Journal of Evolutionary Economics (2021) 31:605–637
https://doi.org/10.1007/s00191-020-00688-2

REGULAR ARTICLE

Product innovation and informal market competition in sub-Saharan Africa

Firm-level evidence

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Published online: 5 July 2020

Abstract
The interaction between formal and informal businesses continues to grow in African countries. Yet, competition from informal enterprises remains one of the top three obstacles formal businesses face in sub-Saharan Africa. This paper investigates the effect of informal competition on the performance of innovative products introduced by formal firms. We combine the World Bank's Enterprise Survey with the Innovation Follow-up Survey for five sub-Saharan African countries, and construct two indicators of informal competition, one regional (local)-specific and the other one industry-specific. We find that local informal competition has a robust negative effect on product innovation intensity of formal firms, while within industry informal competition enhances innovative sales. However, larger firms are less affected by local informal competition and actually get a boost in innovative sales from informal competition. We argue that local informal competition harms the performance of product innovation, but only for formal firms that lack strategic collaborative 'footholds' in the informal economy.

Keywords Informality · Market Competition · Product innovation · sub-Saharan Africa

JEL Classification D22 · L21 · L25 · O17 · O31

1 Introduction

The informal economy in sub-Saharan Africa (SSA) has not only persisted over time, it has also grown over the years to become a critical socio-economic pillar, and a

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source of livelihood for many people (La Porta and Shleifer 2014; Gërxhani 2004). Therefore, scholars and policy makers have been questioning the effects of informality on the activities of formal firms and on the economy as a whole. The informal economy is heterogeneous (Ulyssea 2018; Bargain and Kwenda 2011), with informal and formal enterprises co-existing and operating in a continuum, that is, at different degrees of informality (Ulyssea 2018; Kraemer-Mbula 2016; Kawooya 2014; Chen 2006). As a result, informal enterprises may cause competition to formal enterprises through prices at the 'local-level' where competitive interaction is found to occur in product markets (Ali and Najaman 2015; Gonzalez and Lamanna 2007). While market competition between firms is widely recognised as a driver of efficiency and growth (Aghion et al. 2001), firm-level evidence examining the effect of competition on innovation is inconclusive, and it supports two main opposing views. Some of the studies support the 'Schumpeterian effect' whereby competition has a negative effect on innovation (Hashmi 2013; Aghion and Howitt 1992; Schumpeter 1942), while others provide evidence of the 'escape-competition effect' where competition has a positive effect on innovation (see Aghion et al. 2001; Blundell et al.1999). A new strand of the literature identifies an inverted-U relationship between competition and firm-level innovations (Mendi and Costamagna 2017; Aghion et al. 2005). Most of these studies focus on developed countries and, therefore, examine mainly formal market competition with little implication of informal competition on innovation. In developing countries where the literature of informality has expanded, firm-level data reveal that the competitive behaviour of informal enterprises is one of the top three obstacles formal businesses face in product markets (Mendi and Costamagna 2017; Friesen and Wacker 2013; Gonzalez and Lamanna 2007). However, the economic implications of informal enterprises' activities is found to be under-researched in the literature (Mendi and Costamagna 2017; Bruton et al. 2012). In particular, there are very few studies that investigate the effect of informal product market competition (hereafter informal competition) on the innovation strategies of formal firms in SSA. This paper aims to fill these gaps in the literature.

To face informal competition, formal firms may introduce product innovations by employing vertical product differentiation in order to stay competitive. Innovations, particularly product innovations, remain a primary driver of firm technological competitiveness (market performance) through improvements in product quality, offering of new products or opening up new markets or groups of customers, thereby increasing the firm's market share (Avenyo et al. 2019; Gault 2010; OECD 2005; van Dijk and Sandee 2002). However, imitation and the increasing complementary interaction between formal and informal businesses, coupled with the dynamic behaviours of informal enterprises may be blurring vertical product differences, particularly in the service sector. Consequently, the competitive advantage formal firms may have with vertical product differentiation may be lower in the face of informal competition. This raises the questions: (1) To what extent does informal competition affect formal firms' incentives to innovate? (2) How is the market performance of formal firms affected by informal competition and imitation? This paper investigates these questions, and aims to provide a better understanding of the mechanisms through which these relationships occur in SSA.

The paper contributes to the literature in several ways. It provides, to our knowledge, one of the first empirical evidence assessing the effect of informal competition on the sales of innovative products. It departs from the mainstream literature by analysing informal competition, and from similar studies (for example Mendi and Costamagna 2017), by going beyond the analysis of formal firms' incentives to innovate. We argue that what may be relevant for firms is not only whether to introduce product innovation or not, but how the innovative products perform on the market in the face of competition from both formal and informal enterprises. Analysing the effect of informal competition on product innovation using a binary dependent variable (whether the firm introduces product innovation or not) only determines the incentives to innovate or otherwise. The paper, therefore, goes beyond establishing a relationship between informal competition and the probability of the firm to introduce product innovation by assessing the effect of informal competition intensity on the performance of product innovation in SSA. This paper also contributes to the literature by resolving possible econometric issues of bi-directional causality, and the use of subjective responses that may bias our estimates. We follow (Guiso et al. 2004) and (Ali and Najaman 2015) to construct an innovative 'regional' competitive intensity measure that 'localises' competition at the regional level thereby reducing the possible bi-directional causality between informal competition and sales of innovative products, as well as controlling for a possible bias due to the subjective nature of the data. We also employ the same procedure to construct an industry-level informal competition indicator across industries in each country. These approaches allow us to introduce non-linear effects into our model that could help explain, more rigorously, the relationship between informal competition and formal firms' technological innovativeness (see Ali and Najaman 2015; Aghion et al. 2005; Scherer 1967). In addition, we correct for possible selection bias that can affect our estimations.

To do all these, the paper employs the Enterprise Surveys (ES) and the Innovation Follow-up Surveys (IFS) data sets from the World Bank for 5 SSA countries, namely the Democratic Republic of Congo (DRC), Ghana (GH), Tanzania (TZ), Uganda (UGA) and Zambia (ZAM). Previous studies (see Mendi and Costamagna 2017; Ali and Najaman 2015; Friesen and Wacker 2013; Gonzalez and Lamanna 2007) only employed the ES and, therefore, could not examine the intensity of product innovation. Furthermore, by merging the ES with the IFS, we are able to explore a larger number of variables in order to uniquely introduce additional and important variables that were previously omitted in the literature. For the analysis, we employ two econometric approaches that localise informal competition in the product market at the first-level of estimation, and control for self-selection and sample selection biases at the second level of estimation. The results show that 'local' informal competition matters for the performance of product innovations. Specifically, our results indicate the presence of a 'Schumpeterian effect' where informal competition is found to be detrimental to the performance of product innovations. Our conclusion is also found to be valid when we divide formal firms into sectors, ownership type and size. However, extension to industry-level informal competition indicates an 'escape-competition effect' of informal competitive activities on product innovation in formal firms. Our results also show through indirect mechanisms that firms with larger

market shares tend to display an 'escape-competition effect' following increases in informal competition.

The rest of the paper is organised as follows. Section 2 reviews the relevant literature on the relationship between innovation and product market competition. In Section 3, the model and sources of data are presented. Section 4 presents the results from the empirical estimation in line with the objectives of the paper and discusses our results. Section 5 concludes the paper.

2 Related literature

The economic development literature establishing firm-level relationship between competition and innovation is relatively developed but it remains central in both academic and policy spheres (Peroni and Ferreira 2011; Blundell et al. 1999) as empirical evidence remains inconclusive (Aghion et al. 2005) and 'subtle' (Aghion et al. 2013). As noted, there are two main opposing views on the implication of competition on innovation: the 'Schumpeterian effect' and the 'escape-competition effect'. This section situates our paper into this broad strand of literature.[1]

The literature mainly follows from the seminal contribution by (Schumpeter 1942), with theoretical formalisation by (Aghion and Howitt 1992). The 'Schumpeterian perspective' of the literature essentially considers vertical innovations as 'creative destructions' of the product market and the source of long-run growth. Competition is considered a bane on innovations as it is considered to destroy the underlying incentives of firms to undertake innovation activities through the prospects of lower rents (Hashmi 2013; Aghion et al. 2001; Aghion and Howitt 1992; Schumpeter 1942). This is referred to as the 'Schumpeterian effect'. Employing panel data from the United States of America (USA) and the United Kingdom (UK), and using one minus the average Lerner index as a measure of competition and the citation-weighted patents as a measure of innovation, (Hashmi 2013) found evidence of a 'Schumpeterian effect' in US industries.[2]

In opposition to the 'Schumpeterian effect' is the 'escape-competition effect', according to which increases in competition serve as an incentive to escape market rivalry by stimulating innovation activities and innovations particularly in industries with low technological gap (see Blundell et al. 1999; Aghion et al. 2001). For instance, (Blundell et al. 1999) studied the 'market share, market value and innovation in a panel of British manufacturing firms' by using innovation counts. The authors found an 'escape-competition effect' where 'increased product market competition in the industry tended to stimulate innovative activity' with innovative firms and those with a large market share enjoying higher gains on the stock market. (Boldrin and Levine 2008) developed a competitive model of innovation where the authors examined post-innovation rents under perfect competition. Presenting both 'theoretical and practical' situations, the authors also found positive effects of competition on innovation.

[1] See (Gilbert 2006) for a recent survey of the literature.

[2] In the case of UK industries, the author found only a weak 'Schumpeterian effect'.

A growing part of the literature also identifies a non-linear relationship in the form of an inverted-U, where lower and higher levels of product market competition influence firm-level innovations differently. That is, increases in market competition promote innovation until an optimal point, and inhibits innovation thereafter. In other words, this strand finds both the 'Schumpeterian effect' and the 'escape-competition effect' (see Mendi and Costamagna 2017; Aghion et al. 2005; Scherer 1967). An earlier study by (Scherer 1967) analysed the effect of market concentration on innovative efforts using data for 56 industries in the USA. Measuring innovative efforts as employment of scientists and technical engineers, and market concentration as average industry concentration ratios weighted by shipment values, the author found that lower industry concentrations tend to promote innovative efforts while higher concentrations beyond a threshold tend to inhibit innovative efforts. A similar inverted-U relationship has been recently identified by (Aghion et al. 2005). In a UK panel data investigation where innovation and competition are measured as weighted average patents and one minus the Lerner index respectively, (Aghion et al. 2005) found an inverted-U relationship between product market competition and innovation. The authors argue that industries with low technological gaps tend to have firms that are in 'neck-to-neck' competition with low 'pre-innovation rents.' As a result, incumbent firms try to 'escape-competition' by increasing the technological gap and 'post-innovation rents' through innovations. Reversely, a 'leader-laggard' scenario dominates in industries with higher technological gaps. Higher product market competition in these industries tends to reduce 'post-innovation rents' of leaders and hardly improves the post-innovation rents of laggards resulting in the dominance of the 'Schumpeterian effect' (Aghion et al. 2005, p.702).

One major criticism of the literature reviewed above remains that, the majority of the studies concentrate on developed countries where competition is essentially 'non-dualistic'. That is, firms mainly face competition from their counterparts who are also legally registered. Our paper departs from this literature by analysing a different type of competition, that is, informal competition, where we consider informal firms' competitive activities in product markets. The informal economy is most prevalent in SSA (Schneider et al. 2010), where it dominates economic activities both in terms of output and employment (Heintz and Pollin 2008). For instance, the sector constitutes 80 percent of the labour force and accounts for nearly 55 percent of GDP for many SSA countries (International Labour Office (ILO) 2013; African Development Bank 2013). In Ghana, for example, employment is found to be predominantly informal, employing 86.1% of the working force (Ghana Statistical Service 2012) with the production structure made up of Small-Medium Enterprises (SMEs).

There is a growing body of literature, essentially from Latin America and Africa, examining the effect of informal firms' market activities and behaviours on the performance of formal firms. Employing mainly cross-sectional data from the World Bank's Enterprise Surveys, some of these empirical studies find informal competition and the activities of informal enterprises detrimental to the performance of formal firms and the economy as a whole (Friesen and Wacker 2013; La Porta and Shleifer 2008; Gonzalez and Lamanna 2007). Informal competition is found to most adversely affect formal firms that are small (Ali and Najaman 2015; Gonzalez and Lamanna 2007), financially constrained (Friesen and Wacker 2013), tax constrained

and that operate in industries with high entry cost, low capital and high regulations (Friesen and Wacker 2013; Gonzalez and Lamanna 2007). On the contrary, (Ali and Najaman 2015) found that informal competition has productivity enhancing effects. Using the ES for 33 SSA countries, the authors found that formal firms with higher informal competition tend to increase their productivity and the more so as they are larger. In a cross-country analysis of Latin and African countries, (Mendi and Costamagna 2017)[3] found an inverted-U relationship where informal competition has decreasing and increasing effects on the probability of introducing innovations at higher and lower intensities of competition, respectively. They used as measures of informal competition the number of competitors of the firm, the percentage of firms who consider informal firms as a top-3 obstacle in the region, and the regional average of formal firms who consider informal firms as an obstacle to the operations of the firm. They considered the effect of informal competition on the probability of introducing a new product or a new process. We go one step further by considering also the intensity of product innovations to provide a deeper insight into the relationship between informal competition and the performance of product innovations introduced by formal firms.

3 Methodology

3.1 Data

As noted, the main data sets used for the empirical investigation in this paper come from the Enterprise Survey (ES) and the Innovation Follow-Up Survey (IFS). The ES follows a standard methodology to collect representative enterprise data in 122 countries, allowing for cross-country comparisons. The methodology randomly stratifies firms by sector, size and location thus making the sample in each country representative of the population of firms. The IFS is a representative firm-level data on innovation and innovation activities of firms interviewed during the ES. The IFS is, therefore, a follow-up survey to the ES and covered 19 countries between 2011-2014, out of which 15 of the countries covered are in Africa.[4] In this paper, we employ data for 5 SSA countries: the Democratic Republic of Congo (DRC), Ghana (GH), Tanzania (TZ), Uganda (UG) and Zambia (ZAM).[5]

The descriptive statistics from our sample data are shown in Table 1. Out of 1,225 firms in our sample, 1,220 responded to the questions regarding product innovation. A total of 533 firms, constituting about 43.7%, introduced product innovation while 687 firms, making up about 56.3%, did not introduce any product innovation. The average percentage of sales due to product innovations across all countries under consideration is about 34.55%, with Zambia having the lowest percentage, 26.09%. Out

[3]The only known empirical evidence studying informal competition and innovation.

[4]Both the ES and the IFS were merged at each country-level using a unique identifier, and then appended for a larger sample size.

[5]For comparability, the choice of these countries is based on the use of the same methodology for ES and the IFS, and the fact that for these countries the ES and IFS data were collected in the same year.

Table 1 Descriptive statistics of data by country

	ALL	DRC	GH	TZ	UGA	ZAM
Product innovations						
No. of all firms[a]	1,220	230	334	114	173	369
Innovators	533	90	100	21	103	219
Non-innovators	687	140	234	93	70	150
Sales due to product innovations (Mean %)	34.55	45.71	35.08	44.70	40.97	26.09
Informal competition						
No of all firms	1,225	232	337	114	173	369
Major obstacle (%)	39.10	38.36	24.04	47.37	40.46	50.14
Size of firm						
Small (%)	66.12	68.97	68.55	53.51	63.01	67.48
Medium (%)	26.70	25.86	26.70	28.95	28.90	25.47
Large (%)	7.18	5.17	4.75	17.54	8.09	7.05
Sector of firm						
Manufacturing (%)	50.94	47.84	51.34	52.63	53.76	50.68
Services (%)	49.06	52.16	48.66	47.37	46.24	49.32
Ownership						
Domestic (%)	83.51	81.03	88.72	94.74	86.13	75.61
Foreign (%)	16.49	18.97	11.28	5.26	13.87	24.39
Corruption						
Yes (%)	41.14	52.59	47.48	50.88	28.32	31.17
No (%)	58.86	47.41	52.52	49.12	71.68	68.83
Crime						
Yes (%)	15.35	22.41	5.93	24.56	24.86	12.20
No (%)	84.65	77.59	94.07	75.44	75.14	87.80
Tax						
Yes (%)	5.88	2.59	3.26	10.53	15.61	4.34
No (%)	94.12	97.41	96.74	89.47	84.39	95.66
Marketing						
Yes (%)	14.36	17.39	8.93	11.50	16.37	17.34
No (%)	85.64	82.61	91.07	88.50	83.63	82.66

Source: Enterprise and Innovation Follow-Up Surveys

[a] Note: These are lower than our total (1,225) and our split samples, due to missing observations

of 1,225 responding firms, 39.1% considered competition from informal enterprises as a major constraint with perceptions varying a lot across countries, ranging from 24.04% in Zambia to 50.14% in Ghana. Table 1 also shows the sector and size distributions of our data. The majority of firms (66.12%) in our data set are classified as small, with a total number of workers between 5 and 19. There is an almost equal proportion of firms in manufacturing and services. The majority of firms are owned domestically (about 85%), and do not consider crime (about 85%) and tax (about

94%) as major constraints to their activities. On average, about 86% of all sampled firms do not use the services of a marketing firm/consumer research firm/advertising firm.

3.2 Empirical model

The methodology employed in the ES randomly stratifies firms by sector, size and location, which are assumed to be 'exhaustive' and 'non-overlapping'. However, the number of firms sampled in each stratum (sector, size and location) and across these strata is non-random, resulting in a non-random total sample size (Wooldridge 2002). In addition, a firm's decision to introduce product innovations onto the market is not random but often influenced by a plethora of confounders. As a result of the non-random nature of the decision to introduce product innovations and the sampling design used in the ES, employing OLS may give inconsistent estimates due to the likely selection bias (see Wooldridge 2002; Heckman 1979). The empirical literature also recognises bi-directional causality between innovation and competition, and the need to resolve the possible endogeneity bias (see Hashmi 2013; Aghion et al. 2005). The ES firm-level data regarding the product market competitive behaviour of informal enterprises are mainly perception data, and have been found to be highly subjective and may bias the estimates (Mendi and Costamagna 2017; Ali and Najaman 2015; Friesen and Wacker 2013; Gonzalez and Lamanna 2007). This is because bad performing formal firms are more likely to exaggerate the competitive behaviour of informal enterprises than well performing firms.

This section addresses the above possible biases by employing two main econometric approaches to estimate the effect of informal competition on the percentage of sales of innovative products by formal firms. At the first-level of estimation, we employ a two-step methodology developed by (Guiso et al. 2004) to construct 'local' and industry-level (in extension) informal competition indicators to address the possible endogeneity and subjectivity in the data. At the second level of estimation, we employ a Type II Tobit model (Amemiya 1985) to estimate the effect of the predicted and normalised informal competition variable on the percentage of sales due to innovative products while controlling for other relevant covariates, and correcting for self-selection and sample selection biases.

3.2.1 Model specifications

First-level estimation: Measuring 'local' informal competition

To construct our 'local' informal competition indicator, we employ the two-step econometric procedure developed by (Guiso et al. 2004). As noted, the standardised ES collects firm-level perception data on the product market competitive behaviour of informal enterprises. These perception responses from formal firms have been found to be highly subjective (Mendi and Costamagna 2017; Ali and Najaman 2015; Friesen and Wacker 2013). A common approach in the literature is to aggregate firms' responses across sectors, region or country. In this paper, we use average responses aggregated at the regional level, where firms operating in the same locality (region) have the same informal competition indicator, thereby allowing for variations across

regions within the same country. The use of a regional level aggregation is due to the fact that the region is the lowest level of aggregation beyond the firm in our data.[6] Available empirical evidence, however, found this approach to mitigate the subjective bias and measurement errors in the data as well as to reduce the bi-directional relationship between informal competition and innovation (see Mendi and Costamagna 2017; Ali and Najaman 2015; Friesen and Wacker 2013). The difference between our approach and that of (Mendi and Costamagna 2017) is that, we construct our indicators after controlling for other determinants of informal competition. Despite this, the rank correlation coefficient between our regional indicator and *'obst_region'* in (Mendi and Costamagna 2017) is 0.703 (*p<0.05), suggesting that there is a strong correlation between the two measures.

Following (Gonzalez and Lamanna 2007) and (Guiso et al. 2004), we assume that informal competition is at first only 'local' with informal enterprises competing only in their immediate vicinities. That is, enterprises operate in their immediate product markets with no or very little competitive interaction in national and/or global product markets. Several questions in the standardised ES seek to find out how formal firms perceive the competitive behaviours of informal businesses. To construct our 'local' informal competition indicator, we employ the question in the data set that asks: *Do you think the practices of competitors in the informal sector present: a) no obstacle; b) a minor obstacle; c) a moderate obstacle; d) a major obstacle; e) a very severe obstacle to the current operations of your establishment?* In the ES data set, the above question is further summarised into: Percentage (%) of firms identifying competitors in the informal sector as a major constraint. This latter question presents a binary classification that takes the value 1 if the firm considers the competitive practices of informal enterprises as a major and a very severe obstacle, and the value 0 otherwise. Following (Guiso et al. 2004), we use the binary classification to formalise a non-linear regression equation as:

$$Informal\_competition_{iqj} = \gamma_0 + \gamma_{qj} Region_{qj} + \gamma_2 X_{iqj} + \gamma_I + \gamma_c + \epsilon_{iqj} \quad (1)$$

where $Informal\_competition_{iqj}$ is a binary variable that equals 1 if a firm i located in region q of country j considers the competitive practices of informal enterprises as a major obstacle and equals 0 otherwise. The vector γ_{qj} contains the region dummies in country j. The estimate of the parameter γ_{qj} will be our 'local' informal competition variable. In line with (Ali and Najaman 2015) and (Gonzalez and Lamanna 2007), X_{iqj} includes the firm-level variables, and γ_I and γ_c are respectively industry and country specific effects.

Due to possible differences in the enforcement of laws regarding the clamping down of informal activities in the capital city and the region as a whole, we also introduce a dummy indicating if the firm is located in the capital city or otherwise. The hypothesis is that firms located in the capital city would tend to perceive informal competition as less of a constraint.[7]

[6]The global ES questionnaire have a 'city' variable, which is a lower level of aggregation than region. However, the city variable drops out during the merging and appending process for our sample countries as it is not captured in some of the countries.

[7]See Appendix A for the definitions of all terms and variables.

The coefficients from the first-level probit regression of equation 1 are shown in Appendix B. In line with our hypothesis, the results indicate that firms located in the capital city consider informal competition as indeed less of a major constraint as compared to firms located elsewhere. Foreign-owned firms are less likely than domestic firms to identify the competitive practices of informal enterprises as a major constraint, all other factors held constant. This is in line with the fact that foreign-owned firms tend to serve upscale markets and usually do not compete directly with informal enterprises. Firms with financial constraints tend to consider informal competition as a major obstacle. The probability that formal firms identify the competitive activities of informal enterprises as a major constraint increases if other obstacles to business such as corruption and crime are present. Firms with a higher percentage increase in total sales compared to the previous fiscal year are also less probable to perceive informal competition as a major constraint, indicating the importance of market size.

Following (Guiso et al. 2004) and (Ali and Najaman 2015), in the second stage, we predict our regional local informal competition using the following formula:

$$IPMC_{qj} = 100 * [\hat{\gamma}_{qj} - min(\hat{\gamma}_{qj})]/[max(\hat{\gamma}_{qj}) - min(\hat{\gamma}_{qj})] \quad (2)$$

where $IPMC_{qj}$ is our 'local' informal competition indicator of region q in country j. $\hat{\gamma}_{qj}$ relate to the marginal probabilities of region q in country j. $\max(\hat{\gamma}_{qj})$ and $\min(\hat{\gamma}_{qj})$ refer to the maximum and minimum marginal probabilities respectively. Equation 2 normalises our 'local' informal competition indicator into a range between 0 and 100% where values close to 100% indicate intense informal competition and values close to 0 indicate little informal competition in the vicinity.

Descriptive statistics of our regional informal competition indicator by country and region are presented in Table 2. A look at Table 2 shows variations of our 'local' informal competition indicator across different regions of the same country. Lira, a region in Uganda, has the lowest intensity of 'local' informal competition while Lusaka is found to have the highest. In Tanzania, for example, Arusha has the lowest intensity of informal competition of about 3.1% while Zanzibar has the highest of about 53%. These regional disparities across countries can be explained by the physical size and the population density of these regions ranging from the central region in the Democratic Republic of Congo to the City of Accra in Ghana. In any case, the variations suggest that using a national proxy for informal competition would fail to capture these observed differences across regions. Therefore, we argue that our proposed 'local' informal competition indicator, measured at the regional level, helps to better capture and take into account heterogeneity in the levels of informal competition across regions located in the same country.

Not only are there disparities across countries but also between product innovators and non-product innovators. On average, Tanzania has the lowest intensity of informal competition of about 30% while Zambia has the highest of about 83% (see Table 3). Also, innovators experienced a higher intensity of informal competition of about 60% as compared to the 47% for non-product innovators. This holds for each country except Uganda, where non-innovators tend to experience a higher intensity of informal competition of about 62% compared with 51% for innovators.

Table 2 Description of regions and the indicator of informal competition

Country	Region	Number of firms in data	Number of firms in sample	IPMC (%)
Congo, D.R.	Central	51	29	29.827
	East	95	60	16.170
	South	47	15	21.193
	West	192	128	63.265
Ghana	Accra	275	175	43.485
	North	106	68	16.484
	Takoradi	54	26	32.496
	Tema	114	68	13.187
Tanzania	Arusha	92	14	3.140
	Dar Es Salaam	268	70	32.810
	Mwanza	53	18	24.490
	Zanzibar	74	12	52.590
Uganda	Jinja	79	29	73.626
	Kampala	165	63	87.912
	Lira	37	21	0
	Mbale	48	11	2.512
	Mbarara	54	20	9.419
	Wakiso	66	29	57.614
Zambia	Kitwe	74	65	70.330
	Livingstone	73	37	67.033
	Lusaka	288	182	100
	Ndola	105	85	64.835
TOTAL	22	2410	1,225	

Non-innovators in Uganda may be much similar to informal enterprises in terms of characteristics such as sales (market share) and as a result tend to compete more intensively against informal enterprises than their innovative counterparts.

Table 3 Description of 'local' informal competition indicator by country

	ALL	DRC	GH	TZ	UGA	ZAM
'Local' informal competition (IPMC)						
All firms (Mean %)	52.620	44.185	31.075	29.934	55.263	83.368
Innovators (Mean%)	59.567	45.552	32.053	32.092	50.729	84.681
Non-innovators (Mean%)	47.346	43.371	30.614	29.448	61.933	81.451

Second-level estimation: Type II Tobit model

To estimate the effect of our 'local' informal competition indicator on sales due to new products, we formulate a Type II Tobit model (Amemiya 1985) procedure and estimate the following equation:

Regression equation:

$$y_{iqj} = \alpha_0 + \alpha_1 IPMC_{qj} + \alpha_2 Z_{iqj} + \delta_I + \delta_c + \epsilon_{iqj},\ if\ \ w^*_{iqj} > 0 \tag{3.3}$$

Selection equation:

$$\begin{aligned} w_{iqj} &= 1,\ if\ \ w^*_{iqj} = \beta_0 + \beta_1 IPMC_{qj} + \beta_2 M_{iqj} + \upsilon_{iqj} > 0,\ and \\ 0 &= otherwise \end{aligned} \tag{3.4}$$

where y_{iqj} is the percentage of sales due to new products of firm i located in region q of country j, $IPMC_{qj}$ is our 'local' informal competition indicator in region q of country j. Z_{iqj} is the set of firm-level control covariates. δ_I and δ_c are industry-specific and country-specific covariates that may affect the intensity of innovation, w_{iqj} is a dummy variable taking value 1 if firm i in region q of country j introduced a new product over the last three (3) fiscal years, i.e. when the latent variable $w_{iqj}{}^*$ is strictly positive, and value 0 otherwise. M_i is a set of control covariates that might affect firm i in country j to introduce product innovations and vice versa. ϵ_{ij} and υ_{ij} are both multivariate normally distributed error terms with mean 0, variances equal to 1 and correlation rho12. Z_i and M_i include variables used in (Avenyo et al. 2019), and (Mendi and Costamagna 2017). We are mostly interested in the two parameters α_1 and β_1. The former represents the marginal effect of IPMC on the intensity of product innovation, and the latter is related to the effect of IPMC on the probability to introduce a new product on the market.

3.2.2 Estimation

To estimate the Type II Tobit model, we have employed the 'flexible' conditional mixed process *(cmp)* Stata command which performs a limited-information maximum likelihood estimation by assuming that the errors from both the regression and the selection equations are correlated and bi-normally distributed (see Roodman 2011). The estimated parameters obtained from the simultaneous estimation of the regression and selection equations are in principle more efficient than those obtained from the Heckman two-step procedure, which would first estimate the selection equation, retrieve the inverse Mill's ratio, and insert that one in the regression equation estimated on the selected observations only, in this case the product-innovating firms. The maximum-likelihood estimation, which estimates the two equations jointly is more efficient because it uses the full covariance matrix of the residuals in both equations, assuming the specification to be correct (Roodman 2011).

The variance-covariance matrix is clustered at the regional level. The main regressor of interest is the informal competition indicator. In line with (Mendi and Costamagna 2017), we also control for a range of other determinants of innovation success, namely the use of a marketing firm, two measures of the size of the firm two years lagged - sales and number of employees (log-transformed), four

major perceived constraints for innovation - taxation, corruption, crime and licensing, the labour cost per worker, the experience of the top manager, the age of the firm and its square, government support for innovation, the size of the locality, ownership and country as well as industry dummies. To identify the coefficients from the regression and the selection equation, we use one exclusion restriction, namely the R&D indicator in the selection equation.

In specification (2), we add the square of the local competition indicator to test the possible presence of a 'Schumpeterian effect' and an 'escape-competition effect' at different levels of informal competition. And finally in specification (3), we allow for an interaction between informal competition, the size of the firm and corruption. If the interaction term between informal competition and the size of the firm is significant, for example, the marginal effect of informal competition on innovation in the formal sector would be shown to depend on the size of the firm. Larger or smaller firms would be less or more affected by informal competition, depending on the sign of the coefficient.[8]

4 Empirical results

4.1 Main results and discussion

The empirical results from the estimation of the Tobit Type II model are presented in Table 4. We have estimated three specifications. Panel A presents the estimated coefficients on the explanatory variables of the main regression equation, while panel B presents the ones on the explanatory variables in the selection equation. The associated standard errors are heteroskedasticity-robust and clustered at the regional level. The correlation coefficients of the error terms in the two equations are significant, showing that it was important to control for a possible selection bias. The two error terms are negatively correlated, implying that any omitted variable which would underestimate the probability to innovate would overestimate the intensity of product innovation, that is, the share of total sales due to new products, and vice versa.

Our main results from panel A of Table 4 shows that informal competition in product markets has a significantly negative effect on the intensity of product innovations.[9] This means that an increase in the concentration of informal activities in the immediate vicinity of formal firms reduces the percentage of total sales coming from new products. This result is in line with the 'Schumpeterian effect' also reported by (Hashmi 2013). This negative effect may be explained by the increasing capability of informal enterprises to imitate new technological products introduced by formal

[8]In the presence of the square term of IPMC and the interaction of IPMC with lagged sales, the average marginal effect of IPMC for innovating firms is equal to (the coefficient of IPMC + the coefficient of IPMC squared times IPMC + the coefficient of the interaction term times lagged sales), the whole expression averaged over all observations. This is computed using the nonlinear combinations of estimators (nlcom) in Stata.

[9]We get the same qualitative results when we replace our IPMC measure with *'obst_region'* in (Mendi and Costamagna 2017).

Table 4 Effect of informal competition on product innovation

Estimation method	Limited information maximum likelihood (LIML)							
	A				B			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	% sales, product innovation				Introduce product innovations			
Local competition (IPMC) (%)	-0.190***	-0.321**	-0.493***	-0.477***	-0.001	-0.002	-0.003	-0.001
	(0.056)	(0.148)	(0.148)	(0.151)	(0.003)	(0.006)	(0.007)	(0.007)
Local competition (IPMC) (%) squared		0.001	-0.001	-0.002		0.000	0.000	0.000
		(0.001)	(0.002)	(0.002)		(0.000)	(0.000)	(0.000)
Marketing	6.642*	6.379*	5.103	4.967	0.508***	0.505***	0.506***	0.495***
	(3.400)	(3.450)	(3.392)	(3.451)	(0.127)	(0.128)	(0.130)	(0.130)
Log of sales (USD) (-2)	-1.166	-1.170	-2.872***	-2.994***	-0.023	-0.022	-0.024	-0.028
	(0.888)	(0.896)	(1.009)	(0.989)	(0.025)	(0.025)	(0.037)	(0.038)
Tax	-2.353	-2.141	-1.340	-1.116	0.048	0.051	0.050	0.052
	(3.869)	(3.957)	(3.680)	(3.622)	(0.179)	(0.181)	(0.181)	(0.181)
Corruption	-7.053***	-7.114***	-7.046***	-2.767	-0.173*	-0.173*	-0.173*	0.007
	(2.072)	(2.133)	(2.214)	(3.526)	(0.098)	(0.098)	(0.098)	(0.171)
Licensing	4.978***	4.954***	5.060***	5.176***	0.164*	0.165*	0.164*	0.169*
	(1.763)	(1.788)	(1.742)	(1.764)	(0.098)	(0.098)	(0.097)	(0.098)
Crime	-2.036	-2.294	-2.488	-2.783	0.075	0.075	0.075	0.074
	(2.945)	(2.963)	(3.079)	(3.166)	(0.105)	(0.105)	(0.105)	(0.105)
Log of labour cost per worker (USD)	-0.544	-0.501	-0.768	-0.720	0.024	0.024	0.024	0.023
	(0.832)	(0.836)	(0.855)	(0.882)	(0.035)	(0.035)	(0.035)	(0.036)

Table 4 (continued)

Estimation method	Limited information maximum likelihood (LIML)							
	A				B			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	% sales, product innovation				Introduce product innovations			
Log of total employment (-2)	1.067	1.134	0.630	0.735	0.125***	0.124***	0.124***	0.124***
	(1.616)	(1.642)	(1.543)	(1.622)	(0.048)	(0.048)	(0.047)	(0.048)
Ownership	3.231	3.290	2.933	2.790	-0.091	-0.089	-0.089	-0.089
	(3.640)	(3.696)	(3.710)	(3.566)	(0.080)	(0.080)	(0.081)	(0.079)
Log of experience	-3.586*	-3.579*	-3.731**	-3.738**	0.067	0.066	0.066	0.064
	(1.884)	(1.922)	(1.709)	(1.663)	(0.117)	(0.117)	(0.116)	(0.117)
Support	7.811*	7.722	8.888**	9.187**	0.054	0.055	0.053	0.068
	(4.700)	(4.723)	(4.415)	(4.303)	(0.324)	(0.324)	(0.320)	(0.315)
Log of age	16.228*	15.974*	16.500*	17.027**	0.562*	0.560*	0.556*	0.552*
	(9.057)	(9.129)	(8.570)	(7.992)	(0.291)	(0.290)	(0.294)	(0.301)
Log of age squared	-3.089*	-3.052*	-3.238**	-3.349**	-0.098	-0.098	-0.097	-0.096
	(1.671)	(1.662)	(1.546)	(1.431)	(0.064)	(0.064)	(0.065)	(0.066)
IPMC* Log of sales (USD) (-2)			0.037***	0.038***			0.000	0.000
			(0.014)	(0.013)			(0.001)	(0.001)
IPMC* Corruption				-0.076				-0.004
				(0.047)				(0.003)
R&D					0.588***	0.589***	0.591***	0.599***
					(0.081)	(0.082)	(0.079)	(0.076)

Table 4 (continued)

Estimation method	Limited information maximum likelihood (LIML)							
	A				B			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	% sales, product innovation				Introduce product innovations			
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Size of locality fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
sig_1_cons	19.962***	19.936***	19.832***	19.814***				
rho_12_cons	0-.201**	-0. 200*	-0. 226**	-0.235**				
N	969	969	969	969				
Wald chi^2	2231.76	2231.234	2227.893	2226.762				
Prob > chi^2	0.000	0.000	0.000	0.000				

Notes: Robust standard errors in parentheses, * p < 0.10, ** p < 0.05, *** p < 0.01.
Estimated using *cmp* Stata package for LIML estimation. All standard errors are adjusted for 22 regional clusters

firms or to come up with product innovations on their own (see Fu et al. 2018; Zanello et al. 2016).

This result may also be explained by the increase in the non-competitive interactions between a few formal firms and informal enterprises, mainly through collaborations and outsourcing of economic activities. These non-competitive interactions, where formal and informal enterprises collaborate, may enable a few registered firms to expand the sale of their innovative products through informal enterprises by taking advantage of their dynamic behaviour as well as their 'local' product market acceptance. As a result, formal firms without these non-competitive interactions may perceive intensive competition from informal enterprises, which actually is competition with other formal enterprises that work hand-in-hand with informal enterprises. And finally, another explanation could be that some formal enterprises that were once informal but through their innovative efforts have managed to become formal enterprises now compete with other formal enterprises. However, their perception may still be that their main competition comes from the informal sector.

In panel B, our results show an insignificant effect of informal competition on the probability of introducing product innovation. This suggests that informality of the product market is irrelevant when firms decide whether to introduce product innovations or otherwise. This result, therefore, justifies our claim that firms are more concerned with how product innovations perform in the face of informal competition rather than on the decision to introduce innovations.

To test the inverted-U relationship between informal competition and innovation found recently by (Mendi and Costamagna 2017), we introduced a squared term into our regressions. Results in panels A(2) and B(2) indicate an insignificant effect of the squared term of informal competition on product innovation. These results are contrary to those of (Mendi and Costamagna 2017), who found an inverted-U relationship between informal competition and firms' incentives to introduce innovations. The non-existence of the 'escape-competition effect' may be due to the dominance of the 'Schumpeterian effect', indicating the existence of a high technological gap between formal and informal firms. As a result of this, and the poor intellectual property institutions in these countries, informal enterprises imitate innovative products introduced by formal firms leading to low post-innovation rents and hence lower incentives to innovate by formal firms.

To understand the main transmission mechanisms through which 'local' informal competition affect the performance of product innovations, we interacted our informal competition indicator with the log of total sales lagged. Our results show that a higher level of total sales tends to mitigate the negative effect of informal competition on the performance of product innovations (Table 4: panel A (3)).[10] This may be due to the growing strategic collaboration between formal firms and informal enterprises with informal enterprises working to boost sales of new innovative products introduced by collaborators in the formal economy, particularly in the retail sector. As a result of these strategic interactions, the introduction of new vertically differentiated products perform better in sales even with increased informal competition, holding all other variables constant.

[10]This conclusion is confirmed by the nlcom estimator coefficient of -0.004 with a p-value of 0.001.

This result is also in line with the body of literature that suggests that in product markets where incentives to innovate are low due to high concentration of firms, market 'leaders' tend to strategically create 'channel relationships', where small and laggard firms are used as sales channels (Hausman 2005; Sorescu AB et al. 2003). This channel relationship between 'leaders' and informal enterprises may explain our result that formal enterprises with larger sales tend to experience a lower negative effect of informal competition on the performance of their product innovations. The results in panel A(4) suggest that our 'local' informal competition does not indirectly affect the performance of product innovations through corruption.

As noted by (Blundell et al. 1999), some firms introduce and sell more of innovative products because they have 'marketing advantages' as compared with other firms. We verified this assertion by introducing a marketing dummy that captures whether a firm used services of marketing firm or consumer research firm or an advertising firm. Our results show firms that employ marketing services actually perform better with sales of innovative products (panels A1-A2) and are more likely to introduce product innovations (panels B1-B3).

4.2 Extensions to sector, size and ownership

We extend our analysis to examine the heterogeneity of the effect of informal competition on manufacturing firms, service sector firms, domestically-owned firms, small-sized firms, and medium-sized firms. The empirical results are reported in Table 5. We only display the coefficients related to the effect of informal competition (IPMC) on the share of sales due to new products. In all specifications we run the Tobit Type II model with the same control variables as in Table 4.

The negative direct effect of local informal competition on innovation intensity in formal firms is present in all sub-samples. Only for small firms it is no longer significant, although it is still significant when the interaction terms with sales and corruption are eliminated (both coefficients of which are non-significant). There were too few observations (in parentheses) to run separate regressions for large firms (87), foreign-owned firms (175) and exporting firms (59). We notice that the effect is twice as strong in services as in manufacturing, and much larger in medium-sized firms than in small-sized firms.

In services, competition from the informal firms is likely to be stronger than in manufacturing because of lower levels of technology in services. Because of less required know-how in coming up with new services than with new products, informal firms are capable of imitating new services resulting in higher competition and hence weak innovation performance by formal firms. In the same vein, we would expect small firms to be more susceptible to competition from the informal sector, but instead it is medium-sized firms that experience the greatest threat from the informal sector. The explanation could be in the interaction terms between IPMC with size and corruption.

Our results also show that manufacturing firms and even more service firms, but especially medium-sized firms, that are larger are less affected by competition from the informal sector. Larger firms are more able to protect their new product sales from competition with the informal firms. This may also be due to the differences in

Table 5 Split sample analyses of the effect of informal competition on % sales, all product innovations

Estimation method	Limited information maximum likelihood (LIML)				
	Manufacturing	Services	Domestic ownership	Small-sized	Medium-sized
	(1)	(2)	(3)	(4)	(5)
	% sales, product innovation				
Local competition	-0.385*	-0.573***	-0.274*	-0.370	-0.989***
(IPMC) (%)	(0.207)	(0.183)	(0.162)	(0.261)	(0.225)
Local competition	0.000	-0.002	-0.003	-0.002	-0.003
(IPMC) (%) squared	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)
Log of sales (USD) (-2)	-2.844**	-2.873**	-2.963***	-2.786*	-5.582***
	(1.321)	(1.313)	(0.882)	(1.533)	(1.443)
Corruption	-3.769***	-6.748	-4.283	-7.369	-0.305
	(0.602)	(5.567)	(3.213)	(5.618)	(6.213)
IPMC* Log of sales	0.025	0.045**	0.029**	0.033	0.080***
(USD) (-2)	(0.016)	(0.021)	(0.014)	(0.022)	(0.026)
IPMC* Corruption	-0.148**	0.015	-0.043	-0.042	-0.064
	(0.061)	(0.114)	(0.045)	(0.104)	(0.079)
Country fixed effects	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes
Size of locality fixed effects	Yes	Yes	Yes	Yes	Yes
N	508	461	794	625	275
Wald chi^2	1831.27	1033.754	7066.58	710.27	602.466
Prob > chi^2	0.000	0.000	0.000	0.000	0.000

Notes: Robust standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Used *cmp* Stata package for LIML estimation. All standard errors are adjusted for 22 clusters in Region.
No regression results for large-sized firms due to small number of observations.
All standard errors are robust to heteroskedasticity.
All regressions include control variables in Table 4

non-competitive interactions with the informal economy. Large firms may collaborate with informal firms, outsourcing some of their activities to them or even collaborating with them in innovative activities. But, the results also show that, at least for manufacturing, firms that perceive and identify corruption as a major obstacle to their business are more negatively affected by informal competition, all other things equal.

4.3 Extension to industry-level informal competition

In extending the analysis to the industry-level[11], we followed the two-step econometric procedure presented above in equations 1 and 2 to construct industry-level

[11] See Table 9 in appendix (C) for list of industries and industry classifications.

Table 6 Effect of 'local' and industry-level informal competition on all product innovations

Estimation method	Limited information maximum likelihood (LIML)							
	A				B			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	% sales, product innovation				Introduce product innovations			
Local competition (IPMC) (%)	-0.197***	-0.315*	-0.455**	-0.456***	-0.000	-0.002	-0.003	-0.002
	(0.063)	(0.186)	(0.181)	(0.176)	(0.003)	(0.007)	(0.007)	(0.007)
Local competition (IPMC) (%) squared		0.001	-0.001	-0.001		0.000	0.000	0.000
		(0.002)	(0.002)	(0.002)		(0.000)	(0.000)	(0.000)
Industry competition (%)	0.319***	0.311***	0.326***	0.326***	0.004	0.004	0.004	0.004
	(0.083)	(0.090)	(0.086)	(0.086)	(0.005)	(0.005)	(0.005)	(0.005)
Marketing	5.147	4.971	3.923	3.944	0.495***	0.492***	0.492***	0.482***
	(3.907)	(3.992)	(4.060)	(4.144)	(0.117)	(0.118)	(0.121)	(0.122)
Log of sales (USD) (-2)	-1.326*	-1.338*	-2.814***	-2.814**	-0.020	-0.020	-0.028	-0.032
	(0.760)	(0.769)	(1.071)	(1.104)	(0.024)	(0.024)	(0.040)	(0.042)
Tax	-2.219	-1.973	-1.239	-1.211	0.031	0.036	0.035	0.036
	(4.056)	(4.044)	(3.843)	(3.827)	(0.185)	(0.187)	(0.187)	(0.187)
Corruption	-5.674***	-5.766***	-5.774***	-5.805	-0.191*	-0.193*	-0.192*	-0.031
	(1.700)	(1.735)	(1.745)	(3.902)	(0.101)	(0.101)	(0.101)	(0.167)
Licensing	4.834***	4.902***	5.033***	5.038***	0.178*	0.178*	0.176*	0.178*
	(1.753)	(1.731)	(1.657)	(1.669)	(0.105)	(0.105)	(0.103)	(0.103)
Crime	-3.279	-3.498	-3.568	-3.599	0.083	0.082	0.082	0.082

Table 6 (continued)

Estimation method	Limited information maximum likelihood (LIML)							
	A				B			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	% sales, product innovation				Introduce product innovations			
	(3.154)	(3.229)	(3.391)	(3.487)	(0.086)	(0.087)	(0.087)	(0.086)
Log of labour cost per worker (USD)	-0.632	-0.608	-0.842	-0.835	0.012	0.012	0.013	0.012
	(0.851)	(0.850)	(0.833)	(0.855)	(0.034)	(0.034)	(0.034)	(0.034)
Log of total employment (-2)	0.649	0.704	0.245	0.254	0.098**	0.098**	0.097**	0.098**
	(1.467)	(1.501)	(1.397)	(1.457)	(0.041)	(0.041)	(0.040)	(0.040)
Ownership	2.795	2.933	2.716	2.694	-0.125	-0.122	-0.123	-0.125
	(3.906)	(4.004)	(3.904)	(3.828)	(0.080)	(0.079)	(0.080)	(0.079)
Log of experience	-3.433**	-3.371*	-3.441**	-3.442**	0.040	0.038	0.039	
	(1.716)	(1.773)	(1.607)	(1.600)	(0.111)	(0.110)	(0.110)	(0.110)
Support	7.223*	7.196*	8.077**	8.062**	0.013	0.012	0.013	0.025
	(4.321)	(4.340)	(4.081)	(4.087)	(0.291)	(0.292)	(0.288)	(0.285)
Log of age	18.355**	18.123**	18.559**	18.642**	0.450	0.447	0.439	0.438
	(8.000)	(8.149)	(7.748)	(7.535)	(0.287)	(0.286)	(0.296)	(0.303)
Log of age squared	-3.596**	-3.568**	-3.716***	-3.732***	-0.071	-0.070	-0.069	-0.069
	(1.429)	(1.433)	(1.341)	(1.298)	(0.062)	(0.061)	(0.063)	(0.064)
IPMC* Log of sales (USD) (-2)			0.031**	0.031**			0.000	0.000
			(0.013)	(0.013)			(0.001)	(0.001)

Table 6 (continued)

Estimation method	Limited information maximum likelihood (LIML)							
	A				B			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	% sales, product innovation				Introduce product innovations			
IPMC* Corruption				0.001				-0.003
				(0.054)				(0.003)
R&D					0.589***	0.590***	0.594***	0.602***
					(0.074)	(0.075)	(0.071)	(0.067)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Size of locality fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
sig_1_cons	20.846***	20.815***	20.745***	20.737***				
rho_12_cons	-0. 222***	-0. 219***	-0. 239***	-0. 236***				
N	969	969	969	969				
Wald chi^2	1128.50	1439.12	3190.21	2358.95				
Prob > chi^2	0.000	0.000	0.000	0.000				

Notes: Robust standard errors in parentheses, * p < 0.10, ** p < 0.05, *** p < 0.01.
Estimated using *cmp* Stata package for LIML estimation. All standard errors are adjusted for 22 regional clusters

Table 7 Split sample analyses of local and industry-level competition on % sales, product innovations

Estimation method	Limited information maximum likelihood (LIML)				
	Manufacturing	Services	Domestic ownership	Small-sized	Medium-sized
	(1)	(2)	(3)	(4)	(5)
	% sales, product innovations				
Local competition	-0.256***	-0.672***	-0.233**	-0.236	-0.954***
(IPMC) (%)	(0.072)	(0.193)	(0.106)	(0.249)	(0.206)
Local competition (IPMC)	0.000	0.002	0.002	0.002	0.003
(%) squared	(0.003)	(0.002)	(0.002)	(0.003)	(0.003)
Industry competition (%)	0.378***	0.252*	0.332***	0.299***	0.493***
	(0.117)	(0.141)	(0.100)	(0.080)	(0.145)
Log of sales (USD) (-2)	-2.584**	-3.156**	-2.693***	-2.333	-6.794***
	(1.263)	(1.387)	(1.022)	(1.638)	(1.399)
Corruption	-4.280	-3.086	-7.801**	-10.763*	-3.929
	(6.639)	(6.314)	(3.844)	(5.979)	(6.123)
IPMC* Log of sales	0.016	0.057**	0.017	0.019	0.094***
(USD) (-2)	(0.016)	(0.023)	(0.012)	(0.026)	(0.024)
IPMC* Corruption	-0.004	-0.044	0.041	0.054	-0.013
	(0.078)	(0.141)	(0.053)	(0.082)	(0.070)
Country fixed effects	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes
Size of locality fixed effects	Yes	Yes	Yes	Yes	Yes
N	508	461	794	625	275
Wald chi^2	1053.16	1035.762	1819.390	1430.615	624.031
Prob > chi^2	0.000	0.000	0.000	0.000	0.000

Notes: Robust standard errors in parentheses, * p < 0.10, ** p < 0.05, *** p < 0.01.
Used *cmp* Stata package for LIML estimation. All standard errors are adjusted for 22 clusters in Region
No regression results for large-sized firms due to small number of observations
All standard errors are robust to heteroskedasticity
All regressions include control variables in Table 4

informal competition indicator. In equation 1, we replaced Region by Industry. The industry-level indicator is normalised between 0 and 100 with industries in a country having the least informal competition intensity assigned the value 0 while the industry with the highest informal competition intensity assigned the value 100. This enables us to capture the variations in industry-level informal competition in the same country as well as across different countries. Informal competition now occurs in the same industry and possibly across countries and no longer in the same vicinity across industries.[12]

[12]See Table 10 in appendix (D) for description of our industry-level informal competition indicator in percentages.

Table 6 presents the estimation results showing the effect of both our 'local' and industry-level informal competition indicators on the performance of product innovations in formal firms. The split sample analyses of the effect of 'local' and industry-level informal competition indicators are shown in Table 7. The results from both tables remain similar to the results obtained above, with 'local' informal competition having no significant effect on the probability to introduce new products, and a significantly negative effect on the success of product innovations (Table 6), and more so in services than in manufacturing firms (Table 7). The interaction effect between IPMC and size is again significantly positive in services (Table 7, column 2). The interesting new result here is the significantly positive effect of industry-level informal competition. Informal competition from within the industry produces the 'escape-competition' effect, whereas local informal competition across industries exerts the 'Schumpeterian effect'. This implies that firms in industries with a higher concentration of informal enterprises tend to be more successful in product innovations.

Competition at the local-level depresses the chances of being successful in innovating with a new product whereas within industry competition boosts innovative sales. Again, the effect of industry-level competition does not affect the probability to innovate, only the success of innovation conditional on innovating. It could be that the industry-level informal innovation index captures other industry-specific effects, like the technology-intensity. As the table in appendix D shows, the industry-level informal competition index is generally higher in low-tech than in high-tech industries. In this case, we would expect the success in product innovation to be low in high-tech industries, that is, more prevalent in services than in manufacturing. But, Table 7 shows that the industry-level informal competition effect is stronger in manufacturing than in services, and in medium-sized firms than in small-sized firms. Hence, the explanation must lie elsewhere. We would expect size to be smaller in services than in manufacturing. Hence, it could be that the 'escape-competition' effect of informal competition is related to a scale effect. The bigger the size of firms, the more they are able to contain the competition from informal firms. This result confirms the mitigating effect of size that we already notice when interacting IPMC with sales.

5 Conclusion

Firm-level evidence reveals that the competitive behaviour of informal enterprises is 'unhealthy', and one of the top three obstacles formal businesses face in product markets in sub-Saharan Africa (SSA). The competitive interactions between formal and informal businesses, however, continue to grow with increasing recognition of the 'permanent feature' of the informal economy, particularly in SSA. With limited empirical evidence assessing the economic implications of informal competitive behaviour on formal firms' performance, our paper fills the gap and contributes to the scant literature by examining the effect of informal product market competition on the share of sales due to innovative products introduced by formal firms in SSA.

The World Bank's Innovation Follow-Up Survey was merged with the Enterprise Survey for five SSA countries. Employing two econometric approaches that localise

informal competition in the product market at the first level of estimation, and control for self-selection and sample selection biases at the second level of estimation, we have shown that 'local' informal competition matters for product innovations. That is, competition from the informal market tends to decrease product innovations of formal firms. However, we also found that large firms are less affected by competition from the informal sector in reaching high shares of sales due to new products. We argued that this indirect mechanism is driven mainly through the level of non-competitive interactions (collaborations and outsourcing of economic activities) between formal and informal businesses. The collaboration and outsourcing of economic activities, we argued, enable registered firms to take strategic advantage of the 'local' market acceptance of informal enterprises to expand market size and perform better with product innovations. As a result, formal firms with less or without any collaborative interaction face intensive competition from informal enterprises, and hence lower sales of product innovations. In other words, formal firms with strategic 'footholds' in the informal economy thrive with new products. While competition from the informal sector at the regional level harms innovation by formal firms, competition measured at the industry level stimulates innovation, a result that could also be attributed to a mitigating size effect, but on which more work needs to be done in the future with a larger data set.

The characterisation of informal competition as 'unhealthy' may be, as noted by (Mendi and Costamagna 2017), a result of the wide market acceptance of informal enterprises in local markets, particularly markets serving those in the bottom of the pyramid. Our findings, therefore, provide useful evidence that point to informal enterprises as critical actors in the National System of Innovation (NIS) in SSA. There is the need for policy makers to realise that informal competition does not happen in the shadow, and that informal enterprises matter as actors in Africa's innovation systems. Innovation policies in SSA must, therefore, move beyond, for instance, granting privileges to few registered firms, to nurturing and promoting interaction between formal and informal enterprises.

Our analyses, however, considered product innovativeness only in five SSA countries, and may not capture all the complexities and a complete view of innovation performance in Africa. While this is mainly due to the statistical measurement of other types of innovation and data, future research could consider the effect of informal competition on large-sized firms, and on process, organisational, and marketing innovations, as well as extend the number of countries as data become available. Formal firms may escape informal competition based on the nature and characteristics of products they introduce and sell on product markets. Analyses taking into account the number as well as the diversity of products introduced and sold by formal firms, for instance, may be natural extensions of the paper. Given the available data, this paper has constructed a local informal competition indicator at the 'regional-level'. But regions may vary in size. Future research could consider using a more finely-grained measure of vicinity to test and/or extend our findings. As more data become available, it would also be advisable to try and construct industry specific measures of competition that differ across regions.

Acknowledgements We thank the Editor, Maria Savona, the Editor-in-Chief, Uwe Cantner, and two anonymous referees for their constructive comments. All errors remain ours.

We would also like to thank all participants at the 'Informality and Development' conference in Honour of Elinor Ostrom, Indiana University (2016, Bloomington-Indiana, USA), UNU-MERIT Research Theme 1 Meeting on Economics of Knowledge and Innovation (2016, Maastricht, The Netherlands), and Africa Innovation Summit (2018, Kigali, Rwanda) for their critical remarks.

Funding Information This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Compliance with Ethical Standards

Conflict of interests The authors declare that they have no conflict of interest.

Appendix A: Definition of variables

Product innovation: A binary variable taking the value of 1 if the firm has introduced product innovation over the last 3 fiscal years and 0 otherwise.

Percentage of sales from all product innovations: A continuous variable indicating the percentage of total sales due to innovative products or services. It assumes strict values between 0-100. Zero implies the firm has not introduced any product innovation.

Informal competition: Binary classification that takes the value 1 if the firm considers the competitive practices of the informal sector as a major and a very severe obstacle and the value 0 otherwise.

Region: A categorical variable showing the twenty-two (22) country sampling regions.

Local informal competition indicator (IPMC): A continuous variable that indicates the local informal product market competition across regions of a country. It ranges between zero and one where values close to 1 indicate intense informal competition and values close to 0 indicate little informal competition in the vicinity.

Log of experience: The logarithm of the number of working years of the top manager.

Ownership: A dummy variable that takes value 1 if the firm is foreign-owned and 0 if the firm is owned domestically.

Log of total employment (-2): The logarithm of total number of employees at the end of two lagged fiscal years.

Log of sales (USD) (-2): The logarithm of total sales of output in last three fiscal years converted to United States Dollars using exchange rates in the corresponding fiscal years.

Log of labour cost per worker (USD): The logarithm of labour cost per worker in United States Dollars constructed as total cost of labour/total permanent employees+0.5(temporary employees) converted using exchange rates in the last fiscal year.

Corruption: A dummy variable that assumes value 1 if the firm identifies corruption as a major constraint and 0 otherwise.

Tax: A dummy variable that assumes value 1 if the firm identifies tax rates as a major constraint and 0 otherwise.

Licensing: A dummy variable that assumes value 1 if the firm identifies the time it takes to license as a major constraint and 0 otherwise.

Crime: A dummy variable that assumes value 1 if the firm identifies crime, theft and disorder as a major constraint and 0 otherwise.

Lack of access to finance: A dummy variable that assumes value 1 if the firm identifies access/cost of finance as a major obstacle and 0 otherwise.

Labour regulations: A dummy variable that assumes value 1 if the firm identifies labour regulations as a major obstacle and 0 otherwise.

Size of locality: A categorical variable measuring the size of the locality with 0 if ($< 50{,}000$), 1 if ($\geq 50{,}000$ and $\leq 250{,}000$), 2 if ($> 250{,}000$ and ≤ 1 million) and 3 if large (over 1 million).

Marketing: A dummy variable that assumes value 1 if the firm used services of a marketing firm/ consumer research firm/ advertising firm and 0 otherwise.

Capital city: A dummy variable that assumes value 1 if the firm is located in the capital city and 0 otherwise.

Log of age: The log number of years the firm has been operating.

Log of age square: The square of the log of the number of years the firm has been operating.

Industry: Sectors according to the group classification of ISIC Revision 3.1: group D, construction sector (group F), services sector (groups G and H), and transport, storage communications sector (group I) and IT (group K sub-sector 72).

Sector: A categorical variable that takes value 1 if the firm is engaged in manufacturing and 0 if it is engaged in services. Services combine both retail and other services.

Size of firm: A categorical variable that takes value 0 if the firm is micro (<5), 1 if the firm is small (≥ 5 and ≤ 19), 2 if the firm is medium (≥ 20 and ≤ 99) and 3 if it is large (100 and over).

Support: A dummy variable that takes value 1 if the firm receives government support and 0 otherwise.

R&D: A binary variable taking the value of 1 if the firm has spent on formal R&D activities during the last three years and 0 otherwise.

Appendix B

Table 8 Probit estimation of informal competition as a major constraint

	Informal competition as a major constraint
Foreign ownership	-0.054**
	(0.023)
Lack of access to finance	0.113***
	(0.028)
Tax	0.055
	(0.059)
Corruption	0.040
	(0.029)
Licensing	0.081
	(0.049)
Crime	0.114**
	(0.046)
Labour regulations	-0.115
	(0.082)
Capital city	-0.265***
	(0.071)
Log of labour cost per worker (USD)	0.016
	(0.011)
Log of sales (USD)	-0.023**
	(0.010)
Log of Age	0.041
	(0.116)
Log of age squared	-0.006
	(0.026)
Log of experience	0.004
	(0.024)
Size of locality dummy	Yes
Size of firm dummy	Yes
Industry fixed effects	Yes
Region fixed effects	Yes
Country fixed effects	Yes
N	1225
Wald $chi^2 4$	711.08
Prob $> chi^2$	0.000
Pseudo R^2	0.1326

Appendix C

Table 9 Industry ISIC Rev. 3

Industry of the firm	Frequency (Data)	Frequency (Sample)
Food	216	102
Textiles	67	24
Garments	121	61
Leather	10	7
Wood	72	36
Paper	7	2
Publishing, printing, and Recorded medi	96	51
Chemicals	67	40
Plastics & rubber	46	28
Non-metallic mineral products	72	42
Basic metals	25	14
Fabricated metal products	160	98
Machinery and equipment	22	13
Electronics (31 & 32)	19	10
Transport machines (34&35)	8	3
Furniture	202	97
Construction Section F	60	38
Services of motor vehicles	110	61
Wholesale	148	70
Retail	488	225
Hotel and restaurants: section H	345	160
Transport Section I: (60-64)	71	35
IT	24	8
Total	2,456	1,225

Appendix D

Table 10 Computed industry-level informal competition by country

	DRC	GH	UGA	TZ	ZAM
Industry of the firm					
Food	59.202	59.202	59.202	59.202	59.202
Textiles	-	62.750	62.750	62.528	62.971
Garments	51.884	52.328	51.885	52.550	51.441
Leather	98.226	100	-	94.457	96.674
Wood	55.654	55.654	55.432	55.876	55.432
Paper	-	54.545	-	-	53.880
Publishing, printing, and Recorded medi	20.399	24.834	17.960	22.616	14.856
Chemicals	31.486	33.925	-	33.259	28.160
Plastics & rubber	52.106	52.550	52.106	52.772	51.663
Nonmetallic mineral products	44.789	45.676	44.346	45.676	43.459
Basic metals	52.106	52.328	51.885	-	51.441
Fabricated metal products	31.264	33.703	30.155	33.038	27.938
Machinery and equipment	8.647	-	-	11.086	0
Electronics (31 & 32)	-	83.370	-	80.931	82.927
Transport machines (34&35)	-	32.594	-	31.486	26.164
Furniture	56.984	56.984	56.984	56.984	56.763
Construction Section F	21.729	25.942	19.734	23.947	16.630
Services of motor vehicles	31.929	34.368	30.820	33.703	28.825
Wholesale	49.224	49.667	49.002	49.889	48.337
Retail	40.577	41.907	40.133	41.907	38.803
Hotel and restaurants: section H	27.273	30.377	25.721	29.268	23.282
Transport Section I: (60-64)	41.020	42.350	40.577	42.350	39.246
IT	50.111	50.554	-	50.776	49.446

Note: Means (%) are based on 1,225 sample data

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