Competition and Innovation Behavior of Firms in Sub-Saharan Africa

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Abstract

The paper exploits a comparative panel survey of manufacturing firms in Ghana, Kenya, and Tanzania to investigate the relationship between product market competition and innovation.

We find evidence that the relationship between product market competition and innovation is non-linear and displays an inverted U shape which is robust over several different specifications.

More specifically our results demonstrate that when competition is low to begin with, an increase in competition has a negative effect on innovation as predicted by the Schumpeterian effect. In contrast, we find that an increase in competition when the level of competition is already high results in faster innovation activity as predicted by the escape competition effect. The interaction of these two opposing effects explains the observed non-linear relationship between competition and innovation. Implications for practice and future research are also discussed.

1. Introduction

It is widely recognized that innovation plays a key role in determining productivity. As a matter of fact, one of the stylized facts that has emerged from firm level studies is that productivity is positively related to innovation efforts such as Research and Development (R&D) across firms (Klette and Kortum, 2004). This empirical regularity is very important, given that much of the per capita income differences across countries can be explained by differences in productivity as pointed out by Hall and Jones (1999), Easterly and Levine (2001) and others. Therefore, to the extent that productivity is largely driven by innovation, it is important to understand factors that directly impact innovation at the firm level.

This study exploits a comparative panel survey of more than 1000 firms in four manufacturing industries: textile & garment, food & beverage, metals & machinery and wood & furniture to study the nature of the relationship between product market competition and innovation in Ghana, Kenya, and Tanzania. We consider technological innovation which focuses on the creation or introduction of new and improved products or production processes. The importance of innovation has already been made apparent in the discussion above, and there are several reasons why we focus on the influence of product market competition on innovation. To begin with, the relationship between competition and innovation has fascinated economists for a long time, and yet no general consensus has emerged regarding the nature of this relationship. Both theoretical and empirical studies provide ambiguous evidence, and this points to the complexity of the relationship between competition and innovation. Syverson (2011) notes that competition is one of the most important environmental elements that has an influence on productivity and innovation. It is also closely linked to government policy. Thus, understanding market competition is warranted when considering the innovation implications of government policy interventions designed to alter the intensity of competition in an industry.

We use the Lerner index to calculate an indicator of product market competition which varies between 0 and 1, with higher values indicating greater market competition. On average, we find that this indicator is about 0.8 in value, implying that the average level of market competition in the sample countries is quite high. Our measure of innovation is the technology gap which captures how far a firm's technology standard differs from the best available practices. Lower values of the technology gap measure indicate superior innovation.

We find evidence that the relationship between product market competition and innovation is non-linear and displays an inverted U shape which is robust over several different specifications. More specifically, we find that the linear effect of competition on innovation is positive and statistically significant, while the estimated coefficient on the squared competition term is negative and also statistically significant. The inverted U relationship between product market competition and innovation that is displayed in our results can be explained by the Schumpeterian and escape competition effects. The positive linear effect of competition on innovation is consistent with the Schumpeterian view which points out that when competition is low to begin with, an increase in competition reduces monopoly rents that can be used to fund innovation activities, and at the same time, it also makes firms less capable of appropriating returns from investments in the innovation activities. As a result, more competition in this case has the effect of reducing post innovation rents below pre-innovation rents, and thereby discouraging innovation (Schumpeterian effect). It may also be that low competition prevents incumbent firms from moving closer to the efficiency frontier, and since these firms have to spend a lot of resources to move closer to the frontier, they may not be in a position to respond to increased competition by increasing expenditures on innovation.

The negative squared effect of competition on innovation implies that when competition is very high, an increase in competition results in faster innovation activity. In this case, greater competition has the opposite effect of driving down pre-innovation rents much more than post-innovation rents. This gives rise to the escape competition effect--firms innovate so as to escape competition and earn higher post innovation rents. Also, when competition is high, more efficient firms have an incentive to move even closer to the efficiency frontier. Therefore, along the lines of Aghion et. al. (2005), firms with the highest efficiency innovate because they don't have to spend a lot of resources to stay ahead of competitors. However, as cautioned by Aghion and Griffith (2005), the level of competition corresponding to the turning point of the inverted U curve should be interpreted with caution since the relationship between competition and innovation tends to be dynamic and thus evolves over time.

From a policy standpoint, our results imply that competition enhancing measures will foster more product innovation by incumbent firms in the sample countries. These measures include granting local firms greater opportunities to participate in global business activities through importing, exporting, and the entry of foreign firms. They also include policies such as reforms in regulatory barriers which can have a positive impact on innovation when market competition and productivity is stimulated by the increase in the entry rate of domestic firms.

Sub-Saharan Africa (SSA) has experienced impressive growth in recent years which is expected to surpass 5% in 2014 according to the April 2014 Regional Economic Outlook published by the IMF. There is however growing concern among development partners in the region including the African Development Bank (AfDB) that higher economic growth has not been inclusive or broad based in the sense that it has not provided employment and consumption opportunities for large segments of the population. This is true for the three countries studied in this paper--Ghana, Kenya, and Tanzania-- as well as other countries in the region. Dutz et. al. (2011) provide evidence which shows that national level market competitiveness plays a key role in stimulating innovation-driven inclusive growth. Their analysis shows that firms that innovate hire a larger share of unskilled workers and that the share of unskilled workforce is responsible for much of the employment growth in firms that innovate. Thus, product market competition could play a significant role in fostering growth in SSA that is both sustainable and inclusive, given our findings which provide evidence that product market competition is positively associated with the proclivity of firms to innovate. Policy makers should therefore become familiar with the relationship between innovation and competition, and be aware that this relationship is not necessarily monotonic by nature. To our knowledge, the empirical links between product market competition and innovation in SSA have not been studied before.

The rest of this paper is organized as follows. The next section reviews related theoretical and empirical literature on competition and innovation. Section 3 provides the empirical framework: overview of the data, how product market competition and innovation are measured, and the empirical model used to evaluate the relationship between innovation and product market competition. The main findings from our empirical analysis as well as robustness tests are presented and discussed in section 4. Section 5 summarizes the main findings and implications of the paper, and provides suggestions for the direction of future research.

2. Relevant Literature

2.1. Theoretical Predictions

The theoretical relationship between innovation and competition has been of major interest to Economists for a long time. An enormous literature has emerged as a result. The views presented in this literature can be usefully divided into three categories: the traditional view, the Schumpeterian view, and the Aghion et. al. view. We discuss each of these views in detail below.

The traditional view which has been held to be true for the longest time is that innovation should increase with competition. Pressure from actual and potential competition raises incentives for production efficiency which in turn motivates innovation by incumbent firms (Arrow, 1962; Gilbert and Newbery, 1982). Firms that are more efficient produce at lower cost and gain larger market shares, whereas inefficient firms with higher costs lose market shares, forcing them in some cases to eventually exit the market. The exit of least productive firms creates room for more efficient firms to enter. In such a competitive environment, the adoption of productivity enhancing innovation is essential for firm survival and growth.

The global engagement literature is built around the traditional view and it makes the case that domestic firms innovate and improve their productivity if they are exposed to international competition. There are three key mechanisms through which international competition leads to productivity improvement. The first is exporting. Two main reasons have been put forward to explain productivity differences between exporters and non-exporters. The first reason is based on the self-selection hypothesis according to which additional sunk costs associated with exporting lead to the self-selection of more productive firms (which can overcome these costs) into export markets. The self-selection hypothesis is supported by theoretical models of trade and firm heterogeneity such as Melitz (2003), Bernard et al. (2003) and Yeaple (2005). The second reason is based on the learning-by-exporting hypothesis. Under this hypothesis, knowledge effects from exposure to state of the art technology from foreign buyers and international competitors, as well as exposure to more intense foreign competition increase the post entry productivity of exporters.

The second mechanism is importing. Firms are able to innovate and achieve productivity gains through access to technology and knowledge embodied in imported intermediate materials and capital goods. A third mechanism is foreign direct investment, which in the literature is considered to be the most important channel for international technology transfer, transmission of new ideas, entrepreneurial skills, and other knowledge transfers which can boost firm innovation and productivity (Aitken and Harrison, 1999; Carr et al., 2001). From the traditional viewpoint, it is quite clear that poorly regulated markets can impede innovation. They can be sources of entry barriers, they can raise entry costs, or protect special interest groups, all of which stifles competition and innovation. Inappropriate regulations can also lead to mobility barriers, a costly business environment, and distortions which reduce incentives for existing firms to invest and innovate.

In sharp contrast, the Schumpeterian view is that increased product market competition negatively affects a firm's proclivity to innovate by reducing rents from innovation, since in the absence of monopoly power, a firm may not easily appropriate returns from investments related to innovation (Salop,1977; Dixit and Stigliz, 1977; Romer,1990; Aghion and Howitt, 1992 among others). In other words, large firms with market power tend to be more innovative than firms in competitive markets.

Unlike the traditional and Schumpeterian views, Aghion et. al. (2005) contend that the effect of product market competition on innovation is non-linear. They show that competition can have different effects on the willingness of firms to innovate depending on pre and post innovation rents. Firms that are closer to the efficiency frontier (firms with highest efficiency) are most likely to innovate when faced with higher competition which drives down pre-innovation rents (the rents they earn if they do nothing). These firms have to spend relatively less to stay ahead of new competitors, and thus innovation becomes a mechanism that these firms can use to escape competition and maintain or increase their post innovation rents. This is the escape-competition effect. On the other hand, competition drives down post innovation rents for firms that are farther away from the efficiency frontier. Since these firms have to spend a lot of resources to move closer to the frontier, they respond to increased competition by reducing their expenditures on innovation to minimize costs. In other words, an increase in competition leads to a Schumpeterian effect since it does not help laggards escape competition, and hence they do not have the incentive to innovate. Aghion et. al. (2005) further show in their model that when competition is low, the proportion of efficient firms (also referred to as "neck-and neck" competing firms) is larger, so that the escape-competition effect most likely dominates the Schumpeterian effect. In contrast, when competition is high, there is a larger proportion of laggard firms with low profits, and the Schumpeterian effect is most likely to dominate. Taken together, these two opposing effects therefore imply an inverted U relationship between product market competition and innovation as pointed out by Aghion et. al. (2005).

2.2. Empirical Literature

The different theoretical viewpoints have generated a substantial amount of empirical research on the relationship between product market competition and innovation. There is however no compelling evidence in the research studies in favor of any of the theoretical perspectives. This section reviews some of this empirical literature.

Starting with the traditional view, there is a growing strand of literature which finds that higher bureaucratic barriers to entry reduce productivity growth of existing firms because the disciplinary effects of competition are inhibited. As pointed out by Klapper et al. (2006) and Aghion et al. (2009), entry barriers reduce incentives to innovate and prevent incumbent firms from moving closer to the technological frontier, and this in turn reduces future productivity. As a result, incumbent firms are most likely to become far too reliant on incumbency rents than on productivity gains offered by superior technology. Thus policies such as reforms in regulatory barriers to increase the entry rate of domestic firms increase market competition and productivity (Klapper et.al, 2006; Djankov et. al, 2002), and should also have a positive impact on innovation. A survey of the literature by Crafts (2006) shows that the most significant adverse effects of regulation on economic performance stem from the negative effects on incentives for firms to invest and innovate.

There has been a lot of interest in the literature in examining the role of exporting, importing, and FDI as key mechanisms through which global engagement leads to productivity improvement and hence innovation. The literature has shown that exporters are more productive than non-exporters, and this holds true for a wide range of countries. In their seminal work, Bernard and Jensen (1995) used firm level data to show that labor productivity was approximately a third higher for exporters in the United States over the period 1976-1987. Subsequent firm level studies have found that exporters tend to be more productive in other countries as well. Selected examples include Baldwin and Gu (2003) for Canada, Meller (1995) and Alvarez and Lopez (2005) for Chile, Kraay (2002) for China, Clerides et. al. (1998) and Isgut (2001) for Colombia, Wagner (2005) for Germany, Blalock and Gertler (2004) for Indonesia, Castellani (2002) for Italy, Aw et al. (2000) and Hahn (2004) for Korea, Clerides et. al. (1998) for Morocco and Mexico, and Girma, Greenaway and Kneller (2004) for UK, among others.

The self-selection hypothesis is supported by the empirical literature (for example Clerides et.al.(1998), Bernard and Wagner (1997), Bernard and Jensen (1999), and Aw et. al. (1997)). Furthermore, evidence on productivity differences between future export starters and non-starters provide additional support of the self-selection hypothesis. Future export starters are found to be more productive than future non-exporters in the pre-entry period. While some studies have found evidence of a learning effect from exporting, other studies find no significant differences in productivity between exporters and non-exporters in the post entry period. As such, evidence on the learning-by- exporting hypothesis remains inconclusive (see for example Wagner, 2007). In addition, the evidence from the previous studies reviewed above indicates that export stoppers experience a decline in productivity.

According to Keller (2004), in most countries, foreign sources of technology account for at least 90% of growth in productivity, and only a handful of rich countries are responsible for creating most of the world's new technologies. SSA's heavy dependency on imported capital and intermediate goods is well documented in the literature. Previous country studies by Wangwe (1983), Green and Kadhani (1986), and Davies and Rattso (1993) report a high degree of dependency on foreign capital goods in SSA. For example, estimates of the ratio of capital goods imports to investment by Green and Kadhani (1986) range between 65-75% for the manufacturing sector in Zimbabwe. SSA-wide studies by Moran (1989) and Ndulu (1991) also find a high degree of import dependency. The literature has shown that the use of imported intermediate and capital goods by developing countries improve performance of domestic firms because they provide technology and knowledge that domestic firms do not possess. For example, a recent study of 340 firms in Botswana by Habiyaremye (2013) finds that imported capital goods increase firm productivity. Studies from other regions have also found similar results, including the study by Amiti and Konings (2007) which finds that the liberalization of input tariffs led to gains in productivity for domestic establishments in Indonesia. In a recent study, Seker (2012) also shows that firms that import intermediate products grow faster and innovate more than non-traders in a sample of developing countries.

FDI has long been considered to be an important channel for the transfer of technology and other positive externalities that enhance productivity and innovation in host nations. The evidence from micro productivity studies for the United Kingdom and United States reviewed by Keller (2004) shows that FDI has positive spillovers which are economically significant in some cases. Firm level studies on developing countries report similar results as well, including Yasar and Paul (2007), who find that while both foreign ownership and exporting are positively related to productivity in Turkish manufacturing plants, the effect of foreign ownership is greater than that for exports. The positive productivity effect of foreign ownership is also found to be greater than that of domestically owned firms. For example Hallward-Driemeier, Wallsten, and Xu (2006) show that Chinese enterprises with private foreign ownership are more productive than domestically owned private enterprises. Their results lend support to earlier findings by Xu, Zhu, and Lin (2005) and Zhang, Zhang, and Zhao (2001).

Turning now to the Schumpeterian and the Aghion et. al. views, there has been mixed evidence in the literature. While the earlier studies following Schumpeter (1943) generally found a negative relationship between competition and innovation, subsequent studies such as Scherer (1967) and Kamien and Schartz (1972) found an inverted U relationship instead. Thereafter, other studies such as Geroski (1995), Nickel (1996), and Blundell et. al (1999) report a positive relationship. In recent years, attention has focused more on testing the non-linear relationship between innovation and competition. In their influential study, Aghion et. al. (2005) find strong evidence of an inverted U effect of competition on innovation using panel data for a sample of firms listed on the London Stock Exchange.   This non-linear relationship is explained by their theoretical model which shows that when competition is low, the proportion of efficient or "neck-and neck" competing firms is larger, so that the escape-competition effect most likely dominates the Schumpeterian effect. In contrast, when competition is high, there is a larger proportion of laggard firms with low profits, and the Schumpeterian effect is most likely to dominate. However studies focusing on transition economies by Carlin, et. al (2004) and Gorodnichenko (2009), as well as a recent study on publicly traded firms in the United States by Hashmi (2013) among other studies, do not find support for the inverted U hypothesis.

3. Data and Empirical Framework

3.1. Overview of the Data

The primary dataset for this study is based on a comparative panel survey of firms provided by the Center for the Study of African Economies at Oxford University. It covers four manufacturing industries: textile & garment, food & beverage, metals & machinery and wood & furniture in three Sub-Saharan African countries (Ghana, Kenya, and Tanzania) for the period

1991 to 2003. Unless otherwise stated, all firm-level data used for the study comes from this survey. For each country and year, the data identifies each firm, the manufacturing sector in which the firm operates, output, labor, materials, capital and other inputs used by firms. The data also record other firm characteristics such as educational status of employees, firm's age, ownership structure, and whether a firm participates in the export market. Capital, materials, other inputs, wages and output per worker are deflated such that their values are expressed in real US dollars.

Table 1 shows the number of unique firms by country and industry. The total sample consists of 1054 unique firms that were active between 1991 and 2003. Kenya has the highest number of firms (405) that are almost evenly distributed across the four industries, whereas Ghana has the least number of firms in the sample (274). The highest number of firms is in the wood and furniture industry, with the remaining firms more or less equally distributed in the remaining industries. At the industry level, metal & machinery and wood & furniture both account for about 27 percent of the total number of firms, and the other 46 percent are evenly distributed among the two other industries. Overall, these 1054 unique firms yield a total of 8101 observations over the sample period under consideration (1991-2003).

3.2. Measuring Innovation

Our measure of innovation is the technology gap that captures how far a firm's technology standard differs from the best available practices. To construct the technology gap, we follow the methodology similar to Blalock and Gertler (2009). For each country, we subtract the average total factor productivity (TFP) for each firm in the first four years of the sample (1991 to 1994) from the median TFP for domestic firms with foreign ownership operating in the same industry as the firm, and divide by the average TFP for domestic firms with foreign ownership operating in the same industry. We consider the deviation of domestic firms with no foreign ownership TFP from that of domestic firms with foreign ownership since firms with foreign ownership are considered to possess technology that is close to the international frontier than fully owned domestic firms. To minimize the possibility of TFP and technology gap being contemporaneously correlated, we calculate technology gap using TFP data from 1991 to 1994 and use the same value for each firm across all years. A negative value indicates superior technology above the standard practice in the industry, whereas a positive value indicates inferior technology below standard practice in the industry. For instance, a gap of +0.15 indicates that a firm's technology standard is 15% below the median firm with foreign ownership, whereas a gap of -0.15 indicates that a firm's technology standard is 15% above the median firm with foreign ownership.

Since the TFP and technology gap measurements rely on the residuals of an initial production function estimate, it is important that the first stage production model be correctly specified. A key issue in estimating a firm level productivity model is the potential correlation between unobserved productivity shocks and input choice. A positive productivity shock for instance will encourage profit-maximizing firms to increase output supply by expanding input selection, leading to simultaneity bias in input choice when the model is estimated by Ordinary Least Squares (OLS). To minimize this possibility, we estimate our first stage production function using the Levinsohn-Petrin (2003) and Petrin et al. (2004) estimation strategy. To implement this procedure, let the production technology of a firm be a Cobb-Douglas of the following form:

$$Y_{it} = \beta_0 + \beta_k K_{it} + \beta_m M_{it} + U_{it} \qquad (1)$$

where Y_{it}, is the logarithm of the firm's output per worker, M_{it} is the logarithm of materials per worker and K_{it} is the logarithm of capital per worker. Subscripts i and t represent firm and time respectively, and β_s capture the parameters of the respective explanatory variables. The error term U_{it} has two components, such that $U_{it} = \omega_{it} + \eta_{it}$, where η_{it} is the standard independent and identically distributed (iid) error term that is uncorrelated with capital per worker and materials per worker. The other component ω_{it} is the state component that is observed by the firm but not the econometrician. It impacts the firm's decision rule and consequently its optimal choice of capital and labor, which leads to inconsistent estimates of the relevant β_s since $E[U_{it}|K_{it,}M_{it}] \neq 0$.

Levinsohn and Petrin (2003) show that one can still obtain consistent estimates of the parameters of a production function by using intermediate inputs to correct for the presence of simultaneity bias. In our estimates, we use the logarithm of other inputs as a proxy for intermediate inputs. For robustness and comparison purposes, we also show results obtained by implementing the Olley and Pakes (1996) procedure and the OLS procedure. Further details on how these procedures are implemented and results of our first stage production function estimation are not reported for the sake of brevity, but can be requested from the authors.
After obtaining the parameters in equation (1), TFP is obtained by recovering the residuals using

equation (2) below:

$$TFP_{it} = \exp(Y_{it} - \hat{\beta}_k K_{it} - \hat{\beta}_m M_{it}) \qquad (2)$$

Other measures of innovation such as R&D expenditure and patenting activity could not be analyzed due to lack of data.

3.3. Measuring Product Market Competition

Our main indicator of product market competition is based on the Lerner Index (LI), which we construct using a methodology similar to that of Aghion et. al. (2005) as follows:

$$LI_{it} = \frac{Operating\ Profit_{it}}{Sales_{it}} \qquad (3)$$

Product market competition (PMC) is obtained by averaging LI across firms within an industry as shown below.

$$PMC_{ct} = 1 - \frac{1}{N_{ct}} \sum\nolimits_{i \in c} LI_{it} \qquad (4)$$

Subscripts i, c, and t denote firms, industry, and time respectively, while N represents the number of firms. PMC assumes a maximum value of 1 if there is perfect competition and lower values indicate greater market power. For robustness purposes we also calculate PMC using the Herfindahl Index (HI) described below.

$$HI_{ct} = \sum_{N} \left(\frac{Sales_{itc}}{Sum(Sales_{itc})} \right)^2 \qquad (5)$$

When sales are evenly distributed over a large number of products within an industry, HI approaches zero; and when there is a single product, HI is one. Thus, the more diversified/less concentrated the composition of industry sales, the smaller is the value of the Herfindahl index.

3.4. The Model

We estimate the following benchmark specification with pooled data to evaluate the relationship between innovation and product market competition:

$$techgap_{itj} = \beta_0 PMC_{ctj} + \beta_1 PMC_{ctj}{}^2 + \lambda_c + \delta_j + \tau_t + \varepsilon_{ictj}$$

(6)

were subscripts i, c, j, and t represent firm, industry, country, and time respectively. The dependent variable is innovation which is measured by the technology gap ($techgap$). Product market competition is captured by the variable PMC, and we include both the level and squared terms to assess the non-linear effect of product market competition on innovation. The primary measure of PMC that we use is calculated from the Lerner index using equation (4) above. However, for robustness purposes we also calculate PMC using the Herfindahl index as shown in equation (5) above. To better isolate the effect of product market competition on innovation, our estimation strategy takes into account a series of sector (δ_c), country (λ_j), and time (τ_t) dummies. The country and sector dummies are included to control for unobserved time-invariant differences between countries and sectors that affect the level of innovation in the country and sector/industry respectively, while time dummies control for unobserved country and sector time fixed effects that might affect the level of innovation in the country and sector. The variable ε_{ijtc} is the disturbance term.

4. Main Findings

4.1. Benchmark Results

The benchmark results from equation (6) obtained by estimating different specifications are presented in Table 2. In all estimations, the indicator of product market competition is based on the Lerner index. All specifications are estimated by pooled OLS with robust standard errors shown in parentheses. In column (1), the linear effect of competition on innovation is positive and statistically significant at the one percent level. To capture the non-linear effect of competition on innovation, we add a squared term to the base regression and report the results in column (2). The estimated coefficient on competition remains positive and significant at the one percent level, while the estimated coefficient on the squared competition term is negative and also significant at the one percent level. These results therefore imply that an increase in competition initially has a significant negative effect on innovation up to a point. Beyond this point, a further increase in competition has the opposite effect which actually stimulates innovation. In column (3), we include year fixed effects only, and in column (4) we add industry fixed effects only, and the coefficients on the level and squared terms for competition remain positive and negative respectively, and they are still significant at the one percent level. We re-estimate the model with industry, country, and time fixed effects all included and the results are shown in column (5). We find that the effect of competition on innovation is significant at the one percent level, and there is no diminishing effect on innovation as before. Based on the coefficient estimates, the turning point is at 0.89, which is very close to the maximum value of the Lerner based competition indicator.

The inverted U relationship between product market competition and innovation that is displayed in our results can be explained by the Schumpeterian and escape competition effects. The positive linear effect of competition on innovation implies that when competition is low to begin with, an increase in competition reduces monopoly rents that can be used to fund innovation activities, and at the same time, it also makes firms less capable of appropriating returns from investments in the innovation activities. As a result, the Schumpeterian effect dominates because more competition in this case has the effect of reducing post-innovation rents below pre-innovation rents, and thereby discouraging innovation. It may also be that low competition prevents incumbent firms from moving closer to the efficiency frontier, and since these firms have to spend a lot of resources to move closer to the frontier, they may not be in a position to respond to increased competition by increasing expenditures on innovation.

The negative squared effect of competition on innovation implies that when competition is very high, an increase in competition results in faster innovation activity. In this case, greater competition has the opposite effect of driving down pre-innovation rents much more than post-innovation rents. This give rise to the escape competition effect--firms innovate so as to escape competition and earn higher post innovation rents. Also, when competition is high, more efficient firms have an incentive to move even closer to the efficiency frontier. Therefore, along the lines of Aghion et. al. (2005), firms with the highest efficiency innovate because they don't have to spend a lot of resources to stay ahead of competitors. In Aghion et. al. (2005), the inverted U relationship between product market competition and innovation is explained firstly by the fact that when competition is low, the proportion of efficient firms (also referred to as "neck-and neck" competing firms) is larger, so that the escape-competition effect most likely dominates the Schumpeterian effect. Secondly, when competition is high, there is a larger proportion of laggard firms with low profits, and the Schumpeterian effect is most likely to dominate.

4.2. Robustness Checks

We conduct robustness checks of the baseline specification in three ways. First, we use the Herfindahl index as an alternative measure of product market competition. Second, we perform country level estimations, and lastly we address the problem of potential endogeneity of the competition measure.

4.2.1. Robustness of the product competition measure

To test the robustness of the product market competition measure associated with the Lerner index, we re-estimate the baseline equation with the Herfindahl index (HI) of product market competition. As explained in section 3.3, when sales are evenly distributed over a large number of products within an industry, HI approaches zero, and when there is a single product, HI is one. Thus, the more diversified/less concentrated the composition of industry sales, the smaller is the value of HI. The results are presented in Table 3. All specifications are estimated by pooled OLS with robust standard errors shown in parentheses. The linear effect of HI on innovation in columns (2) –(5) is positive and statistically significant at the one percent level, while the estimated coefficient on HI squared is uniformly negative and significant at the one percent level as well. These results therefore also imply that an increase in competition initially has a significant negative effect on innovation up to a point. Beyond this point, a further increase in competition has the opposite effect which actually stimulates innovation. There is no diminishing effect on innovation. As before, column (3) includes year fixed effects only, column (4) includes industry fixed effects only, while column (5) includes industry, country, and time fixed effects. Our basic results are therefore robust when an alternative measure of product market competition is used in the estimation.

4.2.2. Country level estimations

In our second robustness check, we re-estimate the baseline equation separately for each of the three countries in our sample. For each country, all specifications are estimated by pooled OLS with robust standard errors shown in parentheses. Columns (1)-(3) in Tables 4-6 report the effect of HI on innovation, and columns (4)-(6) report the effect of the Lerner based indicator on innovation. For Kenya (Table 4), both the level and squared terms of the two competition measures are positive and negative respectively in all estimations, and the the estimated coefficients are significant in column (3), column (5) and column (6) which controls for time fixed effects. For Ghana (Table 5), we find similar but insignificant results in column (2) and column (6), while the results in column (5) are also similar and significant. In Tanzania (Table 6), the level and squared terms of the competition measures are positive and negative respectively in all estimations as in the case of Kenya, however, only the estimated coefficients for HI are significant. Our basic results are therefore robust only in some of the country level estimations.

4.2.3. Potential endogeneity of product market competition

There is a potential problem that product market competition could be endogenous due to reverse causality. For example, some firms can increase their market power by being more innovative. We address this potential problem by using three year lagged values of the competition variables. This rules out the possibility that the relationship between innovation and competition is caused by contemporaneous shocks to these variables and by reverse causality. The results are reported in Table 7. Overall, these results are similar to the benchmark results, and this suggests that using current values of the competition variables does not bias the findings. Results obtained for the country level estimations provide additional supportive evidence, but are not reported here for the sake of brevity.

5. Summary and Implications

In this paper, we exploit a comparative panel survey of more than 1000 firms in four manufacturing industries: textile & garment, food & beverage, metals & machinery and wood & furniture to study the nature of the relationship between product market competition and innovation in Ghana, Kenya, and Tanzania. We use the Lerner index to calculate an indicator of product market competition which varies between 0 and 1, with higher values indicating greater market competition. Our measure of innovation is the technology gap which captures how far a firm's technology standard differs from the best available practices. Lower values of the technology gap measure indicate superior innovation.

We find evidence that the relationship between product market competition and innovation is non-linear and displays an inverted U shape which is robust over several different specifications. More specifically, we find that the linear effect of competition on innovation is positive and statistically significant, while the estimated coefficient on the squared competition term is negative and also statistically significant. The inverted U relationship between product market competition and innovation that is displayed in our results can be explained by the

Schumpeterian and escape competition effects. The positive linear effect of competition on innovation implies that when competition is low to begin with, an increase in competition reduces monopoly rents that can be used to fund innovation activities, and at the same time, it also makes firms less capable of appropriating returns from investments in the innovation activities. As a result, the Schumpeterian effect dominates because more competition in this case has the effect of reducing post-innovation rents below pre-innovation rents, and thereby discouraging innovation. It may also be that low competition prevents incumbent firms from moving closer to the efficiency frontier, and since these firms have to spend a lot of resources to move closer to the frontier, they may not be in a position to respond to increased competition by increasing expenditures on innovation.

The negative squared effect of competition on innovation implies that when competition is very high, an increase in competition results in faster innovation activity. In this case, greater competition has the opposite effect of driving down pre-innovation rents much more than post-innovation rents. This give rise to the escape competition effect--firms innovate so as to escape competition and earn higher post innovation rents. Also, when competition is high, more efficient firms have an incentive to move even closer to the efficiency frontier. Therefore, along the lines of Aghion et. al. (2005), firms with the highest efficiency innovate because they don't have to spend a lot of resources to stay ahead of competitors. However, as cautioned by Aghion and Griffith (2005), the level of competition corresponding to the turning point of the inverted U curve should be interpreted with caution since the relationship between competition and innovation tends to be dynamic and thus evolves over time.

From a policy standpoint, our results imply that competition enhancing measures will foster more product innovation by incumbent firms in the sample countries. These measures include granting local firms greater opportunities to participate in global business activities through importing, exporting, and the entry of foreign firms. They also include policies such as reforms in regulatory barriers which can have a positive impact on innovation when market competition and productivity is stimulated by the increase in the entry rate of domestic firms. Some studies have also highlighted the importance of product market competition in fostering innovation-driven inclusive growth which is currently lacking in SSA.

In this study, we only considered the technology gap as the measure of innovation because data on other measures of innovation were not available in our main dataset. Another useful source of information is The World Bank Enterprise Surveys (www.enterprisesurveys.org) which provide a wealth of data that future studies can use to answer a variety of research questions pertaining to innovation in Africa. Below are some examples of questions used by the Enterprise Surveys (under topic H) to collect data on innovation:

a. During the last three years, has this establishment introduced new or significantly improved products or services?
b. During the last three years, has this establishment introduced any new or significantly improved methods of manufacturing products or offering services?
c. During the last three years, did this establishment spend on formal research and development activities, either in-house or contracted with other companies?

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Tables and Figures

Table 1: Number of Unique Firms by Country and Industry

	Wood & Furniture	Food & Bakery	Metal & Machinery	Textiles & Garment	Total
Ghana	77	69	63	65	274
Kenya	96	98	107	104	405
Tanzania	109	76	119	71	375
Total	282	243	289	240	1054

Table 2: Benchmark Results

	(1)	(2)	(3)	(4)	(5)
VARIABLES	Tech_Gap	Tech_Gap	Tech_Gap	Tech_Gap	Tech_Gap
Competition	7.086***	64.349***	55.374***	58.387***	8.225**
(Using LI)	(0.189)	(2.695)	(3.044)	(2.596)	(3.375)
Competition squared		-34.559***	-27.942***	-31.330***	-4.599**
(Using LI)		(1.614)	(1.854)	(1.546)	(2.011)
Observations	8,101	8,101	8,101	8,101	8,101
R-squared	0.148	0.201	0.316	0.284	0.492
# obs.	8101	8101	8101	8101	8101

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

Table 3: Results for HI

	(1)	(2)	(3)	(4)	(5)
VARIABLES	Tech_Gap	Tech_Gap	Tech_Gap	Tech_Gap	Tech_Gap
Competition	-0.516***	3.205***	3.159***	1.086***	1.928***
	(0.057)	(0.307)	(0.382)	(0.305)	(0.314)
Competition squared		-3.130***	-3.192***	-1.213***	-1.887***
		(0.251)	(0.304)	(0.253)	(0.249)
R-squared	0.010	0.030	0.120	0.129	0.399
# obs.	8101	8101	8101	8101	8101

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

Table 4: Results for Kenya

VARIABLES	(1) Tech_Gap	(2) Tech_Gap	(3) Tech_Gap	(4) Tech_Gap	(5) Tech_Gap	(6) Tech_Gap
Competition (HI)	-0.002	0.375	1.020**			
	(0.063)	(0.315)	(0.469)			
Competition^2 (HI)		-0.331	-0.850**			
		(0.271)	(0.384)			
Competition (LI)				0.398*	50.846***	366.048***
				(0.223)	(6.271)	(20.888)
Competition^2 (LI)					-28.843***	-230.231***
					(3.559)	(13.139)
Observations	2,968	2,968	2,968	2,968	2,968	2,968
R-squared	0.000	0.001	0.001	0.001	0.027	0.112
# obs.	2968	2968	2968	2968	2968	2968

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

Table 5: Results for Ghana

VARIABLES	(1) Tech_Gap	(2) Tech_Gap	(3) Tech_Gap	(4) Tech_Gap	(5) Tech_Gap	(6) Tech_Gap
Competition (HI)	-0.206**	0.407	-0.160			
	(0.089)	(0.447)	(0.744)			
Competition^2 (HI)		-0.526	0.109			
		(0.371)	(0.585)			
Competition (LI)				0.884**	17.623***	1.783
				(0.374)	(4.018)	(11.963)
Competition^2 (LI)					-10.608***	-1.406
					(2.559)	(8.725)
Observations	2,774	2,774	2,774	2,774	2,774	2,774
R-squared	0.002	0.003	0.110	0.002	0.008	0.110
# obs.	2774	2774	2774	2774	2774	2774

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

Table 6: Results for Tanzania

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Tech_Gap	Tech_Gap	Tech_Gap	Tech_Gap	Tech_Gap	Tech_Gap
Competition (HI)	-0.812***	6.415***	7.726***			
	(0.083)	(0.607)	(0.720)			
Competition^2 (HI)		-5.588***	-6.614***			
		(0.463)	(0.544)			
Competition (LI)				6.160***	26.220	24.626
				(0.717)	(27.295)	(35.972)
Competition^2 (LI)					-11.811	-3.718
					(15.960)	(21.175)
Observations	2,359	2,359	2,359	2,359	2,359	2,359
R-squared	0.039	0.098	0.109	0.030	0.030	0.090
# obs.	2359	2359	2359	2359	2359	2359

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

Table 7: Results Using 3 Period Lags for Competition Variables

	(2)	(3)	(4)	(5)	(7)	(8)	(9)
VARIABLES	Tech_Gap	Tech_Gap	Tech_Gap	Tech_Gap	Tech_Gap	Tech_Gap	Tech_Gap
Competition (LI)	52.929***	51.181***	46.525***	12.606***			
	(3.042)	(3.271)	(2.911)	(4.059)			
Competition^2 (LI)	-26.889***	-25.366***	-23.354***	-6.563***			
	(1.828)	(2.016)	(1.740)	(2.373)			
				(0.112)			
Competition (HI)					5.662***	4.586***	3.843***
					(0.489)	(0.550)	(0.446)
Competition^2 (HI)					-5.182***	-4.454***	-3.591***
					(0.376)	(0.427)	(0.352)
R-squared	0.299	0.402	0.342	0.482	0.057	0.159	0.127
# obs.	4975	4975	4975	4975	4975	4975	4975

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