.0032)	0.1204	0.0168 (0.0019)	0.0909	0.0214 (0.0017)	0.1034	3.4524 (0.012)***
Bank finance	0.1898 (0.0091)	0.3442	0.1147 (0.0057)	0.2723	0.1437 (0.005)	0.3043	7.3713 (0.0751)***
Finance from non-bank financial institutions	0.0269 (0.0033)	0.1255	0.0338 (0.0033)	0.1557	0.0312 (0.0024)	0.1448	-1.4199 (-0.007)
Trade credit	0.0478 (0.0039)	0.1458	0.037 (0.0028)	0.1313	0.0412 (0.0023)	0.1372	2.3173 (0.0107)**
Other sources	0.0346 (0.0037)	0.1409	0.03 (0.0029)	0.1388	0.0318 (0.0023)	0.1396	0.9720 (0.0046)
No. obs.	1,433		2,274		3,707		

**Notes:** The classification of firms as to innovative and non-innovative is based on innovation: a narrow-based approach where an innovative firm is the one that introduced new/significantly improved products new to the market/industry in the last three years. The mean value is reported, and standard errors are presented in parentheses. The t-value of t-test for two samples is reported along with the difference in mean values (presented in parenthesis) of innovative and non-innovative firms. Equal variance is assumed in the t-test for two samples. Financing sources are measured based on their average proportion for investment financing. \*\*\*, \*\*\*, \*\*\*, Significant at 5 and 1 percent levels, respectively

sources except finance from non-bank financing institutions. Innovative firms' exhibit a relatively higher proportion on the uses of new equity, bank, trade credit, and funding from other sources than non-innovative peers.

In contrast, non-innovative firms use a higher proportion of retained earnings and finance from non-bank financial institutions than innovative firms. Innovative firms used on average 6.36 percent of the bank finance more than non-innovative peers (difference in mean values is given with *t*-value in parenthesis). A statistically significant difference in the mean value of the two groups also observed in the use of trade credit and other sources of finance. Generally, the result confirms *H1* that the financial patterns of innovative firms is basically different from non-innovative firms.

Table IX presents the financing patterns of innovative and non-innovative firms for working capital finance. In this case, the full sample (11,173 firms) is used because a firm must have working capital to finance their day to day operations. The result indicates that innovative firms mostly finance working capital with internal/retained earnings followed by short-term bank finance, trade credit and other sources. The *p*-value of the *t*-test indicates that the null hypothesis the two samples have an equal mean ( $H_0$ : innovative = non-innovative) is rejected at 1 percent significance level for all financing sources except working capital financed using other sources. Thus, we can conclude that the financial patterns of innovative firms', specifically for working capital finance, are different from the non-innovative counterparts. The result provides additional evidence. First, the proportion of retained earnings to finance working capital is approximately 71 percent which is higher than the percentage in the overall finance. Second, the contribution of bank finance decrease from 18 percent for total finance (see Table IX above) to 12 percent for working capital finance. Finally, the share of trade credit in financing working capital (10.28 percent) is relatively higher compared to its share in the overall financing (7.69 percent). The result confirms *H1a* that the working capital financing patterns of innovative firms is different from non-innovative firms.

Table IX presents financing patterns of innovative and non-innovative firms for investment finance. The hierarchy of financial preference of innovative firms for working capital and investment finance is generally the same. However, there is a small difference in the degree of utilization of financing sources. The *p*-value of *t*-test indicates the null hypothesis of the two samples have equal mean for retained earnings, new equity share, bank finance and trade credit, is rejected at 1 percent significant level. Therefore, we can conclude that the investment financing patterns of innovative firms are different from non-innovative firms; hence, *H1b* is confirmed. Regarding the hierarchy of the financial instruments/sources of innovative firms, the above results commonly show a high degree of consistency with the pecking order hierarchy of financial instruments.

#### 4.3 The financial patterns of innovative firms: analysis based on firm size and age

Based on the research of Aterido *et al.* (2013), firms are classified into three categories of size and age. This section is aiming to test whether the financial growth cycle model of financing is valid in the case of innovative firms in Africa. Table XI presents the financing patterns of innovative firms based on their size groups. The hierarchy of the financial instruments/sources for all size groups (micro and small (MSEs), medium and large) is generally the same as the hierarchy observed in the previous sections. The internal/retained earnings are the first followed by bank finance, trade credit, finance from non-bank financial institutions, other sources and finally new equity finance. Due to their growth potentials, innovative MSEs have an advantage in using new equity finance. Medium-sized innovative firms have more access to bank finance than innovative large and MSEs. The use of trade credit to finance innovation increases with the increase in the size of firms. The contribution of other sources of finance such as borrowing from moneylenders, friends and relatives, is generally low but comparatively innovative MSEs use more than medium and large innovative firms.



**Table XI.**  
Financing patterns of  
innovative firms  
across size groups

Firm size	Group	Obs.	Internal/retained earnings	New equity	Bank finance	Non-bank fin. inst. finance	Trade credit	Other sources
MSEs (up to 49 employee)	Innovative	1,054	0.6672 (0.3562)	0.0374 (0.1373)	0.1610 (0.2995)	0.0283 (0.095)	0.0749 (0.1385)	0.0497 (0.1431)
	Non-Innovative	1,744	0.7601 (0.3022)	0.0191 (0.0942)	0.098 (0.2063)	0.0297 (0.1036)	0.0652 (0.1290)	0.0372 (0.1263)
	Combined	2,798	0.7251 (0.3267)	0.0260 (0.1127)	0.1217 (0.2476)	0.0292 (0.1004)	0.0688 (0.1327)	0.0419 (0.1330)
Medium (> 49 < 200 employees)	Difference in mean values		-0.0929 (-7.34)***	0.0182 (4.12)***	0.0629 (6.57)***	-0.0014 (-0.36)	0.0096 (1.86)*	0.012 (2.42)**
	Innovative	241	0.6314 (0.3324)	0.0048 (0.0442)	0.2495 (0.3007)	0.0201 (0.0811)	0.0839 (0.1399)	0.0124 (0.0596)
	Non-innovative	362	0.7143 (0.3185)	0.0099 (0.0787)	0.1643 (0.2404)	0.0241 (0.0939)	0.0772 (0.1539)	0.0148 (0.0817)
Large (200 and above employees)	Combined	603	0.6812 (0.3264)	0.0079 (0.0671)	0.1984 (0.2691)	0.0225 (0.0889)	0.0799 (0.1484)	0.0139 (0.0736)
	Difference in mean values		-0.0829 (-3.08)***	-0.005 (-0.91)	0.0852 (3.85)***	-0.0039 (-0.54)	0.0066 (0.54)	-0.0024 (-0.34)
	Innovative	138	0.6778 (0.2940)	0.0043 (0.0266)	0.2113 (0.2547)	0.0102 (0.0567)	0.0799 (0.1415)	0.0184 (0.1028)
	Non-innovative	168	0.689 (0.3084)	0.0065 (0.0774)	0.2144 (0.2639)	0.011756 (0.0610)	0.0743 (0.1176)	0.0072 (0.0489)
	Combined	306	0.68397 (0.3016)	0.0055 (0.06)	0.2130 (0.259)	0.011 (0.059)	0.0768 (0.1287)	0.0122 (0.0780)
	Difference in mean values		-0.0112 (-0.33)	-0.0022 (-0.32)	-0.003 (-0.11)	-0.0015 (-0.22)	0.0056 (0.38)	0.011 (1.25)

**Notes:** The classification of firms as to innovative and non-innovative is based on innovation: a narrow-based approach where an innovative firm is the one that introduced new/significantly improved products new to the market/industry in the last three years. The mean value is reported, and standard deviations are presented in parentheses. The *t*-value of the *t*-test for two samples is reported in parenthesis along with the difference in mean values of innovative and non-innovative firms. Equal variance is assumed in the *t*-test for two samples. Financing sources are measured based on their average proportion of working capital and investment financing. \*, \*\*, \*\*\*: Significant at 10, 5 and 1 percent levels, respectively

The result presented in Table XI provides additional evidence. First, the difference in financing patterns of innovative and non-innovative firms gradually decreases along with an increase in the firm's size and the difference disappears for large firms. For instance, for the innovative MSEs, the  $p$ -value of the  $t$ -test indicates that the hypothesis the two groups have an equal mean is rejected at 5 percent significance level for all financing sources except for finance from non-bank financial institutions and trade credit. For the medium-sized firms, this difference is statistically significant for only retained earnings and bank finance. Regarding large firms, the  $p$ -value of the  $t$ -test indicates that there is no statistically significant difference in financing patterns of innovative and non-innovative large firms.

Table XII presents the financing patterns of innovative firms across age groups. First, there is a statistically significant difference in the use of internal sources of finance between young, mature and old-innovative and non-innovative firms. However, this difference is not significant in young, mature and old-innovative firms. Second, a statistically significant difference is observed between innovative and non-innovative firms in the use of equity finance. Third, a statistically significant difference also saw in the use of bank finance between the two groups. Approximate 21 percent (young-innovative firms), 16 percent (matured-innovative firms) and 19 percent (old-innovative firms) of the total finance are obtained from the banks. Fourth, the share of finance from the non-bank financial institutions is lower but slightly increase with the increase in firm age. Nevertheless, there is no significant difference between innovative and non-innovative firms in the use of finance from a non-bank financial institution. Fifth, the use of trade credit to finance innovative activities increase along with the increase in firm age. Finally, based on the results of the above further analysis conducted on size and age groups, it is difficult to fully validate the presence of the financial growth cycle model of financing, hence  $H3$  is partially confirmed.

#### 4.4 *The effect of firms financing choice on the probability to innovate*

In this section, we try to investigate the effect of the firm's financing choice on the likelihood to innovate. Each financing source dummy is defined as one if the financing source percentage of a particular firm is higher than the median across all sampled firms of a given country. For instance, the median value of internal/retained funding is 25 percent: the corresponding dummy takes the value of 1 for all firms whose internal financing is higher than 25 percent. The use of such dummies has more explanatory value than the percentage level of each financing source (Fernandez, 2017).

Table XIII presents the result of the binary logit models estimation results. Both approaches to measuring innovativeness, innovation: broad-based and innovation: narrow-based are used. The coefficients and odds ratio are reported. In logistics regression, the odds ratio represents the constant effect of a predictor  $X$ , on the likelihood that one outcome will occur. As a result, it helps to measure the relative impact. However, the sign of the effect should be interpreted based on the sign of the coefficients of each independent variable. Odds ratio equal to 1 implies that there is no difference between the two samples of the study.

The two binary models provide the same evidence that all financing sources included in the estimation positively and significantly affect the probability to innovate. Based on the value of odds ratio, the order of effect from large to small follows the following order: owners' contribution/new equity finance, bank finance, internal/retained earnings, finance from non-bank financial institutions, and finally trade credit. For instance, the odds of being an innovative firm for a firm which uses new equity finance to finance working capital/investment above the median value is 3.3 (innovation is measured at broad-base) times higher than that of a firm used below the median value. Based on the value of the coefficient, a one-unit increase in owners' contribution/new equity financing increase the log-odds of the probability to be an innovative firm by 1.19, holding all other independent variables constant. The positive and significant effect financing sources on the probability to be an

**Table XII.**  
Financing patterns of  
innovative firms  
across age groups

Firm age	Group	Obs.	Internal/retained earnings	New equity	Bank finance	Non-bank fin. inst. finance	Trade credit	Other sources
Young (1-5 years)	Innovative	220	0.6653 (0.3982)	0.0236 (0.1243)	0.2114 (0.3721)	0.0151 (0.0668)	0.0438 (0.1179)	0.0526 (0.1687)
	Non-innovative	418	0.8131 (0.2862)	0.0045 (0.0375)	0.0877 (0.2073)	0.0199 (0.0785)	0.0477 (0.1212)	0.0294 (0.122)
	Combined	638	0.7621 (0.3362)	0.0111 (0.0795)	0.1303 (0.2814)	0.0182 (0.0747)	0.0463 (0.12)	0.0374 (0.1402)
	Difference in mean values		-0.148 (-5.34)***	0.0191 (2.91)***	0.1237 (5.39)***	-0.0048 (-0.77)	-0.0039 (-0.39)	0.0232 (1.99)**
Matured (6-15 years)	Innovative	606	0.6666 (0.3475)	0.0333 (0.1265)	0.1592 (0.2862)	0.0264 (0.093)	0.0784 (0.1396)	0.0533 (0.1454)
	Non-innovative	935	0.7534 (0.3026)	0.0224 (0.1039)	0.0988 (0.2019)	0.0283 (0.0987)	0.0687 (0.1299)	0.0386 (0.1278)
	Combined	1,541	0.719 (0.3238)	0.0267 (0.1134)	0.1231 (0.2403)	0.0276 (0.0964)	0.0725 (0.1339)	0.0444 (0.1351)
	Difference in mean values		-0.087 (-5.22)***	0.0109 (1.84)*	0.0594 (4.77)***	-0.0019 (-0.39)	0.0097 (1.38)	0.0148 (2.1)**
Old (more than 15 years)	Innovative	607	0.6573 (0.3262)	0.0262 (0.1124)	0.1912 (0.2770)	0.0278 (0.0939)	0.0874 (0.1438)	0.0232 (0.0899)
	Non-innovative	921	0.7119 (0.3134)	0.0166 (0.0934)	0.1482 (0.2382)	0.0302 (0.1089)	0.0761 (0.1392)	0.0252 (0.1009)
	Combined	1,528	0.6902 (0.3196)	0.0204 (0.1014)	0.1653 (0.2551)	0.0292 (0.1031)	0.0806 (0.1411)	0.0244 (0.0966)
	Difference in mean values		-0.055 (-3.28)***	0.0096 (1.81)*	0.043 (3.23)***	-0.0024 (-0.45)	0.0113 (1.54)	-0.002 (-0.39)

**Notes:** The classification of firms as to innovative and non-innovative is based on innovation: a narrow-based approach where an innovative firm is the one that introduced new/significantly improved products new to the market/industry in the last three years. The mean value is reported, and standard deviations are presented in parentheses. The *t*-value of the *t*-test for two samples is reported in parenthesis along with the difference in mean values of innovative and non-innovative firms. Equal variance is assumed in the *t*-test for two samples. Financing sources are measured based on their average proportion of working capital and investment financing. \*\*\*, \*\*, \* Significant at 10, 5 and 1 percent levels, respectively

Variables	Innovation: broad base		Innovation: narrow-base	
	Coefficients	Odds ratio	Coefficients	Odds ratio
Internal/retained earnings	0.392 (0.0941)***	1.48 (0.1392)***	0.2684 (0.1041)***	1.3078 (0.1361)***
New equity finance	1.1826 (0.1545)***	3.2628 (0.504)***	0.413 (0.0713)***	1.511 (0.1078)***
Bank finance	0.5417 (0.0962)***	1.7018 (0.1636)***	0.4006 (0.087)***	1.492 (0.1298)***
Finance from non-bank financial institution	0.4289 (0.0939)***	1.5202 (0.1428)***	0.2118 (0.0939)**	1.2359 (0.1161)**
Trade credit	0.3103 (0.1297)**	1.3605 (0.1758)**	0.1716 (0.1223)*	1.1872 (0.1452)*
Other sources of finance	0.2104 (0.1376)*	1.2341 (0.1698)*	-0.061 (0.1246)*	0.9405 (0.1172)*
Log (size)	0.4475 (0.089)***	1.5334 (0.138)***	0.329 (0.0572)***	1.390 (0.0796)***
Log (age)	0.1543 (0.0916)*	1.1668 (0.1068)*	0.0788 (0.1042)	1.082 (0.1127)
Sales growth	0.3671 (0.0724)***	1.4435 (0.1045)***	0.276 (0.0671)***	1.317 (0.0884)***
Foreign-owned	0.1291 (0.0899)*	1.1378 (0.1022)*	0.1611 (0.0942)*	1.1748 (0.1107)*
Government-owned	-0.336 (0.1431)**	0.7143 (0.1022)**	-0.245 (0.1034)*	0.7824 (0.0809)*
Part of large firm	0.1949 (0.0719)***	1.214 (0.0873)***	0.1438 (0.0658)**	1.1547 (0.076)**
Export	0.3008 (0.0864)***	1.3509 (0.1167)***	0.214 (0.0699)***	1.239 (0.0866)***
Manager-female	0.0446 (0.0561)	1.0456 (0.0587)	0.192 (0.0807)**	1.2117 (0.0977)**
Log (experience)	0.0561 (0.0956)	1.0577 (0.1003)	0.133 (0.0833)	1.1423 (0.0952)
Audited	0.4119 (0.0716)***	1.5097 (0.108)***	0.2592 (0.1044)**	1.2959 (0.1352)**
Financial system development (FSD)	-5.41 (0.1425)***	0.0045 (0.0006)***	-3.59 (0.1059)***	0.027 (0.0029)***
Banking competition	-304 (83.86)***	9.80 (8.20)***	-381 (79.875)***	3.60 (2.90)***
Log (GDP per capital)	2.458 (0.0966)***	11.681 (1.1284)***	1.232 (0.1048)***	3.429 (0.3594)***
Depth of credit information	-0.14 (0.0136)***	0.8691 (0.0118)***	-0.152 (0.0089)***	0.8587 (0.0077)***
Constant	-6.455 (0.2893)***	0.0016 (0.0004)***	-4.386 (0.3209)***	0.0124 (0.0034)***
Industry FE	Yes		Yes	
Country FE	Yes		Yes	
Time-dummy	yes		yes	
$p$ -value $\chi^2$	0.000		0.000	
Pseudo $R^2$	0.1458		0.0915	
Log pseudo likelihood	-6583.45			
No. obs.	11,173		11,173	
Number of clusters	28		28	

**Notes:** Definitions of variables are reported in Table III. The dependent variable “innovation” is a binary variable take value = 1 if a firm introduced a new or significantly improved product which is new to the market/industry during the last three years (innovation: narrow-base). In the case of innovation: broad-based, the binary dependent variable takes value = 1, if a firm spends a non-zero amount in R&D, or introduced a new or significantly improved product or process during the last three years, take value = 0, otherwise. Robust standard errors are presented in parentheses and adjusted for clustering at country-level. \*, \*\*, \*\*\*Significant at 10, 5 and 1 percent levels, respectively

**Table XIII.**  
Effect of the firm's financing choice on the probability to innovate

innovative firm is in line with the theoretical argument that access to finance increases the probability of a firm's to engage in innovative activities (Hall, 1992, 2002; Hall and Lerner, 2010; Kerr and Nanda, 2015).

Most of the firm-level control variables, such as firm size, sales growth, ownership, exportation, accounting and auditing practice, being a part of a large group are also found relevant factors for firm's probability to innovate. For instance, the odds of being an innovative firm increased by 1.5 (innovation: broad-based), and 1.4 (innovation: narrow-base) when log-size increased by 1 unit.

#### 4.5 Specification robustness test

Our sample contains a large number of firms from 28 African countries. The surveys for these countries were conducted during different periods. Therefore, we should check the robustness of the major result obtained from the previous analysis. First, we divide the sampled firms based on

the years the survey made and conduct a *t*-test to investigate whether innovative firms exhibit financing patterns different from non-innovative peers across survey waves. The result is presented in Table XIV. The result indicates that the contribution of financing source to the total finance of innovative firms has a small difference across survey waves. Second, we divide the sampled countries into four sub-regions of Africa (East, North, Southern and West). For instance, bank finance contributes by 32 percent of the total finance of innovative firms in Southern Africa whereas, it provides approximately 9 percent of the total finance of innovative firms in West Africa. In Eastern Africa, firms did not use external equity to finance innovation activities. In North Africa, the role of trade credit in financing innovative activities is relatively higher than in other regions. Generally, the major finding is that innovative firms exhibit financing patterns different from non-innovative peers remain unchanged (see Table XV). Finally, the result presented in section 4.3 shows that the statistical and significant difference in financing patterns between innovative and non-innovative firms is mainly observed for MSEs and medium-size firms but not for large firms. This indicates that we should investigate whether the financing sources have, also, a different effect on the probability to innovate for MSEs, medium and large firms. Therefore, we estimate Equation (2d) (see section 3.2) to investigate the effect of MSEs, medium and large firms' financing choices on their probability to innovate. The result is presented in Table XVI. The results show that firms (MSEs, medium and large) that have internal capacities and access to external finance such as finance from the banks and non-bank financial institutions, trade creditor, and other sources above the median value are more likely to innovate. Thus, our result is robust under different specifications.

## 5. Discussions

The results of the hypotheses formulated at the beginning of the study are summarized in Table XVII. Afterward, the results are explained in detail.

The results show a homogeneous picture that innovative firms' exhibit financing patterns different from non-innovative firms. Hence, *H1* postulated as "The financial patterns of innovative firms are basically different from non-innovative" can generally be regarded as confirmed. Our further analysis dividing overall finance into working capital and investment finance also confirms the existence of a significant difference in financing patterns of innovative and non-innovative firms for both working capital and investment financing. Thus, *H1a* and *H1b* are confirmed.

Concerning the hierarchy of financing instruments of innovative firms at the beginnings of the paper we postulated *H2* as "with respect to the hierarchy of financing instruments in innovative firms, internal funds have the highest importance, followed by debt finance (short, middle and long-term) and finally external equity." The result shows that innovation in Africa is mostly financed using internal/retained earnings finance followed by bank finance, trade credit, finance from non-bank financial sectors and other sources. Therefore, the presence of pecking order style of financing is evidenced in the case of innovative firms in Africa and *H2* is thus confirmed.

Furthermore, our thorough analysis based on different specifications provides many additional interesting results. First, the difference in financing patterns of innovative and non-innovative firms gradually decreases and finally disappears along with an increase in the firm size. For instance, in case of MSEs, the differences between the two groups are statistically significant for all financing sources whereas, for medium-sized firms, retained earnings and bank finance remain statistically significant (see Table XI). Second, the difference in financing patterns of innovative and non-innovative firms is more or less observed across all age groups (young, mature and old).

The above general findings are similar to most empirical studies (Bozkaya and De La Potterie, 2008; Hummel *et al.*, 2013; Serrasqueiro *et al.*, 2016). The findings are also consistent with previous studies conducted in developing countries. For instance, Fernandez

Source of finance	The survey year 2013 <sup>a</sup>		The survey year 2014 <sup>b</sup>		The survey year 2016 <sup>c</sup>	
	Innovative	Non-innovative	Innovative	Non-innovative	Innovative	Non-innovative
Internal/retained earning	0.7052 (0.3118)	0.7618 (0.3013)	0.5713 (0.3877)	0.719 (0.3194)	0.704 (0.271)	0.752 (0.297)
Owners cont./new equity	0.001 (0.0001)	0.0004 (0.0147)	0.0727 (0.1829)	0.0573 (0.1619)	0.0002 (0.0033)	0.0011 (0.0125)
Bank finance	0.1637 (0.2507)	0.1154 (0.2172)	0.2101 (0.3606)	0.0905 (0.2)	0.1553 (0.2343)	0.121 (0.2448)
Finance from non-bank financial institutions	0.0211 (0.0847)	0.0302 (0.1085)	0.0326 (0.0942)	0.0227 (0.0719)	0.0184 (0.0924)	0.0277 (0.1096)
Trade credit	0.0833 (0.1426)	0.0774 (0.1431)	0.082 (0.1381)	0.0691 (0.1139)	0.0458 (0.1268)	0.0331 (0.1269)
Other sources	0.0268 (0.112)	0.015 (0.080)	0.0676 (0.1601)	0.0701 (0.1683)	0.0109 (0.0647)	0.0187 (0.0895)
No. obs.	643	1,151	567	648	223	475

**Notes:** The classification of firms as to innovative and non-innovative is based on innovation: a narrow-based approach where an innovative firm is the one that introduced new/significantly improved products new to the market/industry in the last three years. The mean value is reported, and standard deviations are presented in parentheses. The *t*-value of the *t*-test for two samples is reported in parenthesis along with the difference in mean values of innovative and non-innovative firms. Equal variance is assumed in the *t*-test for two samples. Financing sources are measured based on their average proportion of working capital and investment financing.  
<sup>a</sup>Countries survey in 2013 (Djibouti, DR Congo, Egypt, Ghana, Kenya, Morocco, Tanzania, Tunisia, Uganda and Zambia); <sup>b</sup>Countries survey in 2014 (Burundi, Malawi, Mauritania, Namibia, Nigeria, Senegal, South Sudan and Sudan); <sup>c</sup>Countries survey in 2016 (Benin, Cameroon, Cote d'Ivoire, Guinea, Lesotho, Mali, Swaziland, Togo and Zimbabwe). Although WBES for Ethiopia is 2015 because Ethiopia is the only country surveyed in 2015, we include to 2016 survey waves for the analysis.  
 \*\*\*, \*\*, \* Significant at 10, 5 and 1 percent levels, respectively

**Table XIV.**  
Financing patterns of  
innovative firms:  
based on survey  
waves



**Table XV.**  
Financing patterns of  
innovative firms:  
across sub-regions of  
Africa

Source of finance	East African <sup>a</sup>			North African <sup>b</sup>			South African <sup>c</sup>			West African <sup>d</sup>		
	Innovative	Non- innovative	Difference	Innovative	Non- innovative	Difference	Innovative	Non- innovative	Difference	Innovative	Non- innovative	Difference
Internal/retained earning	0.6962 (0.3107)	0.7834 (0.2885)	-0.0872 (-4.57)***	0.6837 (0.3086)	0.7388 (0.3082)	-0.0551 (-2.2)**	0.5976 (0.4288)	0.7894 (0.2945)	-0.1918 (-7.3)***	0.669 (0.3203)	0.6991 (0.3188)	-0.029 (1.54)*
Owners cont./new equity	NA	NA	NA	NA	0.0009 (0.0215)	-0.0009 (-0.62)	0.0001 (0.0027)	0.0012 (0.0132)	-0.0011 (-1.48)*	0.0881 (0.1979)	0.0523 (0.1555)	0.0358 (3.46)***
Bank finance	0.1947 (0.252)	0.128 (0.2326)	0.0667 (4.32)***	0.139 (0.25)	0.1166 (0.2156)	0.022 (1.22)	0.3241 (0.4299)	0.1187 (0.2366)	0.2054 (8.4)***	0.0826 (0.1637)	0.1076 (0.2005)	-0.025 (-2.26)**
Finance from non-bank financial institutions	0.0143 (0.0723)	0.0146 (0.0723)	-0.0002 (-0.059)	0.0296 (0.1067)	0.0487 (0.1396)	-0.0191 (1.8)*	0.0132 (0.0642)	0.0109 (0.0584)	0.0023 (0.53)	0.0417 (0.1075)	0.0323 (0.0996)	0.0094 (1.54)*
Trade credit	0.0766 (0.1345)	0.0562 (0.1225)	0.0203 (2.49)***	0.1212 (0.1723)	0.0823 (0.145)	0.038 (3.12)***	0.0377 (0.1168)	0.0452 (0.1138)	-0.0074 (-0.89)	0.0859 (0.134)	0.0802 (0.1386)	0.0057 (0.71)
Other sources	0.0183 (0.1066)	0.0177 (0.0874)	0.0006 (0.09)	0.0265 (0.1107)	0.0132 (0.0903)	0.013 (1.7)*	0.0273 (0.1087)	0.0353 (0.1217)	-0.008 (-0.95)	0.076 (0.1608)	0.0547 (0.1454)	0.0213 (2.36)**
No. obs.	412	597		211	542		342	425		468	710	

**Notes:** The classification of firms as to innovative and non-innovative is based on innovation: a narrow-based approach where an innovative firm is the one that introduced new/significantly improved products new to the market/industry in the last three years. The mean value is reported, and standard deviations are presented in parentheses. The *t*-value of the *t*-test for two samples is reported in parenthesis along with the difference in mean values of innovative and non-innovative firms. Equal variance is assumed in the *t*-test for two samples. Financing sources are measured based on their average proportion of working capital and investment financing. NA denotes no observation, or no firm uses that sources of finance in the region. <sup>a</sup>East African countries are Burundi, Djibouti, Ethiopia, Kenya, Tanzania, South Sudan and Uganda; <sup>b</sup>North African countries are Egypt, Morocco, Sudan and Tunisia; <sup>c</sup>Southern African countries are D.R. Congo, Lesotho, Malawi, Namibia, Swaziland, Zambia and Zimbabwe; <sup>d</sup>West African countries are Benin, Cameroon, Cote d'Ivoire, Ghana, Guinea, Mali, Mauritania, Nigeria, Senegal and Togo. \*, \*\*, \*\*\*Significant at 10, 5 and 1 percent levels, respectively

Variables	MSEs up to 49 permanent employees Odds ratio	Medium 50–199 permanent employees Odds ratio	Large > 199 permanent employees Odds ratio
Internal/retained earnings	1.4329 (0.1292)***	1.8999 (0.4238)***	2.2191 (0.577)***
New equity finance	3.4829 (0.4845)***	1.051 (0.5621)	1.018 (0.293)***
Bank finance	1.5851 (0.1717)***	2.48 (0.424)***	3.5884 (1.2988)***
Finance from non-bank financial institution	1.4644 (0.1573)***	2.043 (0.594)**	0.8407 (0.4439)
Trade credit	1.432 (0.1709)***	1.1282 (0.2977)	0.9811 (0.2349)
Other sources of finance	1.178 (0.1628)	1.6225 (0.333)**	1.5066 (1.1919)
Log (age)	1.1938 (0.1117)**	1.5826 (0.3117)**	0.8126 (0.2498)
Sales growth	1.4405 (0.0896)***	1.8515 (0.6495)*	3.3139 (1.9257)**
Foreign-owned	1.1395 (0.0796)	1.0822 (0.2282)	2.0512 (0.5238)***
Government-owned	0.6206 (0.1085)**	0.8766 (0.2579)	0.9391 (0.4291)
Part of large firm	1.2599 (0.0925)***	1.2722 (0.2592)	0.9875 (0.2145)
Export	1.5688 (0.1655)***	1.1199 (0.1607)	2.1182 (0.3945)***
Manager-female	1.0053 (0.0705)	1.2628 (0.203)	1.0829 (0.8296)
Log (experience)	1.0109 (0.0903)	1.5262 (0.3549)*	0.7113 (0.5172)
Audited	1.6045 (0.1116)***	1.718 (0.4224)**	1.3475 (0.5865)
Financial system development (FSD)	0.0053 (0.0006)***	0.0007 (0.0002)***	0.0041 (0.0023)***
Banking competition	1.33 (1.66)***	0.0002 (0.0004)	0.002 (0.0001)***
Log (GDP per capital)	12.91 (1.3241)***	28.142 (10.055)***	7.0955 (2.7828)***
Depth of credit information	0.879 (0.0094)***	0.6284 (0.0216)***	0.9025 (0.0674)
Constant	0.0018 (0.0005)***	0.0004 (0.0004)***	0.0165 (0.0327)***
Industry FE	Yes	Yes	Yes
Country FE	Yes	Yes	Yes
Time-dummy	Yes	Yes	Yes
$p$ -value $\chi^2$	0.0000	0.0000	0.0000
Pseudo $R^2$	0.1389	0.2088	0.1833
Log pseudo likelihood	-5,458.26	-759.22	-277.92
No. obs.	9,166	1,418	516
Number of clusters	28	25	20

**Table XVI.**  
Effect of financing  
sources on firms  
probability to  
innovate: based on  
firms size group

**Notes:** Definitions of variables are reported in Table III. The binary dependent variable “innovation” is measured based on innovation: broad-based, takes value = 1, if a firm spends a non-zero amount in R&D or introduced a new or significantly improved product or process during the last three years, take value = 0, otherwise. Robust standard errors are presented in parentheses and adjusted for clustering at country-level. \*, \*\*, \*\*\*Significant at 10, 5 and 1 percent levels, respectively

(2017) in Latin American countries and Barona *et al.* (2015) in Colombia find evidence that innovative firms exhibit financing patterns different from non-innovative peers. Also, their studies show that internal and bank finance is the primary sources of firms to finance innovation.

Innovative firms and projects have unique characteristics: intangibility, uncertain return, moral hazard and high information asymmetry problem that directly affect their choice of a particular financing instrument and access to the external source of finance (Hall and Lerner, 2010; Hall, 1992, 2002; Kerr and Nanda, 2015). This may be one possible reason why the innovative firms show a relatively low proportion of internal/retained earnings finance usage compared to the non-innovative counterparts, yet the internal finance covers 66 percent of the total finances of innovative firms.

In the African case, banks should be the first option for borrowers if the sector dominates the financial system. In this regard, our result cements the fact that bank finance is the most important external source to finance innovation. Approximately, 19 percent of total finance of innovative firms is from bank finance. However, the contribution can be generally regarded as

**Table XVII.**  
Hypothesis and  
results

No.	Derived hypotheses	Results
<i>H1</i>	The financing patterns of innovative firms are basically different from non-innovative firms	Confirmed
<i>H1a</i>	The working capital financing pattern of innovative firms is basically different from non-innovative firms	Confirmed
<i>H1b</i>	The investment financing pattern of innovative firms is basically different from non-innovative firms	Confirmed
<i>H2</i>	With respect to the hierarchy of financing instruments in innovative companies, internal funds have the highest importance, followed by debt finance (short, middle and long) and finally external equity	Confirmed
<i>H3</i>	Innovative firms take advantage of growth potential; as a result, there is a corresponding gain in the importance of internal funding, external equity, trade credit and other credit substitutes than non-innovative firms. At the same time medium to long-term bank financing loses its importance	Partially confirmed
<i>H4</i>	Firms that have internal financing capacity and access to external finance, such as bank finance, finance from non-bank financial institutions, trade credit and other sources above the median value are more likely to innovate	Confirmed

low compared to the sector's overall contribution to the credit market in the region. Banks provide more than 75 percent of the external finances of firms in Africa (Fowowe, 2017). This may be because innovative firms enjoy their growth advantage to attract external creditors (Hummel *et al.*, 2013; Berger and Udell, 1995, 1998). It also helps to alleviate bank credit rationing due to asymmetric information (Biais and Gollier, 1997) and mitigates discriminatory effects caused by a restrictive monetary policy (Saito and Bandeira, 2010), especially for SMEs and young firms during monetary contraction (Biais and Gollier, 1997). Finally, innovative firms use less finance from non-bank financial institutions. This may be due to the following reasons: because non-bank financial institutions (microfinance institutions, credit cooperatives, credit unions or finance companies) take a tiny share of the financial system, because they usually did not finance high-risk projects; instead they focus on funding individual/household and formation of micro-businesses.

Regarding hypothesis *H4*, "firms that have internal financing capacity and access to external finance such as finance from banks and non-bank financial institutions, trade credit, and other sources above the median value are more likely to innovate"; the result of logistics regression shows a clear confirmation of this hypothesis. Interestingly, the proportionate share of equity finance from the total finance of innovative firms is approximately 3 percent, but the effect of this financing source on firm's probability to innovate is the highest among all other financing sources. The major effect of bank finance can be explained as follows: the strict credit evaluation system limits them to grant only successful innovative projects, the consistent follow-ups during post-loan granting which highlights borrowers' ability to complete innovative projects successfully.

Finally, the result of firm-specific control variables included in the estimation is in line with the theoretical foundations and findings of most empirical studies. For instance, several studies conducted in specific developing economy such as Abdu and Jibir (2017) in Nigeria, El Elj (2012) in Tunisia and Goedhuys (2007) in Tanzania find similar evidence that firm size, ownership status, export status and being a part of a large firm affects a firm's probability to innovate. According to these findings, previous studies conducted in developing regions such as Alleyne *et al.* (2017) in Caribbean Fernandez (2017) in Latin American countries show similar results.

## 6. Conclusion

Economic theories have not yet produced a thorough understanding of the link between innovation performance of firms' and their funding sources that are key for an innovative

enterprise to succeed. Besides, it is not clear whether innovative firms' exhibit financing patterns different from non-innovative ones, especially in the developing countries. Recently, Grilli *et al.* (2017) strongly recommended the need to study and assess the quantitative and qualitative evolution of funding dedicated to innovation and industrial R&D. By utilizing a survey of 11,173 firms from 28 African countries, this paper investigates whether innovative firms' exhibit financing patterns different from non-innovative peers and the effect of financing sources on firms' probability to innovate. As a result, the validity of the pecking order theory and the financial growth cycle model is tested.

The results show a homogeneous picture that innovative firms' exhibit financing patterns different from non-innovative firms. Further analysis conducted involved splitting the overall finance to working capital and investment finance which confirms this difference in financing patterns of the two groups. About the hierarchy of financing instruments of innovative firms, innovation in Africa is mostly financed using internal/retained earnings finance, followed by bank finance, trade credit, credit from non-bank financial sectors and other sources including moneylenders, friends, relatives and bonds.

We obtain the following additional results: first, the difference in financing patterns of innovative and non-innovative firms gradually decreases along with an increase in the firm's size and the difference disappears for large firms. For instance, in the case of MSEs, the differences between the two groups are statically significant for almost all financing sources, while only retained earnings and bank finance remain statistically significant in case of medium-sized firms. Therefore, it can be precisely concluded that the financing patterns of innovative and non-innovative firms are different from non-innovative firms specifically, for MSEs and medium-sized firms. Second, age-based separate analysis generally provides the same result as the baseline result.

This study has several limitations that open avenues for future research. The first limitation revolves around the lack of data relating to government funding support for innovation and R&D activities and venture capital financing. There is a high probability that government subsidies and financial support are important sources of financing innovation. The second limitation goes to the cross-sectional nature of the data.

### 6.1 Managerial implications

The result indicates that the hierarchy of financial instruments of innovative firms and their implication on firms' probability to innovate is somewhat complicated. For instance, equity finance is at the bottom in the financial hierarchy but has the largest effect on firms' probability to innovate. Similarly, the retained earnings are on the top of hierarchy but have a lesser effect than equity and bank finance on the firm's probability to innovate. Trade credit finance also takes a higher rank in the financial hierarchy next to retained earnings and bank finance, but among all financial instruments, it is the one with the least effect on the probability to innovate. The management can improve the innovation performance of their company by reducing their dependency on short-term financing and retained earning financing, and increase the use of long-term instruments, such as equity finance and a long-term bank loan. In doing this, improving the quality of the information and the use of professional management tools may help them convey the strategy to practice and can encourage investors to make a long-term capital investment.

### 6.2 Social implications

Our finding indicates that external sources of finance mainly bank finance is an important driver of innovation. However, compared to its dominance in the financial sector in the region, banks are not providing adequate funding to the innovation process. Therefore, it is essential to consider the type of financial structure that supports the innovation process. The regulation of financial systems, particularly banking sectors must go hand in hand with policies that are

aimed at innovation and industrial development. As underdevelopment of financial and banking industries is particularly acute in Africa, design and evaluation of reforms to reduce the adverse effects of financial frictions on productivity and innovation are needed. The financial frictions are particularly detrimental to small or young firms, hence, policies aimed at helping these types of firms are likely to have the biggest effect, e.g. a policy to create a strong banking sector that is willing to provide access to external financing for a broad range of firms, particularly for small and/or young firms. In addition to the development of other mechanisms that would facilitate the use of bank loans, other additional measures such as leverage private capital fund, the increase of public resources directed toward stimulating the innovative activity of businesses may be important mechanisms.

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