Cogent Economics & Finance

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/oaef20

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To cite this article: Sheng Xu, Michael Asiedu & Gabriel Kyeremeh | (2021) Firm productivity, innovation, and financial development, Cogent Economics & Finance, 9:1, 1976359, DOI: 10.1080/23322039.2021.1976359

To link to this article: https://doi.org/10.1080/23322039.2021.1976359

Published online: 21 Sep 2021.

Xu et al., *Cogent Economics & Finance* (2021), 9: 1976359
https://doi.org/10.1080/23322039.2021.1976359

cogent economics & finance

FINANCIAL ECONOMICS | RESEARCH ARTICLE

Firm productivity, innovation, and financial development

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Received: 14 March 2021
Accepted: 31 August 2021

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Reviewing editor:
David McMillan, University of Stirling, Stirling, United Kingdom

Additional information is available at the end of the article

Abstract: This study utilizes firm-level data from the World Bank's Enterprise Survey Indicator Database, conducted between 2009 and 2018 for 32 countries in Africa, to examine the causal relationship between firm productivity, innovation, and financial development. We show evidence that firm innovation significantly and positively affects firm productivity. We also show the mediating role of well-developed financial markets on productivity. In a well-developed financial market, the impact of firm innovation is significant through the facilitation and financing of innovation activities; and innovative firms to boost productivity and lower production costs. These findings are significant for countries in Africa (and other less-developed countries) who spend less on R&D but can adopt or imitate existing innovative ideas from technology-rich countries for accelerated economic growth and increased productivity.

Subjects: Corporate Finance; Banking; Credit & Credit Institutions; Investment & Securities;

Keywords: Firm innovation; financial development; productivity; new technology; new product

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The author of this article is currently a student (Ph.D. - finance) at Zhongnan University of Economics and Law in Wuhan – China. My research interest focuses on inclusive finance and income inequality, firm innovation and productivity (growth theories), financial markets and asset pricing, and monetary policy in developing and emerging economies. This study is closely related to the broader scope of the authors' research interest area as it focuses on how access to credit and robust financial systems can facilitate the synergies between firm productivity and innovation. This study also highlights the importance of a liberalized financial system in developing countries for improved productivity and economic growth by financing firm innovation activities and research and development.

PUBLIC INTEREST STATEMENT

In countries where economic growth is persistently low and nonperforming loans are high, a policy is required to direct the scarce resources in the financial sector to innovative firms. Innovative firms are firms with significantly new products or significantly new technology for production. In this study, we show evidence that firm innovation significantly and positively affects firm productivity. We also show the mediating roles of a well-developed and liberalized financial market on firm productivity. In a well-developed financial market, the impact of firm innovation is significant through the facilitation and financing of innovation activities; and innovative firms to boost productivity and lower production costs. Targeting and financing innovative firms will accelerate economic growth and reduce the size of nonperforming loans in Africa. These findings are very important for countries in Africa (and other less-developed countries) who spend less on R&D but can adopt or imitate existing innovative ideas from technology-rich countries for accelerated economic growth and increased productivity.

1. Introduction

Explanations for the persistent and significant variations in productivity (output per work) across countries have remained a lacuna among economists for years. The assertion that such significant differences in production across countries are mainly due to the investment rate variations has now been primarily aborted. However, (R. E. Hall & Jones, 1999) suggest that total factor productivity (TFP) rather than capital accumulation explains the observed per capita income differences. Obstacles to innovation and adoption are severe to the extent that developing countries adopt arrangements for which the equilibrium outcomes are known to be inferior technologies and inefficiently used (Parente & Prescott, 1999). Weak institutions are the cause of low TFP in poorer countries (Acemoglu & Johnson, 2005). The current global pandemic (Covid-19), the not long ago global financial crisis, and the accompanying uncertainty have boosted global growth concerns but primarily poor and less developed countries in Africa. Similarly, the growth prospects of countries with low TFP remains bleak, even beyond the conclusion of this crisis.

If economic growth is TFP driven, its determinants such as history, geography, and institutional quality will be critical to all economies' economic prospects, especially poor or developing countries. Even though they may be fixed or slow-moving, the rate at which policy can influence these conditions is limited. Conversely, other determinants, such as the degree of financial deepening, can respond to foreign and domestic forces. If this is true, then TFP is not a consequence of a country's endowment or geographical location but a direct and concerted action and influences of economic agents on policies.

An in-depth effort towards research and development can result in entirely new products and processes, thereby moving the global technological frontier but mainly occurs in developed countries. Innovation may consist of adopting and applying existing technology, which reduces the gap between countries advancing towards the international technological frontier while those on the leading edge are also pushing the world frontier. Innovation reveals a strong relationship with the provision of financial services. The adoption and invention of technology are expensive and risky activities, which need financing. Therefore, it is natural and significant to study the impact of a country's financial development on productivity and TFP via the innovation channel.

This study focuses on Africa's firm innovation and financing constraints for two fundamental reasons; low investment in research and development and their repressed financial systems. While capital formation is deficient among African countries, there is also very little investment in research and development in the public and private sectors. For instance, (Kyobutungi et al., 2021) identified that research and development spending in Africa only constitutes 0.42% of GDP against the global average of 1.7%, while monetary credit to the private sector as a percentage GDP in 2020 was only 27.9%. This study seeks to initiate a new paradigm shift from the private sector being held as the engine of growth to find credible evidence that supports the argument that innovation is the critical driver of growth. We also seek to find evidence for financing firm innovation through a robust financial system. This study is also significantly different and adds to the existing literature on the nexus between firm innovation, financing, and productivity in Africa because it examines all the innovation indicators as defined in the World Bank Enterprise Survey data. The study also creates an innovation variable (average innovation) to overcome the problem of endogeneity.

According to the Enterprise survey data, firm innovation is defined as any of the ten innovation benchmarks, including firms adapting existing technology. We establish that firms that adopted or introduced any of the ten innovation benchmarks in the survey data are more productive than their counterparts. We also found that productive firms are small and medium, exporters firms, privately owned, and firms with higher capacity utilization. These results remained robust using various measures of innovation, productivity, such as output per worker, and total factor productivity (TFP) measure and without Nigeria and Egypt. We also overcome the problem of reverse causality by instrumenting for firm-level innovation.

We examined the effects of financial development on the relationship between innovation, productivity, and TFP. The capital-intensive nature of innovative activities tends to require outside and large financing sources; we anticipate innovation to be positively associated in countries with a relatively more developed financial system. However, we are also looking for evidence supporting the claim that financial sector development increases innovation activity effectiveness. The central intuition behind this causal link relies on the financial system's ability to allocate capital optimally.

Good innovation projects are more likely to be funded than bad ones in a country with a well-developed financial sector. In other words, robust financial systems "select" the projects or firms with the highest underlying productivity. Such a competitive market-based selection process indicates that innovation activities are more effective in countries with a high financial development level. We estimate the causal link between firm productivity and innovation by including an interaction term between financial sector development and firms' innovative activity in regression to test this hypothesis. The results show that firm innovation has a positive and significant impact on productivity in financially developed countries. Our results are robust to the firm, industry, country-level controls, varying productivity, innovation, and financial sector development measures.

In summary, the findings suggest that innovation is significant for firm performance, and its effect on productivity is mediated through the financial sector.

2. Literature review and hypothesis statement

Theory and evidence suggest that well-developed financial systems facilitate firm financing, which represents one of the ways through which financial development stimulates economic growth (Levine, 2005). (Beck et al., 2000) identified that financial intermediaries significantly and positively impacted total factor productivity growth. (Levine, 2005) argue that countries with weak contract enforcement are mostly characterized by the application of inefficient technologies, low aggregate total factor productivity (TFP), large variation in labor productivity across industries, and large employment shares in industries with low productivity. A related study (D'Erasmo & Moscoso Boedo, 2012) predicted that countries with the poor ability of debt enforcement and high costs of formality witness poor allocative efficiency and large output shares produced by low productivity among informal sector firms. They also predicted a 25% drop in total factor productivity due to constraints of doing business relative to the US. (Moll, 2014) argued that even if financial frictions are unimportant in the long run, they tend to matter in the short run, and analyzing steady-states only can be misleading on examining the effect of financial frictions on capital misallocation and aggregate productivity. (R. E. R. E. Hall & Jones, 1999) identified that the variations in capital accumulation, productivity and output per worker are driven by variations in institutions and government policies, all termed as social infrastructure. Therefore differences in physical capital and educational attainment can only partially account for the differences in output per worker. Evidence shows that variations in physical capital and intangible capital cannot explain the large differences in incomes worldwide, but variations in savings rates are of little significance (Prescott, 1998). Instead, what is significant is total factor productivity (TFP). While several studies have predicted positive relationships between financial sector development and economic growth, (Rajan & Zingales, 1996) identified that financial development reduces the cost of external firm financing. (Verdier et al., 2010) show that innovation is critical for firm performance and augments firm productivity. They also established the mediating roles of the financial system on firm productivity. Such that in a well-established financial system, firms maximize the full impact of the innovation activities. (Van Ark, 2004) identified the main driver of TFP of the firm as R&D capital, ICT capital, Human capital, and organizational capital. Accordingly, these factors are core to the performance of the firm reflected in assets or financial structure. (Kancs & Siliverstovs, 2016), found a non-linear relationship between R&D expenditure and firm productivity in firm-level data for OECD countries. (Ugur et al., 2016) also reported that the impact of R&D on productivity is much smaller and heterogeneous than indicated in the previous literature. (Ferrando & Ruggieri, 2018) found a negative elasticity coefficient of −18% in Euro-Area countries between 1995 and

2011 between total factor productivity (TFP) and financial constraint. The effect increases significantly in small, young, and private firms over time. In a sample of 130,840 manufacturing Chinese firms between 2001 and 2007, (Chen & Guariglia, 2013) observed that firm productivity is severely influenced by financial constrains especially for illiquid foreign and private firms. In addition, foreign non-exporter firms exhibit greater dependence of productivity on cash flow than exporters. (Bournakis & Mallick, 2018) also reported the adverse effects of corporate tax on TFP in a sample of 7400 manufacturing firms in UK from 2004 to 2011. High rates of corporate taxes negatively affects productivity growth through R&D activities (B. B. Hall & Van Reenen, 2000) and on the cost of capital (Devereux & Griffith, 2003).

Studies on NGOs' impact on developing the Global Reporting Initiative (GRI), including (Sisaye, 2021), show that sustainability accounting rulemaking has evolved, leading to several accounting reporting standards. The standards have improved the extent and boundaries of environmental and socio-economic performances that businesses disclose in the Global Reporting Initiative (GRI). (Alareeni & Hamdan, 2020) show that environmental, social, and governance (ESG) disclosure are positively associated with firm performance among listed US and S&P 500 companies. They further found that the effect of environmental, social, and governance (ESG) measures, corporate social responsibility (CSR), environmental (EVN), and corporate governance (CG) is higher for firms with high assets and high financial leverage.

The need for sustained efforts at reinforcing governance rules to avoid adverse effects due to failure to apply corporate governance rules is highlighted by (Alrayyes & Al Khaldy, 2019). They found a negative relationship between firm board size and CEO duality and earnings management among firms listed on the Palestine stock exchange. They also show that earnings management and board independence are positively related. The study findings find support for board independence concerning the activities of firm executives in making decisions that affect earnings management. The roles of intellectual capital (IC) are vital in transforming every economy's financial development and knowledge-driven sectors but mostly less developed countries. Low-income countries conventionally have research and development per capita and weak financial sector indices. (Buallay et al., 2019) found a positive association between intellectual capital efficiency and firm performance indices, i.e., return on equity (ROE) and market performance (Tobin's Q) in Islamic banking in the Gulf region.

While some studies suggest that firm size can be detrimental to their performance, (Derbali, 2021) shows Moroccan banks ply on their size to accelerate their performance. Banks in Morocco have continued to expand their networks as they are yet to attain sizes that will negatively affect their performance. Large banks in Moroccan do not follow the concept of economy of scale. (Awad et al., 2021) found results complementing the neoclassical view on private investment. They show that the interest rate in Palestine is negatively related with domestic private investment but exhibited no long-run relationship. Among other factors, (Nassar, 2018) shows that human capital efficiency is effective than structural capital and capital employed in the issue of value creation among listed companies before and after the 2008 financial crisis in Istanbul. Structural capital efficiency plays an insignificant role in value creation before and after the crisis. However, capital employed efficiency played a significant role in firm value creation after the 2008 financial crisis.

This paper addresses how firm-specific innovation activity affects firm productivity and the financial sector's roles in facilitating productivity. We employed firm-level data downloaded from the World Bank Enterprise Survey, which covers over 18,015 firms within 32 African countries; firstly, we establish a connection between a firm's innovative activities and its productivity. We control for country, industry, and firm-specific factors that include measures of the investment climate such as access to finance.

3. Estimating firm productivity

Starting from a fundamental concept, total output is defined as a function of total factor productivity of the form $F(A,K,hL) = Y = AQ(K,hL)$. It is further extended to its intensive form as in equation 1.

$$y = Aq(k,h) \tag{1}$$

$$A = g(t, X_{ijc})exp(u_i) \tag{2}$$

$$\frac{\partial g}{\partial t} \geq 0, \frac{\partial^2 g}{\partial t^2} \leq \geq 0 \tag{3}$$

Where y is the firm value-added per worker, *A is total factor productivity, k is capital per worker, h is labor augmenting factor (is human capital per worker), i is innovation,* X_{ijc} *is a matrix of other firms (i), industry (j), or country-specific(c) explanatory variables and* u_i *is the random error term. Productivity is assumed a positive function of innovation but allows for increasing, constant or decreasing returns to innovation. The level of total factor productivity A is difficult to estimate as it is an unobservable variable endogenously determined with value-added and input choices. Ideally, the effects of innovation and other X variables on productivity A is estimated by linking TFP to the observable variables. TFP is, however, inferred indirectly through output per worker since it is not directly observable,*

By applying log to the system equations 1 and 2, we get

$$log(y_i) = log(q_i) + log(A_i) \tag{4}$$

$$log(A_i) = log(g(i_i, X_{ijc})) + u_i \tag{5}$$

The systems equations above can be estimated either in levels or by taking the first differences and estimating the system equations in growth rates. Each option presents drawbacks (Verdier et al., 2010) *and* (Escribano & Guasch, 2005) *For instance, estimating the system equations in growth rates avoids specifying a functional form for* $F(A,K,hL)$ *it requires a sufficiently long time-series. It has also been identified by* (Chamberlain, 1982; Griliches & Mairesse, 1997; Verdier et al., 2010) *that estimating systems equations at first differences suffers from a weak instrument problem. We avoid these problems associated with the first difference; the system equations are estimated at levels.*

The Cobb-Douglas production function of the form $q(k) = AK^{\alpha_k}h^{\alpha_k}$ *is chosen, meaning that production is log-linear in inputs, i.e.*

$$log(y_i) = \alpha_k log(k_i) + \alpha_h log(h_i) + log(A_i) \tag{6}$$

$$log(A_i) = \alpha_{innov} innovation_i + \alpha_i log(X_i) + \alpha_j log(X_j) + \alpha_c log(X_c) + u_{ijc} \tag{7}$$

We also assume constant elasticity estimates across firms in the same industry and within the same country given that: $\alpha_{kj}^c = \alpha_k, \alpha_{hj}^c = \alpha_h$ *for each country c and industry j.*

We further assume that markets are perfectly competitive; hence, productivity estimates will reflect only factors related to pure technological productivity.

The effects of innovation, firms, industry and country characteristics are indirectly inferred through the earlier discussion's estimated firm output. We adduce this indirect inference by estimating a single regression obtained by substituting equation (6) into equation (7):

$$log(y_{ijc}) = \alpha_k log(k_i) + \alpha_h log(h_i) + \alpha_{innov} innovation_i + \alpha_i(X_i) + \alpha_j(X_j) + \alpha_c(X_c) + u_{ijc} \tag{8}$$

Table 1. Country and distribution of firms

	Freq.	Percent	Cum.
South Sudan	738	4.10	4.10
Benin	150	0.83	4.93
Cameroon	361	2.00	6.93
Chad	153	0.85	7.78
CÃ´te d'Ivoire	361	2.00	9.79
DRC	529	2.94	12.72
Djibouti	266	1.48	14.20
Egypt	2,897	16.08	30.28
Ethiopia	644	3.57	33.86
Gambia	151	0.84	34.69
Ghana	720	4.00	38.69
Guinea	150	0.83	39.52
Kenya	781	4.34	43.86
Lesotho	150	0.83	44.69
Liberia	151	0.84	45.53
Malawi	523	2.90	48.43
Mali	185	1.03	49.46
Mauritania	150	0.83	50.29
Morocco	407	2.26	52.55
Mozambique	601	3.34	55.89
Namibia	580	3.22	59.11
Niger	151	0.84	59.94
Nigeria	2,676	14.85	74.80
Senegal	601	3.34	78.13
Sierra Leaon	152	0.84	78.98
Swaziland	150	0.83	79.81
Tanzania	813	4.51	84.32
Togo	150	0.83	85.16
Tunisia	592	3.29	88.44
Uganda	762	4.23	92.67
Zambia	720	4.00	96.67
Zimbabwe	600	3.33	100.00
Total	18,015	100.00	

In competitive inputs markets, estimates of equation 8 generate unbiased results of the vector $\alpha = [\alpha_k, \alpha_h, \alpha_{innov} innovation_i, \alpha_i, \alpha_j, \alpha_c]$ *by the least-squares estimator.*

$$log(A_i) = log(y_{ijc}) - \alpha_k log(k_i) - \alpha_h log(h_i) \quad (9)$$

where α_k *is the least-squares estimate of* α_k *and* α_h *is the least-squares estimate of* α_h

The resulting estimate of TFP is then regressed on innovation and other control variables in a second step.

4. Data and methodology

The data sources and variable descriptions use in this empirical analysis are discussed in this section. This study employs firm-level data for manufacturing firms in 32 African countries from the World Bank's Enterprise Survey Indicator Database, https://www.enterprisesurveys.org

conducted between 2009 and 2018, complemented with cross-country data on various financial development measures. The country with the largest share of firms in the dataset is Egypt (16.08 percent), followed by Nigeria (14.85 percent), and Tanzania (4.51 percent), as presented in Table 1. Firms report the net book value of fixed assets and total sales and information on employees, wages, and costs. Estimates of firm productivity are derived from this information. The primary dependent variable is output per worker measured by the log of total sales per worker in U.S. dollars (all estimates are converted to US$ using official 2010 constant US$). Tables 2 and Table 3 present the pairwise correlation matrix and summary statistics of key variables of interest. We report that even though most correlation coefficients are statistically significant at 5%, they are most weakly correlated. The mean age of firms is 22.8 years, while the oldest firm is 172 years old, and the youngest is two (2) years old. Top managers' experience also averages at 16 years.

The study also employs the net book value of the firm's total assets as a measure of capital. As an alternative dependent variable, we provide results using the Solow residual to measure productivity and control for capital inputs using firm assets' direct measures.

A set of questions on firm innovation are posed to firm owners whether they engaged in specific innovative activities. These questions include the number of resources invested in R&D. This study, however, limits the questions on the firm's innovation activities to the firms introduction of a New Product, new or significantly improved methods of manufacturing products (New Technology), new or significantly improved logistical or business support processes, new or significantly improved organizational structures or management practices, introduced new or significantly improved marketing methods, did this establishment spend on formal research and development activities, either in-house or contracted with other companies, did this establishment give employees some time to develop or try out a new approach or new idea about products or services, business process, firm management, or marketing, and other related innovation questions such as whether the firm has ISO certification and using technology licensed from a foreign-owned company, excluding office software; following (Ayyagari & Maksimovic, 2007), who argued that innovation in countries located far inside their production possibility frontier might mostly be imitating and adopting instead of inventing this study focuses more on the other set of questions asked than on R&D spending.

Most importantly, we acknowledge that our sample consists of only African countries that are predominantly less developed economies and are most likely operating within their frontier. Also, (Gorodnichenko et al., 2010) argued that using R&D expenditure as a basis of innovation may be inappropriate. Their reason being that R&D expenditures generate not all innovations, and formal R&D measures are typically biased against small firms.

The study also examined the causal relationship between financial development, innovation, and productivity, through different country-level proxies of financial development. The primary measure of financial development is firms with a line of credit. Two other alternative measures of a country's financial development are also considered: stock market capitalization as a percentage of GDP and financial openness. These measures examine the various channels through which financial development affects productivity. Data on Stock market capitalization is obtained from the World Development Indicators database. The data for financial openness is sourced from the dataset by (Lane & Milesi-Ferretti, 2007) and is defined as the ratio of the sum total cross-border assets and liabilities to GDP.

5. Baseline model specification

This study's key dependent variable is output per worker measured by log total sales per worker in constant 2010 U.S. dollars. An alternative measure of total factor productivity was constructed for a robustness check. The study employed ten (9) measures of firm innovation as indicated in the enterprise survey data, including the introduction of a new product, new or significantly improved methods of manufacturing products (New Technology), new or significantly improved logistical or

Table 2. Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) Firm age	1.000									
(2) Capacity Utilis.					−0.099*			1.000		
					0.000					
(3) Private Domes.				0.039*		−0.019		1.000		
				0.000		0.179				
(4) Foreign Private			−0.045*		0.022		−0.801*		1.000	
			0.000		0.117		0.000			
(5) Government			0.087*	−0.020		−0.150*		0.010	1.000	
			0.000	0.163		0.000		0.257		
(6) M. Experience		0.499*	−0.001		0.002		−0.004		0.039*	1.000
		0.000	0.952		0.869		0.658		0.000	
(7) Exporter		−0.012	−0.007	−0.014		0.019*		0.006	−0.009	1.000
		0.181	0.614	0.119		0.036		0.482	0.321	
(8) Ave_ino		0.060*	0.019	−0.047*	0.063*		0.016	0.026*	−0.006	1.000
		0.000	0.176	0.000	0.000		0.083	0.004	0.470	
(9) Output per worker	0.039*		0.095*	−0.092*	0.108*	0.016	0.109*	0.032*	0.041*	1.000
	0.000		0.000	0.000	0.000	0.083	0.000	0.001	0.000	

* shows significance at the .05 level

business support processes, new or significantly improved organizational structures or management practices, introduced new or significantly improved marketing methods, did this establishment spend on formal research and development activities, either in-house or contracted with other companies, did this establishment give employees some time to innovate or try out a new approach or new idea about the products or services, business process, firm management, or marketing, and other related innovation questions such as whether the firm has ISO certification and using technology licensed from a foreign-owned company, excluding office software. In the basic regressions, Industry j and Country c are industry and country dummies. In contrast, Firm *i* is a matrix of firm characteristics (age, size, exporter status, foreign-owned, government-owned) and factor inputs. Our baseline model is equation (10), and we modify it to assess the impact of finance and business climate constraints, financial development on productivity.

$$log(y_{ijc}) = CST + \alpha_{innov} innovation_i + \alpha_i(Firm_i) + \alpha_j(Industry_j) + \alpha_c(Country_c) + u_{ijc} \quad (10)$$

6. Innovation and financial development

The study further examines the mediating roles of the financial sector on productivity by testing the hypothesis that the effect of innovation on productivity is mediated through financial development; hence financial underdevelopment is a setback for innovative firms. The mediating role of the financial sector is captured through an interaction term financial development and average innovation ($Avg - innovation_i \times Finan\_dev_c$) as in equation 10 .

$$log(y_{ijc}) = CST + \alpha_{fin} Avg - innovation_i \times Finan\_dev_c + \alpha_i(Firm_i) + \alpha_j(Industry_j) + \alpha_c(City - Country_c) + u_{ijc} \quad (11)$$

7. Measuring productivity

This section provides the mechanism through which we estimate an alternative measure of productivity to output per worker, i.e., TFP. We estimate TFP by constructing a Solow residual equation and thereby regressing it on firm, industry, and country-level characteristics. This is achieved by considering the firm i output follows a Cobb-Douglas production function of the form

$$Y_i = AK_i^{\alpha_K} L_i^{\alpha_L} \quad (12)$$

Taking logs of both and re-arranging equation 12 gives,

$$log(A_i) = log(Y_i) - \alpha_K log(K_i) - \alpha_L log(L_i) \quad (13)$$

We define α_K and α_L as shares of capital and labor costs, respectively as

$c_s^k = \frac{r \times capital}{r \times capital + w \times Labbor}$ *and* $c_s^l = \frac{w \times Labor}{r \times Capital + w \times Labor}$ *Following* Escribano and Guasch (2005), *we assume the cost of capital r, is 10% of the net book value of all assets of the firm, and $w \times Labor$ is the total cost of labor.*

Equation 13 is formally expressed in terms of the Solow residual (TFP) and can be computed as;

$$TFP\_cs\_kl = ln(Output) - c_s^k * ln(Capital) - c_s^l * ln(Labor) \quad (14)$$

Tables 7 *and* Tables 8 *reports the results of equation (11) using TFP as a measure of firm productivity. The results still remain significant as before. We also established the mediating roles of firm innovation through financial development.*

8. Controlling for endogeneity

To overcome the main concerns associated with our analysis of the relationship between firm innovation and productivity (out per worker), namely (i) measurement errors associated with microdata and (ii) the likelihood of innovation and productivity been jointly determined. We follow (Angrist & Krueger, 2001) *and mirrors* (Verdier et al., 2010) *to address these problems through the use of*

Table 3. Descriptive Statistics

Variable	Obs	Mean	Std.Dev.	Min	Max
Firm age	12,304	22.813	14.679	2	172
Capacity Utili.	5016	67.698	24.23	0	100
Private domestic	12,157	81.304	36.25	0	100
Foreign private	12,149	12.889	30.866	0	100
Government	12,160	.498	5.082	0	100
Capital/worker	2581	12.068	3.266	−2.833	25.82
Top Manag. Exp	12,099	16.207	10.546	2	70
Exporter firms	14,974	6.274	19.685	0	100
Ave_inno	12,442	.179	.483	0	5.5
Output per work.	11,515	8.607	3.548	4.437	21.969

average innovation (Average_Innovate) by firm in a similar location-size within a country also as a measure of innovation.

9. Results and discussion

We present in Table 4 the results of the regression estimate between firm productivity measures (log of output per worker) and the interaction between average firm innovation and financial development measures (Stock market capitalization as a percentage of GDP, Firms with a line of credit, and financial openness) with firm characteristics, industry and country dummies as controls for unobserved heterogeneities.

In column 1, we find the average innovation positively and significantly affects firm productivity. Similarly, the interaction between average innovation and financial development (Stock market capitalization as a percentage of GDP, firms with a line of credit, and financial openness) yields positive effects on productivity, as indicated in columns 5 and 6 of Table 4. This finding confirms the mediating and facilitating function of the financial market on productivity through firm innovation. Access to external funding for innovative firms stimulates productivity. These findings are supported by the findings of earlier studies, including (Beck et al., 2000; Levine, 2005; Van Ark, 2004), who established a positive and significant relationship between financial intermediation and productivity. For instance, the study finds that a unit increase in average innovation will cause a 0.374 increase in firm productivity. Similarly, a unit increase in firm capacity utilization will cause a 0.008 increase in firm productivity.

In Table 5, we employed all the questions on firm innovation as captured in the World Bank's Enterprise Survey Indicator Database, including *(New Product, new or significantly improved methods of manufacturing products (New Technology), new or significantly improved logistical or business support processes (H3), new or significantly improved organizational structures or management practices (H4a), introduced new or significantly improved marketing methods (H4b), did this establishment spend on formal research and development activities, either in-house or contracted with other companies (H5), did this establishment give employees some time to innovate or try out a new approach or new idea about the products or services (H6), business process, firm management, or marketing (H7), and other related innovation questions such as whether the firm has ISO certification (B8) and using technology licensed from a foreign-owned company (E6), excluding office software)*. We show that all the indicator variables for firm innovation positively and significantly affects firm productivity except the innovation on new product (H1). We also show that firm age, capacity utilization, top managers' experience, and firm ownership (both private domestic and

Table 4. Firm Productivity, Average Firm Innovation, and Financial Development

The regression model estimated as $log(y_{ijc}) = CST + \alpha_{innov} innovation_i + \alpha_i(Firm_i) + \alpha_j(Industry_j) + \alpha_c(Country_c)$; log of firm-level output per worker and TFP is the dependent variable. Innovation is firm-level innovation and a dummy variable that takes a value of 1 if a firm responded yes and 0 if the firm responded no. It is measured by New Product, new or significantly improved methods of manufacturing products (New Technology), new or significantly improved logistical or business support processes (H3), new or significantly improved organizational structures or management practices (H4a), introduced new or significantly improved marketing methods (H4b), did this establishment spend on formal research and development activities, either in-house or contracted with other companies (H5), did this establishment give employees some time to innovate or try out a new approach or new idea about the products or services (H6), business process, firm management, or marketing (H7), and other related innovation questions such as whether the firm has ISO certification (B8) and using technology licensed from a foreign-owned company (E6), excluding office software. Firm represents a set of firm-level controls variables including capacity utilization, firm age, size, the proportion of skilled workers, as well as firm ownership structure (% ownership by government, % foreign-owned, % private domestic), and if it is an exporting firm. Industry represents industry dummies, City Size represents location dummies, and the country represents country dummies.

			LINE OF CREDIT	STOCK MARKET	FO
	OPW	TFP	OPW1	OPW1	OPW1
Average_Innov	0.374**	0.247			
	(0.178)	(0.276)			
Ln(firm age)	0.377***	−0.855***	0.396***	5.048*	0.031
	(0.106)	(0.231)	(0.106)	(1.924)	(1.345)
Capacity Utilization	0.008***	0.000	0.008***	−0.009	−0.005
	(0.002)	(0.005)	(0.002)	(0.025)	(0.009)
Private Domestic	0.004**	−0.007	0.004**	−0.037**	−0.010
	(0.002)	(0.007)	(0.002)	(0.012)	(0.010)
Private Foreign	0.022***	0.001	0.022***		
	(0.003)	(0.007)	(0.003)		
Government	0.001	0.003	0.000		
	(0.009)	(0.022)	(0.009)		
Top Manager Exp.	0.012**	0.007	0.012**	−0.059	0.026
	(0.005)	(0.011)	(0.005)	(0.081)	(0.056)
Top Female Manager_dummy	0.133	0.733*	0.129	−0.186	1.061
	(0.188)	(0.435)	(0.188)	(1.339)	(0.685)
Exporter	0.008***	0.007	0.008***		0.028

(*Continued*)

Table4. (*Continued*)

	(0.003)	(0.006)	(0.003)		(0.022)
Firm size					
Medium	0.222	0.343	0.214		0.413
	(0.158)	(0.309)	(0.158)		(1.158)
Small	0.082	0.230	0.068	−0.738	−0.535
	(0.157)	(0.308)	(0.157)	(1.250)	(1.215)
Location Size	0.115***	−0.021	0.115***	−3.388*	0.824
	(0.042)	(0.078)	(0.042)	(1.351)	(0.730)
Location Region	−0.001	0.001	−0.002**	−0.033***	−0.019
	(0.001)	(0.003)	(0.001)	(0.005)	(0.015)
Firm legal status					
Listed comp.	−0.158	−0.030	−0.200		2.294
	(0.215)	(0.370)	(0.214)		(1.919)
Non-Traded comp.	−0.291*	0.037	−0.308*		−1.729
	(0.176)	(0.375)	(0.176)		(1.120)
Sole proprietor firms	0.275**	0.841***	0.272**	−1.883	−1.815**
	(0.124)	(0.248)	(0.124)	(1.307)	(0.692)
Industry	−0.029***	−0.018***	−0.028***	0.002	−0.030**
	(0.004)	(0.007)	(0.004)	(0.054)	(0.014)
Part of establishment	−0.396***	−0.721***	−0.397***	−2.407	−3.878**
	(0.054)	(0.118)	(0.053)	(2.517)	(1.669)
Average_innoX.K8			0.095		
			(0.221)		
Average_innoXSTMCP				0.019*	
				(0.008)	
Average_innoX.FO					0.646***

(*Continued*)

Table4. (*Continued*)

					(0.152)
_cons	6.770***	2.734***	6.866***	18.613**	16.043***
	(0.438)	(1.011)	(0.438)	(6.510)	(5.085)
Obs.	4709	1933	4709	17	43
R-squared	0.086	0.107	0.085	0.890	0.669

Robust standard errors are in parenthesis

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 5. Firm Productivity and Firm Innovation Activities

The regression model estimated as $log(y_{ijc}) = CST + \alpha_{innov} innovation_i + \alpha_i(Firm_i) + \alpha_j(Industry_j) + \alpha_c(Country_c)$; log of firm-level output per worker and TFP is the dependent variable. Innovation is firm-level innovation and a dummy variable that takes a value of 1 if a firm responded yes and 0 if the firm responded no. It is measured by New Product, new or significantly improved methods of manufacturing products (New Technology), new or significantly improved logistical or business support processes (H3), new or significantly improved organizational structures or management practices (H4a), introduced new or significantly improved marketing methods (H4b), did this establishment spend on formal research and development activities, either in-house or contracted with other companies (H5), did this establishment give employees some time to innovate or try out a new approach or new idea about the products or services (H6), business process, firm management, or marketing (H7), and other related innovation questions such as whether the firm has ISO certification (B8) and using technology licensed from a foreign-owned company (E6), excluding office software. Firm represents a set of firm-level controls variables including capacity utilization, firm age, size, the proportion of skilled workers, as well as firm ownership structure (% ownership by government, % foreign-owned, % private domestic), and if it is an exporting firm. Industry represents industry dummies, City Size represents location dummies, and country represents country dummies

Log of Output per worker	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
							OPW1	OPW1	OPW1	OPW1	OPW1
New product	0.169										
	(0.106)										
Ln(firm age)	0.385***	0.388***	0.362***	0.365***	0.312***	0.372***	0.362***	0.328***	0.327***	0.270**	0.356***
	(0.106)	(0.106)	(0.105)	(0.106)	(0.105)	(0.106)	(0.106)	(0.104)	(0.107)	(0.106)	(0.104)
Capacity Utilization	0.008***	0.008***	0.008***	0.008***	0.008***	0.008***	0.008***	0.008***	0.008***	0.008***	0.008***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Private Domestic	0.004**	0.004**	0.004**	0.005**	0.005**	0.004**	0.005**	0.005**	0.004**	0.004**	0.004**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Private Foreign	0.022***	0.022***	0.022***	0.022***	0.022***	0.022***	0.023***	0.022***	0.022***	0.020***	0.020***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Government	0.000	0.000	0.000	0.001	0.001	−0.000	0.000	−0.001	−0.001	−0.002	−0.001
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Top Manager Exp.	0.012**	0.012**	0.013**	0.013**	0.014**	0.012**	0.014**	0.013**	0.014***	0.014**	0.014**
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)

(*Continued*)

Table5. (*Continued*)

Top Female Manager_ dummy	0.130	0.129	0.132	0.142	0.158	0.145	0.135	0.139	0.133	0.152	0.141
	(0.188)	(0.188)	(0.187)	(0.188)	(0.187)	(0.188)	(0.188)	(0.186)	(0.188)	(0.186)	(0.187)
Exporter	0.007***	0.007***	0.007***	0.007***	0.007***	0.007***	0.007***	0.008***	0.007***	0.007***	0.007***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Firm size											
Medium	0.211	0.212	0.194	0.203	0.206	0.207	0.205	0.166	0.211	0.206	0.190
	(0.158)	(0.158)	(0.158)	(0.158)	(0.157)	(0.158)	(0.157)	(0.157)	(0.157)	(0.157)	(0.158)
Small	0.064	0.064	0.051	0.057	0.078	0.064	0.065	0.026	0.061	0.070	0.048
	(0.157)	(0.157)	(0.157)	(0.157)	(0.156)	(0.157)	(0.156)	(0.156)	(0.156)	(0.156)	(0.157)
Location Size	0.110***	0.112***	0.099**	0.100**	0.095**	0.109***	0.103**	0.098**	0.096**	0.103**	0.107***
	(0.042)	(0.042)	(0.042)	(0.041)	(0.041)	(0.042)	(0.042)	(0.041)	(0.042)	(0.041)	(0.041)
Location Region	−0.002**	−0.002**	−0.002*	−0.002*	−0.002**	−0.002**	−0.002*	−0.003**	−0.002**	−0.002**	−0.002*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Firm legal status											
Listed comp.	−0.183	−0.189	−0.132	−0.128	−0.085	−0.161	−0.139	−0.173	−0.135	−0.144	−0.173
	(0.214)	(0.213)	(0.213)	(0.212)	(0.212)	(0.213)	(0.213)	(0.211)	(0.213)	(0.212)	(0.213)
Non-Traded comp.	−0.300*	−0.307*	−0.278	−0.273	−0.238	−0.295*	−0.287	−0.297*	−0.269	−0.268	−0.300*
	(0.176)	(0.176)	(0.176)	(0.175)	(0.175)	(0.176)	(0.176)	(0.175)	(0.175)	(0.177)	(0.176)
Sole proprietor firms	0.271**	0.272**	0.271**	0.270**	0.293**	0.278**	0.269**	0.258**	0.261**	0.272**	0.265**
	(0.124)	(0.124)	(0.124)	(0.124)	(0.123)	(0.124)	(0.124)	(0.123)	(0.124)	(0.123)	(0.124)
Industry	−0.028***	−0.028***	−0.027***	−0.027***	−0.026***	−0.027***	−0.027***	−0.026***	−0.026***	−0.026***	−0.028***
	(0.004)	(0.004)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.003)
Part of establishment	−0.388***	−0.392***	−0.382***	−0.388***	−0.377***	−0.390***	−0.391***	−0.379***	−0.392***	−0.395***	−0.388***

(*Continued*)

Table5. (*Continued*)

	(0.054)	(0.054)	(0.053)	(0.054)	(0.054)	(0.054)	(0.054)	(0.053)	(0.053)	(0.053)	(0.053)
H2		0.156									
		(0.115)									
New technology			0.488***								
			(0.107)								
h4a				0.518***							
				(0.112)							
H4b					0.846***						
					(0.114)						
H5						0.347***					
						(0.113)					
H6							0.449***				
							(0.110)				
H7								1.070***			
								(0.131)			
H8									0.579***		
									(0.119)		
ISO cert.										1.066***	
										(0.178)	
E6											0.926***
											(0.164)
_cons	6.808***	6.842***	6.747***	6.740***	6.710***	6.795***	6.723***	6.817***	6.846***	7.120***	6.857***
	(0.440)	(0.438)	(0.437)	(0.437)	(0.433)	(0.437)	(0.438)	(0.433)	(0.435)	(0.435)	(0.433)
Obs.	4709	4709	4709	4709	4709	4709	4709	4709	4709	4709	4709
R-squared	0.086	0.085	0.089	0.090	0.097	0.087	0.089	0.099	0.090	0.094	0.093

Robust standard errors are in parenthesis

*** p < 0.01, ** p < 0.05, * p < 0.1

private foreign) significantly and positively affect firm productivity. The study finds that a unit increase in firm age, capacity utilization, managers experience, private domestic ownership, and private foreign ownership will cause firm productivity to increase by 0.385, 0.008, 0.012, 0.004, and 0.022 in model 1 of Table 5. These results are consistent with the findings of (Buallay et al., 2019) found that there is a positive association between intellectual capital efficiency and firm performance indices, i.e., return on equity (ROE) and market performance (Tobin's Q) in Islamic banking in the Gulf region.

Table 6 presents the regression results on business climate on firm productivity as an extension of the baseline regression model. We identify that business obstacles such as access to capital as an obstacle, business licensing and permits, political instability, corruption, labor regulations, number of competitors, and inadequately educated workforce adversely affect productivity. Table 6 shows that labor regulations, number of competitors, and inadequate educated workforce are negatively and statistically significant at 1% and 5%, respectively. A unit increase in the activities of competitors causes firm productivity to decline by 0.006.

Tables 7 and Tables 8 are the robustness check results after taking out two countries (Nigeria and Egypt) with the largest firms. Our results remain robust for both the mediating effect of financial development and firm innovation on productivity.

Table 1 is the tabulation of the countries under consideration and their representative firms. The country with the largest share of firms in the dataset is Egypt (16.08%), followed by Nigeria (14.85%), and Tanzania (4.51%)

The pairwise correlation matrix of the variables is reported in Table 2. The results show that the variables are weakly correlated and primarily statistically significant at 5%. The weak correlation between the variables suffices that our models are less likely to suffer from multicollinearity.

The descriptive of the study are reported in Table 3; the observations of the study range from 2,581 for capital per worker to 14,974 for exporter firms. The difference in the number of observations is attributed to omitted values in the World Enterprise Survey Database. The mean values of the variables: firm age, capacity utilization, private domestic ownership, foreign private ownership, government ownership, capital per worker, top managers experience, exporter firms, average innovation and output per worker 22.813, 67.698, 81.304, 12.889, 0.498, 12.068, 16.207, 6.207, 0.179 and 8.607 respectively.

In Tables 7 and Tables 8, we report for robustness check after taking out two countries (Nigeria and Egypt) with the largest number of firms. Our results remain robust for both the mediating effect of financial development and firm innovation on productivity. From Table 7 above, we observe that, the interactive terms between average firm innovation and stock market capitalization and financial openness are positive and statistically significant in Models 5 and 6 at 10% and 1%, respectively.

We show that all the indicator variables for firm innovation positively and significantly affect firm productivity. We also show that firm age, capacity utilization, managers' experience, and firm ownership (both private domestic and private foreign) significantly and positively affect firm productivity. The study finds that a unit increase in firm age, capacity utilization, managers' experience, and private foreign ownership will cause firm productivity to increase by 0.355, 0.007, 0.010, and 0.015 in model 1 of Table 8. This result is consistent with the findings of (Buallay et al., 2019) found that there is a positive association between intellectual capital efficiency and firm performance indices, i.e., return on equity (ROE) and market performance (Tobin's Q) in Islamic banking in the Gulf region. Further, we find that New Product, new or significantly improved methods of manufacturing products (New Technology), significantly improved logistical business support processes (H3), significantly improved organizational

Table 6. Firm Productivity and Busines Environment

The regression model estimated as $log(y_{ijc}) = CST + \alpha_{innov} innovation_i + \alpha_i(Firm_i) + \alpha_j(Industry_j) + \alpha_c(Country_c)$; log of firm-level output per worker and TFP is the dependent variable. Innovation is firm-level innovation and a dummy variable that takes a value of 1 if a firm responded yes and 0 if the firm responded no. It is measured by New Product, new or significantly improved methods of manufacturing products (New Technology), new or significantly improved logistical or business support processes (H3), new or significantly improved organizational structures or management practices (H4a), introduced new or significantly improved marketing methods (H4b), did this establishment spend on formal research and development activities, either in-house or contracted with other companies (H5), did this establishment give employees some time to innovate or try out a new approach or new idea about the products or services (H6), business process, firm management, or marketing (H7), and other related innovation questions such as whether the firm has ISO certification (B8) and using technology licensed from a foreign-owned company (E6), excluding office software. Firm represents a set of firm-level controls variables including capacity utilization, firm age, size, the proportion of skilled workers, as well as firm ownership structure (% ownership by government, % foreign-owned, % private domestic), and if it is an exporting firm. Industry represents industry dummies, City Size represents location dummies, and the country represents country dummies.

Log of Output per worker	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
								OPW1	OPW1	OPW1	OPW1	OPW1
Access to Fianace Obs.	−0.184***											
	(0.027)											
Ln(firm age)	0.397***	0.410***	0.362***	0.478***	0.395***	0.395***	0.395***	0.390***	0.394***	0.362***	0.371***	0.409***
	(0.106)	(0.106)	(0.106)	(0.140)	(0.106)	(0.106)	(0.106)	(0.106)	(0.106)	(0.106)	(0.105)	(0.115)
Capacity Utilization	0.008***	0.009***	0.008***	0.014***	0.008***	0.008***	0.008***	0.008***	0.008***	0.008***	0.008***	0.007***
	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Private Domestic	0.005**	0.005**	0.002	0.002	0.004**	0.004**	0.004**	0.004**	0.004**	0.005***	0.006***	0.004**
	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Private Foreign	0.022***	0.022***	0.020***	0.024***	0.022***	0.022***	0.022***	0.022***	0.022***	0.022***	0.023***	0.022***
	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Government	−0.001	0.000	−0.000	−0.009	0.001	0.001	0.001	0.001	0.001	−0.001	−0.002	0.002
	(0.009)	(0.009)	(0.009)	(0.012)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Top Manager Exp.	0.013**	0.012**	0.010*	0.009	0.012**	0.012**	0.012**	0.012**	0.012**	0.013**	0.013**	0.011*
	(0.005)	(0.005)	(0.005)	(0.007)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)
Top Female Manager_dummy	0.089	0.071	0.094	0.110	0.136	0.136	0.131	0.132	0.131	0.138	0.112	0.205
	(0.189)	(0.190)	(0.190)	(0.218)	(0.188)	(0.188)	(0.188)	(0.188)	(0.188)	(0.189)	(0.191)	(0.192)
Exporter	0.006**	0.007***	0.008***	0.012***	0.007***	0.007***	0.007***	0.007***	0.007***	0.007***	0.007***	0.008***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Firm size												

(*Continued*)

Table6. (*Continued*)

Medium	0.218	0.225	0.186	0.333*	0.208	0.206	0.205	0.209	0.207	0.206	0.198	0.243
	(0.158)	(0.159)	(0.159)	(0.200)	(0.158)	(0.158)	(0.158)	(0.158)	(0.158)	(0.159)	(0.159)	(0.169)
Small	0.050	0.053	0.056	0.267	0.055	0.054	0.055	0.054	0.056	0.071	0.071	0.092
	(0.157)	(0.158)	(0.158)	(0.199)	(0.157)	(0.157)	(0.157)	(0.157)	(0.157)	(0.158)	(0.158)	(0.167)
Location Size	0.084**	0.090**	0.128***	0.097*	0.113***	0.112***	0.113***	0.112***	0.112***	0.085**	0.062	0.147***
	(0.042)	(0.042)	(0.042)	(0.050)	(0.042)	(0.042)	(0.042)	(0.042)	(0.042)	(0.042)	(0.042)	(0.044)
Location Region	−0.001	−0.002	−0.003***	−0.004***	−0.002**	−0.002**	−0.002**	−0.003**	−0.002**	−0.002	−0.001	−0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Firm legal status												
Listed comp.	−0.078	−0.116	−0.270	0.380	−0.205	−0.201	−0.203	−0.201	−0.201	−0.041	0.025	−0.420*
	(0.215)	(0.216)	(0.213)	(0.280)	(0.213)	(0.213)	(0.213)	(0.213)	(0.213)	(0.215)	(0.216)	(0.233)
Non-Traded comp.	−0.263	−0.295*	−0.367**	−0.338	−0.328*	−0.325*	−0.326*	−0.325*	−0.327*	−0.295*	−0.221	−0.219
	(0.176)	(0.176)	(0.177)	(0.227)	(0.175)	(0.175)	(0.175)	(0.175)	(0.175)	(0.176)	(0.177)	(0.184)
Sole proprietor firms	0.265**	0.273**	0.292**	0.419***	0.275**	0.280**	0.274**	0.271**	0.275**	0.273**	0.276**	0.192
	(0.124)	(0.124)	(0.126)	(0.150)	(0.124)	(0.124)	(0.124)	(0.124)	(0.124)	(0.124)	(0.124)	(0.131)
Industry	−0.023***	−0.022***	−0.031***	−0.020***	−0.028***	−0.028***	−0.028***	−0.028***	−0.028***	−0.022***	−0.018***	−0.027***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Part of establishment	−0.184***	−0.207***	−0.461***	−0.362***	−0.401***	−0.401***	−0.398***	−0.397***	−0.398***	−0.123*	−0.012	−0.489***
	(0.062)	(0.064)	(0.055)	(0.092)	(0.053)	(0.053)	(0.054)	(0.053)	(0.053)	(0.066)	(0.066)	(0.061)
Practices of competitors		−0.147***										
		(0.027)										
Biggest obstacle1			0.026***									
			(0.005)									
Biggest obstacle2				−0.179***								
				(0.026)								
Tax rates					−0.049							
					(0.038)							

(*Continued*)

Table6. (*Continued*)

Tax administration						−0.051						
						(0.042)						
Business licensing and permits							−0.009					
							(0.047)					
Political instability								−0.034				
								(0.041)				
Corruption									−0.014			
									(0.039)			
Labor regulations										−0.246***		
										(0.034)		
Inadequately educated workforce											−0.303***	
											(0.031)	
Number of competitors												−0.006**
												(0.002)
_cons	7.026***	6.690***	6.826***	7.016***	7.032***	7.039***	6.921***	7.014***	6.946***	7.254***	7.085***	7.184***
	(0.439)	(0.439)	(0.444)	(0.577)	(0.450)	(0.452)	(0.457)	(0.461)	(0.460)	(0.442)	(0.440)	(0.481)
Obs.	4674	4668	4597	3539	4706	4706	4706	4706	4706	4638	4621	4302
R-squared	0.094	0.088	0.090	0.116	0.085	0.085	0.085	0.085	0.085	0.095	0.104	0.085

Robust standard errors are in parenthesis

*** p < 0.01, ** p < 0.05, * p < 0.1

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Table 7. Firm Productivity, Average Firm Innovation and Financial Development (Robustness checks)

The regression model estimated as $log(y_{ijc}) = CST + \alpha_{innov} innovation_i + \alpha_i(Firm_i) + \alpha_j(Industry_j) + \alpha_c(Country_c)$; log of firm-level output per worker and TFP is the dependent variable. Innovation is firm-level innovation and a dummy variable that takes a value of 1 if a firm responded yes and 0 if the firm responded no. It is measured by New Product, new or significantly improved methods of manufacturing products (New Technology), new or significantly improved logistical or business support processes (H3), new or significantly improved organizational structures or management practices (H4a), introduced new or significantly improved marketing methods (H4b), did this establishment spend on formal research and development activities, either in-house or contracted with other companies (H5), did this establishment give employees some time to innovate or try out a new approach or new idea about the products or services (H6), business process, firm management, or marketing (H7), and other related innovation questions such as whether the firm has ISO certification (B8) and using technology licensed from a foreign-owned company (E6), excluding office software. The firm represents a set of firm-level controls variables including capacity utilization, firm age, size, the proportion of skilled workers, as well as firm ownership structure (% ownership by government, % foreign-owned, % private domestic), and if it is an exporting firm. Industry represents industry dummies, City Size represents location dummies, and country represents country dummies.

	(1)	(2)	(3)	(4)	(5)
	OPW1	TFP	OPW1	OPW1	OPW1
Average Innovation	0.010	0.117			
	(0.070)	(0.142)			
Ln(firm age)	0.370***	−0.842***	0.372***	5.073*	0.080
	(0.112)	(0.232)	(0.112)	(1.917)	(1.346)
Capacity Utilization	0.008***	0.001	0.008***	−0.009	−0.005
	(0.002)	(0.005)	(0.002)	(0.025)	(0.009)
Private Domestic	−0.001	−0.004	−0.001	−0.037**	−0.010
	(0.002)	(0.007)	(0.002)	(0.012)	(0.010)
Private Foreign	0.016***	0.004	0.016***		
	(0.003)	(0.008)	(0.003)		
Government	0.014	0.003	0.014		
	(0.011)	(0.022)	(0.011)		
Top Manager Exp.	0.010	0.006	0.010	−0.059	0.024
	(0.006)	(0.011)	(0.006)	(0.082)	(0.056)
Top Female Manager_dummy	0.051	0.665	0.051	−0.203	1.055
	(0.207)	(0.427)	(0.207)	(1.379)	(0.685)
Exporter	0.011***	0.008	0.011***		0.027

(*Continued*)

Table7. (*Continued*)

	(0.003)	(0.006)	(0.003)		(0.022)
Firm size					
Medium	0.211	0.373	0.209		0.383
	(0.170)	(0.313)	(0.170)		(1.146)
Small	0.090	0.207	0.087	−0.724	−0.550
	(0.170)	(0.310)	(0.171)	(1.234)	(1.203)
Location Size	0.185***	−0.095	0.185***	−3.414*	0.814
	(0.066)	(0.111)	(0.066)	(1.376)	(0.732)
Location Region	−0.007***	0.000	−0.007***	−0.046***	−0.025
	(0.002)	(0.004)	(0.002)	(0.007)	(0.020)
Firm legal status					
Listed comp.	−0.230	0.079	−0.233		2.218
	(0.225)	(0.374)	(0.224)		(1.925)
Non-Traded comp.	−0.362*	0.098	−0.364*		−1.740
	(0.187)	(0.376)	(0.187)		(1.116)
Sole proprietor firms	0.448***	0.962***	0.447***	−1.896	−1.821**
	(0.136)	(0.247)	(0.136)	(1.298)	(0.692)
Industry	−0.051***	−0.028***	−0.051***	0.006	−0.050**
	(0.006)	(0.010)	(0.006)	(0.090)	(0.024)
Part of establishment	−0.305***	−0.716***	−0.305***	−2.424	−3.874**
	(0.055)	(0.120)	(0.055)	(2.546)	(1.671)
Average_inno*.K8			−0.021		
			(0.113)		
Average_inno*STMCP				0.010*	
				(0.004)	
Average_innoX.FO					0.323***

(*Continued*)

Table7. (*Continued*)

Average_Innov					(0.076)
_cons	7.690***	2.610**	7.695***	15.120*	16.934***
	(0.503)	(1.038)	(0.502)	(6.616)	(4.843)
Obs.	4067	1858	4067	17	43
R-squared	0.099	0.114	0.099	0.890	0.668

Robust standard errors are in parenthesis

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

structures (H4a), significantly improved marketing methods (H4b), did this establishment spend on formal research and development activities, either in-house (H5), new idea about the products or services (H6), business process, firm management, or marketing (H7), and other related innovation questions such as whether the firm has ISO certification (B8) and using technology licensed from a foreign-owned company (E6) are significant and positively affect firm productivity 1% at significance.

From Table 8, the study reports that a unit increase in significantly improved organizational structures or management practices (H4a), significantly improved marketing methods (H4b), spending on formal research and development activities, either in-house or contracted with other companies (H5), establishment give employees some time to innovate or try out a new approach or new idea about the products or services (H6), business process, firm management, or marketing (H7) will cause productivity to increase by 0.719, 0.927, 0.445, 0.632 and 1.107, respectively.

10. Conclusion and policy recommendation

The study employed firm-level data from the World Bank's Enterprise Survey Indicator Database, https://www.enterprisesurveys.org conducted between 2009 and 2018 for 32 African countries. Good innovative projects are more likely to be funded than bad ones in a country with a well-developed financial sector. In other words, robust financial systems "select" the projects or firms with the highest underlying productivity. Such a competitive market-based selection process indicates that innovation activities are more effective in countries with a high financial development level. This study examined the firm productivity-innovation nexus by employing a typical Cobb-Douglas production function to examine the causal link between firm productivity and innovation. The study also explored the mediating role of financial sector development on productivity through firm innovation activity. Our results show that innovation has a significant positive impact on productivity in financially developed countries.

Our findings are consistent with (Levine, 2005), who found that financial intermediation stimulates economic growth even in developed economies. Similarly, (Beck et al., 2000) identified that financial intermediaries significantly and positively impacted total factor productivity growth. We show evidence that firm innovation significantly and positively affects firm productivity. Our results are consistent with the findings of (Verdier et al., 2010), who identified that innovation is critical for firm performance and productivity. We also established the mediating roles of the financial system on firm productivity. Such that in a well-established financial system, firms maximize the full effect of the innovation activities. Similarly, Van Ark (2004) identified the firm's main driver of TFP of the firm as R&D capital, ICT capital, Human capital, and organizational capital. Accordingly, these factors are core to the performance of the firm reflected in assets or financial structure.

We also show the mediating roles of a well-developed financial market on productivity. In a well-developed financial market, the impact of firm innovation is significant through the facilitation and financing of innovation activities and innovative firms to boost productivity and lower production costs.

These findings are essential for countries in Africa (and other less-developed countries) who spend less on R&D but can adopt or imitate existing innovative ideas from technology rich countries for accelerated economic growth and increased productivity. The study also provides insight into the banking and financial industry player with the growing rate of nonperforming loans. Innovative firms are productive; hence they can pay their lines of credit. The findings of the study also have significant originality and value. Summarily, the findings shall assist at better helping policymakers at state and private levels, monetary policy authority and bankers, and researchers better understand and appreciate the interrelationship between the financial sector, financing firm innovation and firm productivity, and ultimately the growth of the economy.

Table 8. Firm Productivity and Firm Innovation Activities (without Egypt and Nigeria)

The regression model estimated as $log(y_{ijc}) = CST + \alpha_{innov} innovation_i + \alpha_i(Firm_i) + \alpha_j(Industry_j) + \alpha_c(Country_c)$; log of firm-level output per worker and TFP is the dependent variable. Innovation is firm-level innovation and a dummy variable that takes a value of 1 if a firm responded yes and 0 if the firm responded no. It is measured by New Product, new or significantly improved methods of manufacturing products (New Technology), new or significantly improved logistical or business support processes (H3), new or significantly improved organizational structures or management practices (H4a), introduced new or significantly improved marketing methods (H4b), did this establishment spend on formal research and development activities, either in-house or contracted with other companies (H5), did this establishment give employees some time to innovate or try out a new approach or new idea about the products or services (H6), business process, firm management, or marketing (H7), and other related innovation questions such as whether the firm has ISO certification (B8) and using technology licensed from a foreign-owned company (E6), excluding office software. Firm represents a set of firm-level controls variables including capacity utilization, firm age, size, the proportion of skilled workers, as well as firm ownership structure (% ownership by government, % foreign-owned, % private domestic), and if it is an exporting firm. Industry represents industry dummies, City Size represents location dummies, and country represents country dummies.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	OPW1	OPW1	OPW1	OPW1	OPW1	OPW1	OPW1	OPW1	OPW1	OPW1	OPW1
New product	0.243**										
	(0.121)										
Ln(firm age)	0.353***	0.359***	0.320***	0.322***	0.276**	0.336***	0.317***	0.298***	0.271**	0.257**	0.342***
	(0.112)	(0.112)	(0.111)	(0.111)	(0.111)	(0.112)	(0.112)	(0.110)	(0.113)	(0.112)	(0.111)
Capacity Utilization	0.007***	0.007***	0.007***	0.007***	0.007***	0.007***	0.007***	0.007***	0.007***	0.007***	0.007***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Private Domestic	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.000	−0.001	−0.001	−0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Private Foreign	0.015***	0.015***	0.015***	0.015***	0.015***	0.015***	0.015***	0.015***	0.015***	0.014***	0.014***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Government	0.015	0.015	0.016	0.016	0.016	0.014	0.015	0.014	0.014	0.011	0.012
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Top Manager Exp.	0.010*	0.010	0.010*	0.010*	0.011*	0.010*	0.011*	0.011*	0.013**	0.011*	0.011*
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Top Female Manager_dummy	0.051	0.052	0.045	0.053	0.075	0.064	0.042	0.062	0.043	0.079	0.068
	(0.207)	(0.207)	(0.205)	(0.206)	(0.205)	(0.207)	(0.206)	(0.205)	(0.206)	(0.205)	(0.206)
Exporter	0.011***	0.011***	0.011***	0.011***	0.011***	0.011***	0.011***	0.012***	0.011***	0.011***	0.011***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)

(*Continued*)

Table8. (*Continued*)

Firm size											
Medium	0.214	0.212	0.188	0.199	0.204	0.204	0.198	0.171	0.208	0.208	0.197
	(0.169)	(0.169)	(0.169)	(0.169)	(0.168)	(0.169)	(0.168)	(0.169)	(0.169)	(0.169)	(0.169)
Small	0.090	0.088	0.074	0.076	0.106	0.088	0.084	0.056	0.083	0.100	0.072
	(0.170)	(0.170)	(0.170)	(0.169)	(0.169)	(0.170)	(0.169)	(0.169)	(0.169)	(0.170)	(0.170)
Location Size	0.176***	0.179***	0.160**	0.159**	0.164**	0.177***	0.167**	0.161**	0.149**	0.166**	0.175***
	(0.066)	(0.066)	(0.066)	(0.066)	(0.066)	(0.066)	(0.066)	(0.066)	(0.066)	(0.066)	(0.066)
Location Region	−0.007***	−0.007***	−0.007***	−0.007***	−0.007***	−0.007***	−0.007***	−0.007***	−0.007***	−0.007***	−0.006***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Firm legal status											
Listed comp.	−0.203	−0.216	−0.144	−0.138	−0.097	−0.183	−0.150	−0.194	−0.147	−0.169	−0.205
	(0.224)	(0.224)	(0.222)	(0.222)	(0.222)	(0.223)	(0.223)	(0.221)	(0.222)	(0.222)	(0.223)
Non-Traded comp.	−0.352*	−0.363*	−0.330*	−0.321*	−0.276	−0.350*	−0.340*	−0.354*	−0.317*	−0.320*	−0.359*
	(0.187)	(0.187)	(0.188)	(0.186)	(0.187)	(0.187)	(0.187)	(0.186)	(0.186)	(0.188)	(0.187)
Sole proprietor firms	0.450***	0.450***	0.460***	0.464***	0.490***	0.465***	0.464***	0.431***	0.440***	0.442***	0.442***
	(0.136)	(0.136)	(0.136)	(0.136)	(0.135)	(0.136)	(0.136)	(0.135)	(0.136)	(0.136)	(0.136)
Industry	−0.050***	−0.051***	−0.048***	−0.048***	−0.046***	−0.049***	−0.047***	−0.047***	−0.047***	−0.048***	−0.050***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Part of establishment	−0.291***	−0.298***	−0.281***	−0.288***	−0.280***	−0.293***	−0.292***	−0.281***	−0.293***	−0.307***	−0.299***
	(0.056)	(0.055)	(0.055)	(0.055)	(0.055)	(0.056)	(0.055)	(0.055)	(0.055)	(0.055)	(0.055)
H2		0.190									
		(0.132)									
New technology			0.638***								
			(0.123)								
h4a				0.719***							
				(0.131)							

(*Continued*)

https://doi.org/10.1080/23322039.2021.1976359

Table8. (*Continued*)

H4b					0.927***						
					(0.131)						
H5						0.445***					
						(0.132)					
H6							0.632***				
							(0.127)				
H7								1.107***			
								(0.146)			
H8									0.814***		
									(0.140)		
ISO cert.										0.967***	
										(0.192)	
E6											0.784***
											(0.179)
_cons	7.615***	7.667***	7.580***	7.588***	7.537***	7.642***	7.566***	7.613***	7.714***	7.876***	7.633***
	(0.503)	(0.502)	(0.500)	(0.499)	(0.496)	(0.500)	(0.500)	(0.497)	(0.497)	(0.498)	(0.499)
Obs.	4067	4067	4067	4067	4067	4067	4067	4067	4067	4067	4067
R-squared	0.100	0.100	0.106	0.107	0.112	0.102	0.105	0.113	0.108	0.106	0.104

Robust standard errors are in parenthesis

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

11. Limitation of the study

The study averse that, while innovation and access to finance are vital factors underlying productivity and growth prospects in Africa, further investigation is recommended to examine the effect of law and property rights, accountability and corruption, and political stability on firm innovation and productivity.

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Disclosure statement
No potential conflict of interest was reported by the author(s).

Funding
The authors received no direct funding for this research.

Citation information
Cite this article as: Firm productivity, innovation, and financial development, Sheng Xu, Michael Asiedu & Gabriel Kyeremeh, *Cogent Economics & Finance* (2021), 9: 1976359.

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***Cogent Economics & Finance* (ISSN: 2332-2039) is published by Cogent OA, part of Taylor & Francis Group.**