# Innovation and Firm Productivity: Empirical Evidence from Ghana

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**Abstract:** The study investigates empirically the impact of innovation on firm productivity in Ghana. In examining the relationship between innovation and firm productivity, two robust Instrumental Variable estimation techniques (Two Stage Least Squares and Optimal Generalized Methods of Moment) have been employed so as to cure any endogeneity problems that may exist in our models. The study realized that innovation impacts positively on the productivity of firms. Both process and product innovation have strong positive relationship with firm productivity in Ghana. It is also noted that while most employees in Ghanaian firms have got formal education, less practical or on-job training is offered to the employees by the firms. This study does not only serve as a reference work for subsequent investigations on the impact of innovation on productivity in Ghana, but it also serves as a guide to policy makers on drafting innovation policies.

**Keywords:** Process Innovation; Product Innovation; Productivity; Instrumental Variable Technique and Ghana

**JEL Classification:** D22

## 1. Introduction

Innovation is very essential for economic growth and productivity (Schumpeter, 1942). This is achieved through the efficiency gains, the creation and satisfaction of new wants generated by innovation (Romer, 1990; Baumol, 2002; Bhide, 2011). Due to the huge role innovation plays in productivity, many scholars have studied the link between innovation and productivity. These studies have however presented varied findings. While some have found strong positive relationship between innovation and productivity[4], others have established negative link between innovation and productivity.[5] A part from the above, there is yet other group of studies that have

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[4] See (Gu & Tang, 2004; Castellani & Zanfei, 2006; Tang & Le, 2007; Kolasa, 2008; Pruett & Thomas, 2008; Jorgenson, 2011; Maaso & Vahter, 2012; Crowley & McCann, 2015; Siedschlag & Zhang, 2015; Alvarez et al 2015, etc.)
[5] See (Roper et al., 2008; Janz et al., 2004 etc.).

discovered that innovation has less impact on productivity of firms (Mohnen, 1992; Bernstein, 2002 etc.).

Based on the above varied findings, this paper investigates empirically the link between innovation and productivity in Ghana. The study departs from previous studies in the following ways. Most of the previous studies have been conducted on more advanced economies like the USA, UK, Canada, Ireland, Poland, Germany, Italy etc to the neglect of developing countries. Meanwhile due to the differences in both innovative and economic advancement between the developed and developing countries, findings in developed countries in respect of innovation and productivity link may not be applicable to developing countries hence the need for a study in a developing country.

Besides, most of the previous studies used a single indicator of innovation as a measure of innovation. This however does not capture innovation fully as argued by Bernstein (2002) and Gu and Tang (2004). This can therefore be a potential bias for earlier findings. Our study constructed innovation index by the use of multiple correspondence analysis by including all the innovation indicators. Additionally, most of the earlier studies have not taken care of potential biases induced by simultaneity, omitted variables and unobserved industry specific effects in their estimations. In this study, we have used instrumental variable estimator which has the power to control for both heteroskedasticty and endogeneity problems that can bias findings thus producing robust results.

## 2. Theoretical and Empirical Literature

The link between innovation and productivity came to light following the seminal work of Schumpeter (1934). According to Schumpeter (1934), the entrepreneur is the architect of innovation in life. He indicated that innovation comes from the discovery of entrepreneurs. This discovery leads to new products, new processes, opening of new markets, new ways of organizing the business and finally new sources of supply. All these discoveries are meant to enhance productivity by way of enhancing efficiency and reducing cost of production in businesses so as to maximize profit for shareholders. Following this, Solow (1957) argued that long run productivity growth cannot be explained by investment in fixed capital alone. This goes to support the theoretical observation that productivity growth cannot be sustained through investments that have the propensity to suffer diminishing return with time. All things being equal, without technology and knowledge, investment in every physical capital suffers diminishing returns. Thus, investment in knowledge is required to stop the decline in returns from investment in tangible capital, education and training. Innovation hence leads to improvements in productivity (Thomson & Webster, 2013). Other scholars believe that innovation causes efficiency, creates and satisfies new wants (Romer, 1990; Baumol, 2002; Bhide, 2011). Aghion and Howitt, (1992) observed that the link between innovation and productivity is not a unidirectional but a bidirectional in nature.

Gordon and McCann (2005) see innovation as a composition of three elements which include newness, improvement and overcoming uncertainty (improving market share). The OECD (2005) Oslo Manual classifies innovation into the following; product, process, marketing and organizational innovations. Innovation in this regards is referring to both technological and non-technological aspects of innovation. It encompasses a lot of issues that bring about efficiency and improvement in productivity. From a theoretical perspective, innovation in firms is an enhancer of productivity and must be encouraged. On the empirical front, varied findings have been established. A host of studies in advanced and emerging countries have established a positive significant relationship between innovation and productivity.[1] Notwithstanding the non-existence of negative theoretical link between innovation and productivity, empirical studies have proven otherwise. Studies that have found that innovation impacts negatively on productivity are available[2] This implies that there is no consensus among scholars in the linkage between innovation and productivity hence the need for more researches to through light on the subject matter. In the case of Africa and Ghana, there is complete dearth of knowledge on this linkage.

## 3. Data and Methodology

### 3.1. Data and Sample

The study employed cross-sectional secondary data of the standardized version of the World Bank Enterprise Survey (WBES) on Ghana for the investigation. We used the latest version of the WBES for Ghana which took place in 2013. The data is sourced from the World Bank website. The WBES provides a firm level dataset on a sample of service and manufacturing firms across emerging and developing countries in the world. The survey uses face-to-face interview preceded by a random sampling technique and consistent methodology of implementation across all surveyed countries. In the survey both qualitative and quantitative information are sought from business owners and managers in the service and manufacturing firms of the private sector. The information contained in the survey are categorized under

[1] See (Huergo & Jaumandreu, 2004; Gu & Tang, 2004; Mairesse et al., 2005: Griffith et al., 2006; Parisi et al., 2006; Chudnovsky et al., 2006; Pianta & Vaona, 2006; Masso & Vahter, 2008; Tang & Le, 2007; Mairesse & Robin, 2009; Masso & Vahter, 2012; Crowley & McCann, 2014; Gallego et al., 2015; Alvarez et al., 2015; Baumann & Kritikos, 2016).

[2] See (Janz et al, 2004; Duguet, 2006; Loof and Heshmati, 2006; Van Leeuwen and Klomp, 2006; Raffo et al, 2008).

the following headings; sales and supplies, degree of competition, capacity, land, crime, finance, business-government relations, labour, business environment and performance.

### 3.2. Construction of Innovation Index

Unlike previous studies, we have created an innovation indexes using multiple correspondent analyses (MCA). MCA is chosen as it is very appropriate for our data. It does not only assign weight according to the significance of the variables in the index but it is well suited for creation of indexes that have binary variables as components. It is viewed as a generalization of principal component analysis when the variables are binary or categorical in nature (Asselin, 2002; Abdi & Valentin, 2007). The MCA indexes are created using a standard correspondence analysis on an indicator matrix whose entries are coded as 0 or 1 and the MCA extracts the first factorial axis which retains the maximum information contained in the matrix. In this instance the index, $innovation_i$, is a function of some underlying variables $Q_{ij,}$ such that $Q_{ij}$ represents firm i's possession or usage of a particular innovation element or the lack or non-usage of it j (Booysen et al., 2008; Johnston & Abreu, 2013; Akotey & Adjasi, 2015).

$$Innovation_i = f\{Q_{ij}\} \qquad (5)$$

$$ProductInnovation_i = Q_{i1} + Q_{i2} \qquad (6)$$

$$ProcessInnovation_i = Q_{i1} + Q_{i2} + Q_{i3} \qquad (7)$$

Where $Q_{ij}$ is a binary variable and takes the values 1 if firm i uses or have innovation element j, and 0 if otherwise. Following previous studies[1] we adopt the MCA innovation index as stated below in computing the weight of the individual process innovation elements:

$$\boldsymbol{a_i = \sum_{k=1}^{k} F_{1k}\, d_{ki}}$$

Where *i*th firm innovation index is $\alpha_i$, $d_{ki}$ is the *k*th value of the binary variables (with k=1…K) indicating the firms' innovation variables included in the index construction. $F_{1k}$ is the MCA weights generated for the analysis. The weights generated are shown below in table 1.

By firm innovation, we are referring to product innovation and process innovation. According to OECD (2005, p. 46), product innovation is the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses while a process innovation is the implementation of a new or significantly improved production or delivery method. We adopt the World Bank

[1] See (Benzicri, 1973; Van Kem, 1998; Booysen et al, 2008; Akotey & Adjasi, 2015).

Enterprise Survey database definitions with modifications where product innovation is made up of the combination of two variables: international quality certificate and foreign technology license; while process innovation is made up of three variables: usage of email, possession of website and having audited financial statements.

**Table 1. Weight Generated from the MCA**

| Variables | Categories | Weight |
|---|---|---|
| *Process Innovation* | | |
| Email | Uses email in transaction | 0.745 |
| | Does not use email in transactions | -1.387 |
| Website | Has a website | 1.428 |
| | Does not have a website | -0.716 |
| Audited Financial Statement(AFS) | Are audited by external auditors | 0.823 |
| | Are not audited by external auditors | -1.146 |
| *Product Innovation* | | |
| Internationally Recognized Quality Certificate(IRQC) | Has IRQC<br>Does not have IRQC | 2.936<br>-0.341 |
| Technology License(TL) | Has TL | 2.418 |
| | Does not have TL | -0.414 |
| | | |

### 3.2. Analytical Procedure

From the literature[1] on how to model the relationship between firm process innovation and productivity, we have adopted the model below.

$$Y_i = X_i\beta + \varepsilon_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$Where\ Y_i\ is\ the\ Productivity\ while, X_i\ is\ the\ vector\ of\ independent\ variables.$

The expanded form of the model takes the forms as follows;

$$Productivity_i = \beta_0 + \beta_1\ Innovation_i + \beta_2 Controls_i + \varepsilon_i \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$Where\quad \varepsilon_i = \mu_i + v_i \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

$$v_i = individual\ firm\ effects$$

The main independent variable *innovation* is measured as an index of product innovation and process innovation. Our a priori expectation is that innovation will have a positive impact on productivity. This is premised on the background that innovation causes efficiency, creates and satisfies new wants at the same time (Romer, 1990; Baumol, 2002; Bhide, 2011). From literature, our dependent variable, productivity is measured in several ways depending on the nature and availability of the data. Some studies have defined it as the log of value added per worker (Crepton et al., 1998; Mairesse & Robin, 2009) while some refer to it as the log of sales per

[1] See (Gu & Tang, 2004; Pianta & Vaona, 2006; Tang & Le, 2007; Masso & Vahter, 2012; Crowley & McCann, 2014; Baumann & Kritikos, 2016).

worker(Griffith et al., 2006; Jefferson et al. 2006; Van Leeuwen & Klomp, 2006). Yet there is another group that have measured productivity by way of total factor productivity growth (Chudnovsky et al., 2006; Loof & Heshmati, 2006). In this study we have adopted the log of sales per worker as the measure available in our dataset. We included in our model, training, size, age, top management experience, access to finance and capacity utilization as our control variables. The detailed descriptions of the variables are presented in Table 2 below.

**Table 2. Variable Description**

| Variable | Definition |
|---|---|
| Import | Dummy variable equal to one if the firm imported any intermediate goods |
| Process Innovation | It is an index computed by the usage of Multiple Correspondence Analysis (MCA) technique. It is made of the following: Ownership of Website, Usage of Email to communicate with clients and having Audited financial statements by external auditors. |
| Training | Dummy variable equal to one if the firm run formal training for its employees |
| Age | Log of Survey year minus year the firm started operation |
| Sales | Log of total annual sales of the firm |
| Size | It refers to the number of employees of the firm. |
| Top Management Experience | The number of years of experience gained by top managers in the sector of the firm |
| Access to finance | Dummy variable equal to one if the has savings or current account |
| Capacity Utilisation | The output of the firm as a proportion of the maximum output possible utilizing all their capacities |
| Education | The number of employees who had at least secondary education |
| Labour Productivity | Log of Total sales per employees |

### 3.4. Instrumental Variable

As noted earlier, in as much as innovation can influence productivity, productivity on the other hand can also determine innovation. This therefore has the propensity to bias our results with endogeneity problems. To overcome the endogeneity problems in our estimation, we used the instrumental variable two stage least square (IV2SLS) estimation technique. IV2SLS has the power to control for all unobservable factors and measurement errors in the model (Baum, 2008). To produce unbiased results under the IV model, an observed variable which is the instrumental variable is required which has a strong correlation with Productivity and the main independent variable but does not correlate with the error term. These assumptions of the, IV as summarized by Khandker et al. (2010) are as follows:

$$Correlate\ with\ Innovation: \mathrm{cov}(z, FDI) \neq 0$$

$$Uncorrelated\ with\ the\ error\ term(\varepsilon): \mathrm{cov}(z, \varepsilon) = 0$$

Where z is the chosen instrument. We selected import dummy as our instrument for both process innovation and product innovation. Firms that import are expected to have access to good technological tools and alternative ways of performing their activities. It is therefore expected to have a positive relationship with innovation. This view has been supported by these studies (Turner, 1980; Levinsohn 1991). However, firm's ability to import does not guarantee that such firms will have higher productivity.

Our first stage regression is an ordinary least squares (OLS) regression but has the selected instruments, $z_i$, as additional independent variables. Following the approach of Khadker et al. (2010); Janzen and Carter (2013) and Akotey and Adjasi (2015) the first stage regression is:

$$Innovation_i = yz_i + \phi x_i + \mu_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 4$$

Where Innovation$_i$ is the innovation index index, $z_i$ is the selected instrument $x_i$ is a vector of covariates which affect a firm's innovation ability and $\mu_i$ is the error term. In the second stage, the predicted innovation (Innovation$_i$) is substituted in equation (4) to obtain the outcome equation (Khandker et al., 2010).

$$\Pr oductivity_i = \alpha X_i + \beta\, Innovation_i + \varepsilon_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots .5$$

$$\Pr oductivity_i = \alpha X_i + \beta(\hat{Y}Z_i + \hat{\phi} X_i + \mu_i) + \varepsilon_i \ldots\ldots\ldots\ldots\ldots\ldots 6$$

Where $\hat{Y}Z_i + \hat{\phi} X_i + \mu_i$ is the predicted innovation. Under the IV the impact of innovation on Productivity is $\hat{\beta}_{iv}$.

The validity of our instruments is very crucial in determining the robustness of our results. Every valid instrument must satisfy the condition of instrument relevance and instrument exogeneity. Where an instrument fails to pass the test of relevance the instrument is said to be weak and the results produced from such an instrument will be biased. According to Stock and Watson (2007), the rule of thumb in checking for weak instrument is that in a situation where there is a single endogenous regressor, a first-stage F-statistic less than 10 indicates that the instrument is weak. Stock and Yogo (2005) have however provided for a formal test for weak instrument. In their test, the null hypothesis is that the instruments are weak and the alternative hypothesis is that the instruments are strong. The strong instruments are those for which the bias of 2SLS estimator is at most 10% of the bias of the OLS estimator.

This test entails the comparison of the F-statistic with a critical value that depends on the number of instruments. For a test with a 5% significance level, this critical value ranges between 9.08 and 11.52, so the rule of thumb of comparing F-statistic to 10 is a good approximation to the Stock and Yogo test. To test for the relevance of these instruments chosen, we employed the critical values of Stock and Yogo (2005) and the minimum Eigen value of Cragg and Donald (1993). To reject the null hypothesis and conclude that the instruments are valid, the Cragg and Donald (1993) minimum Eigen value must be greater than the Stock and Yogo (2005) critical value. As shown in table 7 in the appendix for our post estimation tests, our minimum eigen values of Cragg and Donald (1993) are all greater than the Stock and Yogo (2005) critical values of LIML size of nominal 5% Wald test at 10% or 15%. Thus we conclude that both of the instruments are relevant and hence the results produced from the IV estimation are unbiased. We did not test for instrument validity in our models since our models are just identifies (our endogenous variables are equal to the instruments).

## 4. Empirical Findings

### 4.1. Descriptive Statistics

Indicated in table 3 below are summary statistics of the variables used in the study. The total number of firms used in the study is 710 which are made up of manufacturing and service firms. On the average, the firms are doing better on product innovation than process innovation with a mean of 0.01 process innovation and 0.58 product innovation. Majority of employees of the firms are noted to be educated with an average of 66.95% of employees having had education. This could be attributed to the educational requirements most firms impose on their jobs. On the contrary however, on the average, fewer firms give formal training to their employees. It is only about 39% of firms that grant formal training to their employees. Contrary to most literature that SMEs have low access to finance, about 95% of the firms have access to finance. On expertise of top management, the minimum number of years of experience is 2 while we have as high as 64 years of experiences being the maximum. Averagely 16years of experience is what top management have.

One of the challenges with economic models is multicollinearity which can lead to biased results. As a result we run a correlation matrix which is shown in table 4. From the matrix, it is realized that though some dependent variables have some amount of positive correlation among themselves, the highest coefficient of correlation is between access to finance and size (0.43). This shows that all our independent variables can be put in one model without any problem of multicollinearity arising.

**Table 3. Summary Statistics**

| Variable | Mean | Std. Dev. | Min. | Max | Observations |
|---|---|---|---|---|---|
| Process Innovation | 0.01 | 1.00 | -1.42 | 1.47 | 710 |
| Product Innovation | 0.58 | 1.14 | 0.05 | 4.48 | 698 |
| Labour Productivity | 9.73 | 1.79 | 5.70 | 16.27 | 547 |
| Log of size | 1.79 | 1.04 | 0 | 6.2 | 640 |
| Education | 66.95 | 33.74 | 0 | 100 | 669 |
| Training dummy | 0.39 | 0.49 | 0 | 1 | 705 |
| Access to finance dummy | 0.95 | 0.22 | 0 | 1 | 710 |
| TME | 16.24 | 9.31 | 2 | 64 | 696 |
| Capital Utilisation | 65.21 | 19.09 | 9 | 100 | 308 |

**Table 4. Correlation Matrix Among the independent variables**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| **1. Product Innovation** | 1.00 | | | | | | | |
| **2. Process Innovation** | 0.27* | 1.00 | | | | | | |
| **3. Log of size** | 0.32* | 0.37* | 1.00 | | | | | |
| **4. Education** | 0.09* | 0.35* | 0.16* | 1.00 | | | | |
| **5. Training dummy** | 0.18* | 0.32* | 0.19* | 0.14* | 1.00 | | | |
| **6. Access to Finance** | 0.04 | 0.19* | 0.43* | 0.17* | 0.07 | 1.00 | | |
| **7. Top Management** | -0.03 | 0.05 | 0.03 | -0.05 | 0.03 | 0.02 | 1.00 | |
| **8. Capacity Utilisation** | 0.06 | 0.13* | 0.03 | 0.06 | 0.13* | -0.02 | 0.05 | 1.00 |

## 4.2. Regression Results

Tables 5 and 6 below show our regression results for IV2SLS and IVOGMM estimations respectively on the linkages between innovation and productivity. From the results presented in table 5 below, it is realized that as per our a priori expectations, both process and product innovations are strongly and statistically significant positively at 1% and 5% significant level respectively. Productivity is positively impacted by both process and product innovation in the Ghanaian firms. This is possible through the following channels: First, innovation reduces inefficiencies, wastages, idle times and encourages efficiencies in production. Secondly it reduces the number of employees and possibly the time needed to carry out a particular task. And finally it opens up more opportunities by way of creating new markets, expanding markets and the need to even produce more to satisfy the new opportunities created by innovation. The 2SLS results have been confirmed by our GMM results presented in table 6 which also indicate a positive significant results on both process and product innovation.

These results are in support of earlier studies carried out in Canada, Iriland, Germany, Estonia, Columbia and Chile (Gu & Tang, 2004; Tang & le, 2007; Masso & Vahter, 2012; Crowley & McCann, 2014; Gallego et al., 2015; Alvarez et al., 2015). It does not however support some other earlier studies which concluded that innovation leads to lower productivity.[1] On the controlled variables, the study revealed that education impacts positively on productivity when modeled with process innovation but has no impact on productivity in the process innovation. Similarly, while training of staff leads to negative impact on productivity in process innovation model, it has no impact at all on productivity in the product innovation model. Size, access to finance, top management experience and capacity utilization are all found to have no impact on productivity in Ghana.

**Table 5. Instrumental variables two stage least square regression**

| | (1) | (2) |
|---|---|---|
| **Independent Variables** | **Labour Productivity** | **Labour Productivity** |
| Process Innovation | 1.552***(0.402) | |
| Product Innovation | | 1.421**(0.702) |
| Log of size | -0.0708(0.183) | 0.0075(0.217) |
| Education | -0.0038(0.0053) | 0.0081*(0.0043) |
| Training dummy | -0.606*(0.336) | -0.157(0.334) |
| Access to Finance dummy | -0.124(0.865) | 0.841(0.695) |
| Top Management Experience | 0.0154(0.0146) | 0.0118(0.0150) |
| Capacity Utilisation | -0.0045(0.0087) | -0.0089(0.009) |
| Sector dummy | Yes | Yes |
| Constant | 10.44***(1.356) | 7.760***(0.987) |
| | | |
| Observations | 155 | 222 |
| R-squared | 0.150 | 0.161 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

**Table 6. Instrumental variables optimal GMM regression**

| | (1) | (2) |
|---|---|---|
| **Independent Variables** | **Labour Productivity** | **Labour Productivity** |
| Process Innovation | 1.552***(0.456) | |
| Product Innovation | | 1.421*(0.985) |
| Log of size | -0.0708(0.207) | 0.0075(0.266) |
| Education | -0.0038(0.0052) | 0.0081*(0.0042) |
| Training dummy | -0.606*(0.312) | -0.157(0.377) |
| Access to Finance dummy | -0.124(0.508) | 0.841*(0.496) |
| Top Management Experience | 0.0154(0.0139) | 0.0118(0.0152) |
| Capacity Utilisation | -0.0045(0.0099) | -0.0089(0.0094) |
| Sector dummy | Yes | Yes |
| Constant | 10.44***(1.216) | 7.760***(0.896) |
| | | |
| Observations | 155 | 222 |
| R-squared | 0.136 | 0.143 |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

[1] See (Janz et. al., 2004; Duguet, 2006; Loof & Heshmati, 2006; Van Leeuwen & Klomp, 2006; Raffo et. al., 2008).

## 5. Conclusion and Policy Recommendations

Innovation in firms has being a huge catalyst in productivity and hence a boaster for economic growth (Bloomtrom & Sjoholm, 1999). This study thus set out to investigate empirically the impact that innovation in firms have on the productivity of firms in Ghana. The study made use of the latest surveys of World Bank Enterprise Survey dataset available for Ghana. Using IV2SLS and IVOGMM estimation techniques, the study established that both process and product innovation have got positive impact on the productivity of firms in Ghana. It is also noted while most employees in Ghanaian firms have got formal education, less practical or on-job training is offered to the employees by the firms. It is hence encouraged that for firms to have higher productivity that can propel the country into economic growth, innovation should be one of the major pursuits of the country.

The core competence of a firm is seen as a driving force of innovation. This core competence can be tangible or intangible (Vega-Jurado et al., 2008). Supporting this view, most empirical studies have noted the importance of internal resources and capacities to be critical in innovation of firms. Thus it is believed in many industries, R&D, investment in machinery and equipment together with the development of human capital are major driving forces in firm innovation (Jaffe, 1986; Crepton et. al., 1998; Romer, 1990; Griliches, 1998; Fred, 2003; Roper et. al., 2008).

We hence, recommend that at the firm level, firms should invest more on their R&D, machinery and equipment which are the major conduits to innovation. Besides, investments into the education and training of employees so as to enable them adapt to changes and have the ability to use innovative tools with ease. At the national level, we recommend that government should put in place the needed infrastructure such as good roads, electricity and telecommunication infrastructure. Besides, government should create the enabling business environment so as to attract quality foreign investments which also have higher propensities to diffuse innovation into local firms.

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## Appendix

**Table 7. Post Estimation Tests on the Instrumental Variable Model**

| **First Stage regression Test** | | | | |
|---|---|---|---|---|
| *Process Innovation* | Critical Values | | | |
| **Stock and Yogo (2005)** | 10% | 15% | 20% | 30% |
| 2SLS size of nominal 5% Wald test | 16.38 | 8.96 | 6.66 | 5.53 |
| LIML size of nominal 5% Wald test | 16.38 | 8.96 | 6.66 | 5.53 |
| Cragg and Donald (1993) | Minimum Eigen Value Statistics=18.1397 | | | |
| Summary Statistics | R-sq=0.4490; Adj R-sq=0.4188; Partial R-sq=0.1105; Prob>F=0.0000 | | | |