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ABSTRACT

Labor Mobility and Innovation in Africa*

We develop a theoretical model to investigate whether short-term mobility differentially affects innovation in product or process and carry out an empirical analysis with a focus on Africa using firm-level data from the World Bank Enterprise Survey, as well as complementary country level information collected by the World Bank, the World Trade Organisation, and the United Nations. We find that labor mobility positively affects innovation: on average, a 10% increase in the flow of international visits per 10,000 inhabitants is associated with a 0.4 increase in the probability to innovate in products/services or process, supporting the use of labor mobility as an effective mechanism to diffuse productive knowledge and foster innovation. The probability of innovation as a result of short-term mobility is 0.4 higher in Africa overall – especially in East Africa – vis-à-vis the rest of the world, and strongest in the case of innovation in products and services rather than process, suggesting limited capability to produce entirely within the continent. The results are robust to a variety of approaches controlling for endogeneity, which include a control function approach and the use of an instrumental variable based on a gravity model. Focusing only on arrivals for business and professional purposes, our findings show stronger evidence that African firms are more likely to innovate as a result of short-term mobility compared to the rest of the world.

JEL Classification: F20, F22, J24, J61, O14, O55
Keywords: innovation, labor mobility, Africa

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1 Introduction

Innovation is a desirable activity as it is an endogenous and sustainable source of economic growth (Romer, 1990), but it is typically associated with high- rather than low-income countries, as its determinants include developed infrastructures, financial capital, R&D investments, and a well-trained labour force. Advances in globalisation over the past decades and the ongoing 4th industrial revolution, however, have shown that innovation can also flourish in economies where income is low, employment is informal, capital and credit finance are scarce, and the quality of institutional settings is below world standards. For instance, since its launch in 2007 in Kenya, the mobile money transfer service M-Pesa has sparked innovations in financial services such as credit, investments, loans, and insurance to millions of people[1], expanding first across Africa and then in countries beyond the continent, such as India, Afghanistan, and Romania.

To understand whether examples like M-Pesa are just exceptions or whether it is possible to leap-frog economic development without being endowed with modern infrastructure or the time to replicate the development steps historically experienced by high-income countries, we study the determinants of innovation with a focus on Africa. In particular, we explore the potential role of international labor mobility, as proxied by international short-term inflows of visitors, as a mechanism capable of transferring knowledge and innovations, and spurring employment, entrepreneurship, and growth – consequently, worthy of attention and policy support. To do so, we use data from the World Bank Enterprise Survey (WBES). This firm-level data contains questions on whether firms have recently introduced new products or services, or new processes – a better reflection of innovation activity than using R&D expenditures or patents when informality is high, as is the case in Africa. We combine this data set with information sourced from the World Development Indicators, the World Trade Organization and the United Nations Conference on Trade and Development.

The idea of labor mobility as a channel to transfer knowledge applies to mobility of citizens living both outside the continent and, perhaps especially, within it. In recent years, Africa has seen an intensification of discussions around regional integration through the adoption of the African Free Continental Trade Area (AfCFTA), including labor mobility, though Africans still need a visa to travel to 46% of other African countries, according to the 2020 Africa Visa Openness Index (African Development Bank and African Union, 2020). Whether such restrictions also constrain innovation in Africa is a question that needs to be addressed with some urgency, as countries explore the promotion of innovation and economic development by removing restrictions to factor movements.

[1]With 100 million active accounts representing more than 10% of adults with mobile money accounts in 2014, Africa has been the first region of the world in terms of mobile money subscriptions. South Asia is a distant second with 40 million active mobile money accounts (2.6% of adults with mobile money accounts), followed by Latin America and the Caribbean (1.7%), East Asia Pacific (0.4%), Middle East and North Africa (0.7%), Europe and Central Asia (0.3%). (McKinsey: https://www.mckinsey.com/industries/financial-services/our-insights/mobile-financial-services-in-africa-winning-the-battle-for-the-customer).

The empirical analysis considerably expands our previous research (Mbaye and Tani, 2020) by comparing the role that international mobility plays in Africa vis-à-vis other regions of the world. It also complements research on innovation in the continent (El Elj and Abassi, 2014), which has so far explored the role of disembodied factors such as firm size and openness to trade, as measured through export intensity, competition or foreign ownership, and firm resources captured through access to credit, R&D, employees' training, and the gender of the top management (Ayalew et al., 2020).

We start the analysis with a theoretical model to better frame the question addressed and the empirical and policy insights that may be derived. Unlike previous models focusing on the permanent resettlement and unskilled labor, we analyze the case of a temporary shock to highly educated labor that takes the form of higher short-term mobility. The ensuing theoretical treatment relies on a partial equilibrium approach in which higher mobility of labor leads firms to respond by increasing their investments in either products or process. This is critical to identify what type of innovation is affected by short-term mobility. Put differently, our analysis lays out the theoretical conditions – and develops the empirical evidence – to analyze whether labor mobility has a differential impact on innovation in products or services, or in processes and hence on the type of industries that is advantaged by higher labor mobility. As a result, we shed light on the mechanisms through which labor mobility affects innovation in Africa, based on which supportive policies can be developed.

Our empirical strategy is based on a pooled OLS cross-section with tourism arrivals as the main variable of interest. We also control for firm-level characteristics and national macro indicators as well as country and year fixed effects. We run the analysis for the entire sample before comparing Africa with the rest of the world. We run various robustness checks to address the potential endogeneity of short-term visits and hence provide a causal interpretation to the estimates obtained. In particular, we use instrumental variable (IV) estimations drawing on the control function methodology (Wooldridge, 2015) and a gravity model-based approach following (Frankel and Romer, 1999).

We find that labor mobility positively affects innovation. On average, a 10% increase in the flow of international visits per 10,000 inhabitants is associated with a 0.4 point increase in the probability to innovate in products/services or in process. The probability to innovate as a result of short-term mobility is 0.4 point higher for Africa, and especially in East Africa, vis-à-vis the rest of the world (using instrumental variables – IV – regression). Results are strongest in the case of innovation in products, suggesting a limited capability to produce within the continent. Overall, the results support that labor mobility can be an effective mechanism to diffuse productive knowledge and foster innovation in Africa. Using an alternative measure of short-term mobility capturing arrivals for business and professional purposes, we find stronger evidence that African firms innovate more compared to the rest of the world as short-term mobility increases.

The rest of the paper is organized in a brief literature review (section 2) followed by the theoretical model (section 3) and the description of the data and the empirical approach undertaken (section 4 and section 5, respectively). The results are then presented (section 6) before concluding remarks (section 7).

2 Literature review

Innovation, reflecting a definition by (Schumpeter, 1934) is "the implementation of a new or significantly improved product, process, marketing or organizational method in business practices, workplace organization or external relations (OECD and Eurostat, 2005). While easy to define in theory, in practice innovation encompasses many activities, and its measurement is challenging. Some authors have used output measures to identify its presence, such as firm profitability, the number of new products or patents created, or changes in total factor productivity. Other authors have instead applied input-related measures such as expenditures in R&D or the number of scientists and technical personnel. Neither approach however captures the intermediate activities leading to innovation itself, such as the number of previous unsuccessful attempts, or the cumulative knowledge accruing from the process of learning from mistakes. Furthermore, innovation is often not registered or patented. As a result, knowledge diffusion has been used as an alternative measure of innovation, under the maintained hypothesis that knowledge exchanges can lead to the adoption of new technology, product, or process. In turn, knowledge diffusion has been measured with international exchanges such as trade, or people's movements (Bahar and Rapoport, 2018; Jaffe et al., 1993), including temporary visits (Andersen and Dalgaard, 2011; Piva et al., 2018), and the migration of highly skilled people (Bahar et al., 2020; Bahar and Rapoport, 2018; Choudhury, 2016; Dos Santos and Postel-Vinay, 2003; Rapoport, 2018). In the existing literature, migrants are viewed as critical intermediaries to diffuse productive knowledge from their origin countries as they can bring diversity, new ideas or ways of doing business to their destination countries, to name a few.

Research on short-term labor visits is limited and mostly focused on high-income countries, for which data is more commonly available. This stream of research suggests that short-term mobility does effectively raise productivity and innovation[2] through the exchange of ideas between home and host countries (Storper and Venables, 2004), international collaborations (Hellmanzik, 2013; Kerr, 2008; Miguélez, 2018), and the reduction of information asymmetries and productivity shifts (Bahar and Rapoport, 2018).

Much less work exists on short-term visits in low-income countries, often for lack of suitable data. Yet, it is known that labor mobility is high in countries with large informal

[2] The point estimates of the effects of visits are on the order of 0.02 to 0.05, so that a 10% increase in the number of visitors results in a 0.2–0.5% increase in innovation or productivity (Hovhannisyan and Keller, 2015; Piva et al., 2018). Other results show that this effect is even stronger since even a 1% increase in bilateral travel increases productivity by 0.2% (Andersen and Dalgaard, 2011).

sectors. For example, in Africa, 80% of immigration happens within the region (African Development Bank, 2019) and is mainly driven by labor mobility. The only study focusing on Africa is Mbaye and Tani (2020), which covers 34 countries over the period 2011–2016. Shortterm mobility positively affects innovation (the point estimate is about 0.4%) and emerges as an effective channel for development alongside other determinants such as investments in R&D, foreign direct investments, and trade.

We contribute to this literature by expanding the number of countries to over 100, including low-, middle- and high-income nations over a 14-year period. We also develop a conceptual framework to frame the type of innovation as main outcome, and disentangling, both theoretically and empirically, the effect of short-term visits on innovation in product or services on the one hand, and on innovation in processes on the other.

3 Model

Labor mobility has been acknowledged as a source of productivity as it enhances innovation and contributes to generating ideas (e.g., Piva et al., 2018). Yet, the mechanics of such effects are rarely formalized. This section aims at filling this gap by presenting a partial equilibrium microeconomic model in which higher mobility of labor leads firms to respond by increasing their investments in processes or products.

The model is an adaptation of Gray et al. (2020), which studies the effect of a labor supply shock in the United Kingdom triggered by the freedom of movement enjoyed by Central and Eastern European citizens after 2004, following their countries' accession to the European Union. While the original model focuses on unskilled labor, reflecting the skill composition of recent Eastern European migrants to the United Kingdom, we analyze the complementary case of a shock to highly educated labor. Mobility is empirically found to affect almost exclusively highly educated workers (Ackers, 2005; Andersen and Dalgaard, 2011; Salt, 1992).

A unique feature of our analysis, contrary to Gray et al. (2020), is that the shock examined is not a permanent resettlement of people. Labor mobility contributes to the gross flows of workers moving across borders, but it has no real effect on either net flows or permanent labor endowments in the places of origin and destination. Labor mobility consists of temporary movements that last a few days rather than weeks or months. Despite its short duration, it has a profound influence on the skills embodied in the people affected by the movement because it equips them with new information, experience, and tacit knowledge (Dosi et al., 1988; Tani, 2014; Von Hippel, 1988) – an essential source of value and comparative advantage for firms (Cohen and Levinthal, 1989; Nonaka and Konno, 1998). Mobility positively affects the productivity of visiting and visited individuals (Dowrick and Tani, 2011). As a result, it may be represented as a positive shock to the stock of skilled labor available to a country, as it augments the country's human capital endowment.

Consider then a world formed by several distinct economies where each domestic labor market contains $i = 1, ..., n$ firms that produce output Y^{i}. S denotes the skilled labor supplied, and its full utilization implies the equilibrium:

$$S = \sum_{i=1}^{N} c_S^i(A^i, W) Y^i \tag{1}$$

where $c_S^i(A^i, W)$ is the unit requirement of skilled labor associated with firm i, A^i is a vector or factor augmenting technologies available to firm i and W is a vector or domestic factor prices. Analogously to Gray et al. (2020), the domestic partial equilibrium response to a labor supply shock is obtained by totally differentiating (1), which yields:

$$dS = \sum_{i=1}^{N} Y^i c_{SA^i}^i dA^i + \sum_{i=1}^{N} c_S^i dY^i + \sum_{i=1}^{N} Y^i c_{SW}^i dW \tag{2}$$

where $c_{SA^i}^i$ represents the response of firm i's unit requirement of skilled labor with respect to that firm's production technologies, and c_{SW}^i is a vector of cross-price derivatives of the unit requirement of skilled labor with respect to domestic factor prices.

Expression (2) suggests that a higher mobility (dS) shock to the domestic supply of (skills embodied in) skilled labor is offset by changes in the demand for skills due to adjustments in the firm's technology, a shift in firm's output, or a change in domestic factor prices.

As in Gray et al. (2020), we rely on Acemoglu (2007) to predict that an increase in the supply of a factor leads firms to prefer technological changes that use that factor intensively, raising its demand: $\sum_{i=1}^{N} Y^i c_{SA^i}^i dA^i$. Hence, higher mobility raises the supply of skilled labour and induces firms to adjust their technologies to use more of it in their productions through process innovation (dA^i). Clearly this prediction applies to countries that already employ technologies enabling the adjustment of skilled labour use.

As shown by the second term in 2, higher mobility can lead to an increase in total output and the total demand for skilled labour, $\sum_{i=1}^{N} c_S^i dY^i$. This can take the form of either higher average output per product or higher number of products, as per Rybczynski's theorem Wong (1995). The composition of output will therefore shift towards firms that use skilled labor more intensively at the expense of the output of other firms. As a result, one would expect sectors such as services, which use skilled labor relatively intensively, to expand the quality or range of products supplied.

Finally, the term $\sum_{i=1}^{N} Y^i c_{SW}^i dW$ suggests that higher labour mobility brings a change in the relative price of skilled labour relative to the price of other factors of production, which leads to a change in the demand for skilled workers. In Gray et al. (2020), the change in relative prices leads to higher opportunity costs of engaging in productions that use intensively the factors unaffected by the supply shock. In our case, however, there is evidence that not only is mobility associated with a premium, but that premium rises with it; the most mobile skilled workers enjoy the highest premium (Anderson et al., 2006). As a result, to the extent that innovation uses skilled labour intensively, the mobility-induced increase in the supply of skilled labour may not carry over lower skill premia. In such circumstances, mobility may erode firms' incentives to innovate.

As in Gray et al. (2020), we do not explore the effects of mobility to labor demand for unskilled workers, though demand may rise due to complementarities between skilled and unskilled labor (Peri and Sparber, 2009). Our analysis also assumes that national labor markets are perfectly segmented, and that a shock in a market does not result in international spillovers. It is also possible that process innovations raise firm productivity and the profitability of new products, leading to product innovation. At the same time, there may be within-firm tradeoffs between process and product innovation activity in the use of shared inputs, especially in the short run, which may end up providing alternative choices between process and product innovations. Overall, the channels formalized in equation (2) above imply that the effects of higher mobility on product and process innovations are ultimately determined by empirical analyses.

4 Data

4.1 Variables, measurement, and data sources

We use both firm-specific and country-level data from various sources. Firm-level data are sourced from the Word Bank Enterprises Survey (WBES)[3], a dataset of firm surveys covering a broad range of business environment topics with rich information on businesses across the world. It surveys business owners and top managers by sector, mainly focusing on cities and/or regions of major economic activities.

Our measure of innovation is primarily a dummy equal to 1 if a firm has introduced a new product/service or a new process over the last 3 years and 0 otherwise. This measure is respectively sourced from question h1: "*Have you introduced new products or services over the last 3 years?* and question h5 "*During the last 3 years, has the establishment introduced a new or significantly improved process* of the WBES database. In some estimations, innovation is alternatively coded 0 (when the firm has introduced neither a new product/service nor a new process), 1 (introduced a new product/service or a new process) and 2 (introduced both a new product/service and a new process) Questions h1 and h5 are also used separately to disentangle the effect of short-term mobility depending on the type of innovation.

[3]Source: http://www.enterprisesurveys.org.

Other firm-specific variables include whether the enterprise has invested in R&D during the last fiscal year, the log of firm's size measured with the total number of full-time employees, adjusted for temporary workers[4], and whether it holds an internationally recognized quality certification. Information on the ISIC code of the enterprise's main product or service (variable *isic*) allows us to account for the sector activity in the innovation dynamics. The WBES's initial combined dataset comprises 158,781 surveyed firms from 144 countries. Given some missing answers to our variables of interest and country-specific data availability constraints, the largest working sample is made up of 83,097 enterprises from 113 countries across the world over the period 2006–2019. The countries list is provided in Table B4 in the Appendix.

We combine the WBES with country-level variables from various data repositories. We capture short-term labor mobility through tourism arrivals data from the World Bank's World Development Indicators (WDI), sourced from the World Tourism Organization (WTO). Arrivals data measure the flows of international visitors, including both tourists and same-day non-resident visitors, in the country for a period not exceeding 12 months, and for a purpose not related to a remunerated activity within the country visited. Other types of travellers (such as border, seasonal and other short-term workers, long-term students, and others) are thus excluded. Although the data are referred to as tourism, they record trips with various purposes including not only holidays and leisure but also other purposes such as training, or business and professional visits[5]. More precisely, our measure of short-term labor mobility consists of tourists per 100 inhabitants, that is, the number of arrivals divided by population size multiplied by 100.

Other country-level data include GDP growth rate, trade (sum of exports and imports, as a percent of GDP), and FDI inflows in percent of GDP, all taken from the WDI. Given that the outcome variable seeks to determine whether the firm has innovated over the past three years, the country-level variables are averaged over the corresponding three years referred to in the survey.

4.2 Descriptive analysis

Innovation in the sense used in this paper relates to the ability of a firm to upgrade its existing products or services or develop new ones; or introduce or develop new processes. This definition is a good way to capture innovation activity. Among the surveyed African firms, half (50.9%) have introduced new or significantly improved products or services and/or processes over the three years preceding the survey (Figure 1). Africa is the third most innovating region relative to other regions in the world, after Latin American and

[4]Only 28 observations have no employees. Using the log of number of employees can be allowed without causing selection bias.

[5]For more details, see the UN World Tourism Organization's Methodological Notes to the Tourism Statistics Database: https://www.e-unwto.org/doi/epdf/10.18111/9789284421473.

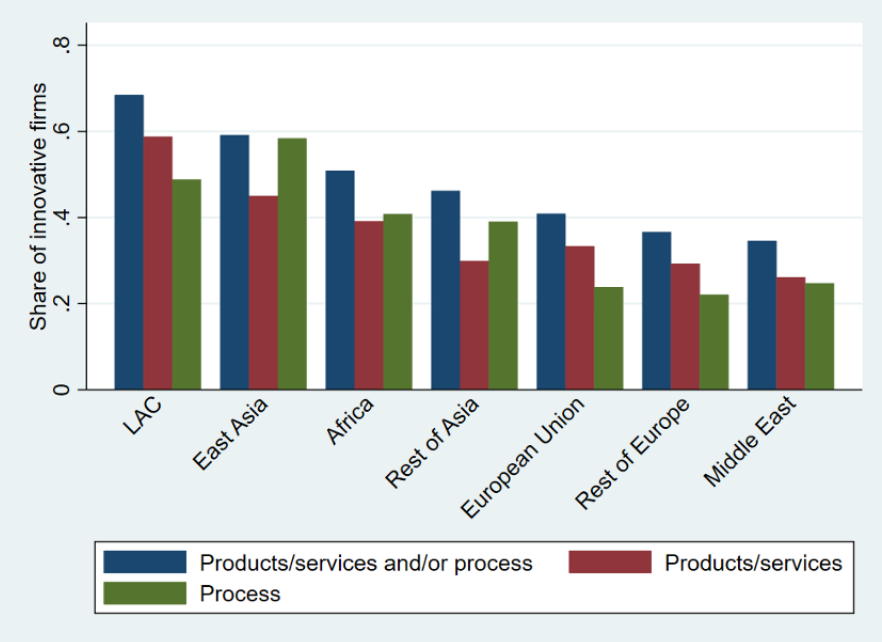

Figure 1: Share of innovating firms by region

the Caribbean (68.5%), and East Asia (59.1 %) and ahead of Asia excluding East Asia (46.2%), European Union (EU) (40.9%), Europe excluding EU (36.7%), and the Middle East (34.6%). This trait of Africa's private sector in terms of innovation sets the ground for future higher productivity and stronger competitiveness. Innovation in products/services and innovation in process are almost equally important in Africa. The share of innovating firms over the period of study is about 40% for both types of innovation, above the full sample shares of 38%. The performance of Africa as the third most innovating region is preserved in either type of innovation, far above the 26.2% of Middle East innovating firms in products and the 22.1% non-EU- member European innovating firms in process.

Africa's innovation trends mask significant cross-country variation as shown by Table B6 in the Appendix, which ranks African countries according to the share of innovative firms. The total share of innovative firms is highest in East Africa (64.8%) with countries such as Rwanda, Kenya, and Uganda accounting for more than 75% of innovating firms. As noted by Mbaye and Tani (2020), the case of Rwanda is compelling. The 20172018 Global competitiveness index ranked Rwanda as the 44th most innovating country out of 137 countries, ahead of many Asian and Latin American countries (Schwab, 2017). Other East African countries are also experiencing a rapid economic and digital transformation. For example, Africa is now the world leader in "mobile money", and East African countries are leading this trend. At the other extreme, North Africa is on average the least innovating region in Africa, with 25.5% of innovating firms. For instance, Egypt, an African giant, accounts for less than than 25% of firms that innovate and is among the five bottom performers.

As a first step towards exploring the possible contribution of short-term labor mobility to

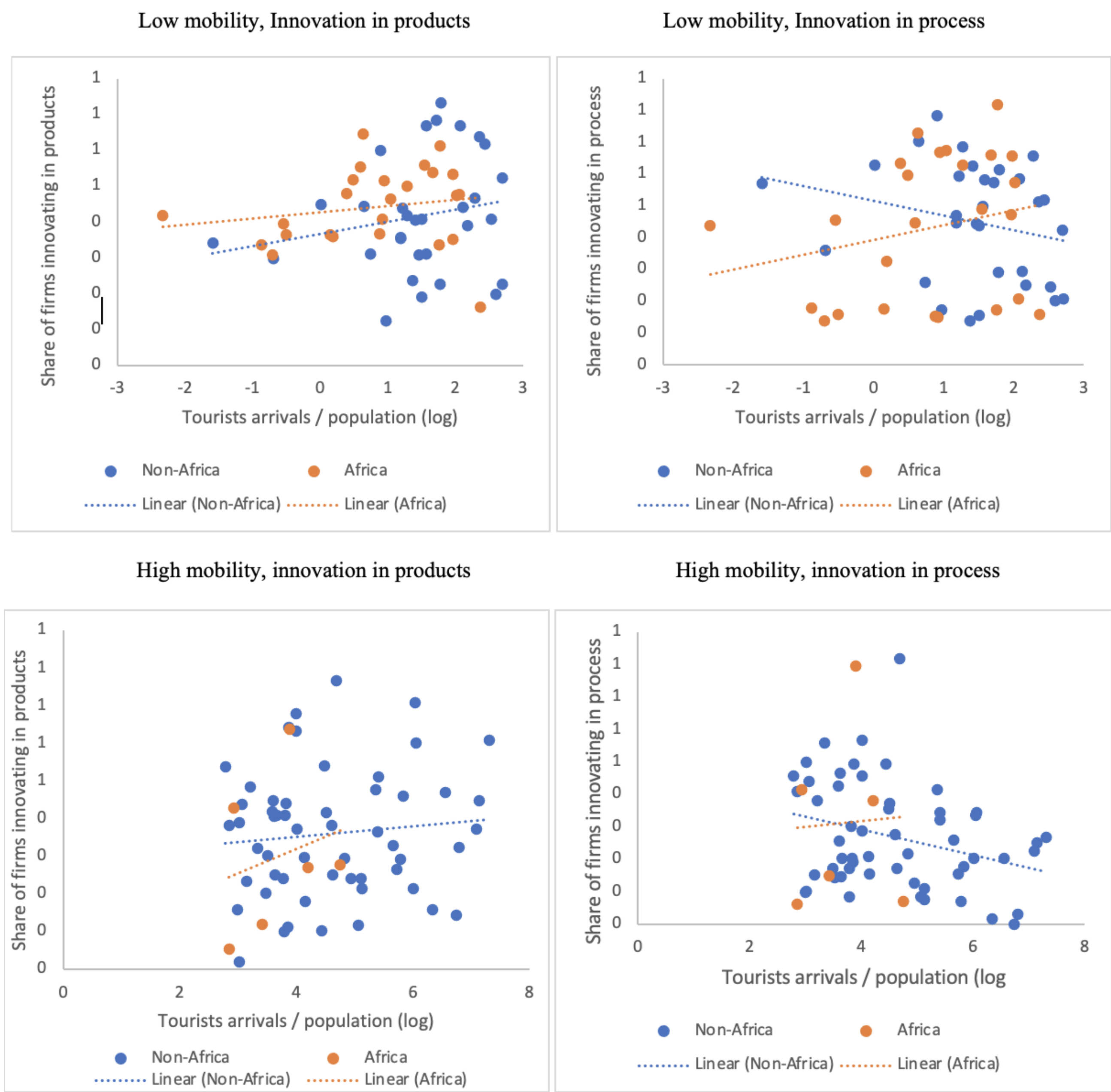

Figure 2: Tourist arrivals and innovation

innovation dynamics in the world with a focus on Africa, Figure 2 explores the correlation between the two variables. In order to limit the influence of observations with very high shares of tourist arrivals in destination country populations, which include countries hosting world-famous historical or natural sites and wildlife sanctuaries, or that have a small population, two graphs are presented for each type of innovation, after splitting the sample in two groups, labelled as "low" and "high" mobility countries respectively[6].

The graphs depict a positive association between tourism arrivals and the share of innovating firms in Africa, whatever the type of innovation considered, supporting a priori that short-term international visits contribute to innovation in Africa. Unlike African countries where tourist arrivals correlate positively with innovation in process, the link is found to be negative outside Africa. The picture seems to indicate that overall, short-term visits drive more innovation in Africa than in the rest of the world. This first insight into the relationship between short-term migration and innovation will receive a more rigorous treatment in the econometric section. Finally, Table 1 provides summary statistics on the variables used in the regression analysis.

Table 1: Data summary – working sample

Variables	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
Innovation in PSP	102737	0.5	0.5	0	1
Innovation in products	102415	0.4	0.5	0	1
Innovation in process	100773	0.4	0.5	0	1
Tourist (log)	102737	2.7	1.8	-2.7	7.3
R&D	86602	0.2	0.4	0	1
Size (log)	101965	3.4	1.4	-1.1	12.0
Certification	100896	0.2	0.4	0	1
Growth	102113	4.9	2.6	-7.6	14.2
FDI	101414	3.4	5.6	-5.7	97.1
Trade	101436	70.7	37.1	19.5	348.0

Notes: PSP stands for product/service or/and process.

5 Methodology

The empirical analysis is based on the following linear probability model:

$$Innov_{ijt} = \alpha_0 + X_{ijt}\alpha_1 + C_{jt}\alpha_2 + \alpha_3 TA_{jt} + \mu_j + k_t + \varepsilon_{ijt} \quad (3)$$

[6]The threshold we use to distinguish between low- and high-mobility countries is 15%. Although this is arbitrary, this choice also lies in the fact that it is just below the sample median (18.8%) and allows us to have an acceptable number of observations for African countries falling within the high-mobility category.

where $Innov_{ijt}$ represents innovation variables of firm i in country j and year t. The first innovation variable is a dummy equal to 1 if a firm has introduced a new product/service or process, or both, in the last 3 years and 0 otherwise. In some estimations, innovation is alternatively coded 0 (when the firm has introduced neither a new product/ service nor a new process), 1 (introduced a new product/service or a new process), and 2 (introduced both a new product/service and a new process). We further consider separately innovation variables, looking at whether a firm has introduced a new product/service or if it has introduced a new process.

The main variable of interest, TA, measures the number of tourist arrivals in country j in year t as a per cent of the population. The vector of variables X includes firms' characteristics that can influence their ability to be productive and innovative. These variables are a dummy equal to 1 if the firm has invested in R&D in the previous year; a variable measuring the size of the firm; and a dummy equal to 1 if the firm holds an international quality certification. The vector of variable C includes country-level data, namely GDP growth, openness to trade and FDI capturing macroeconomic conditions that can affect both firms' level of innovation and short-term mobility. μ_j captures country fixed effects controlling for countries' time-invariant unobservable characteristics, while k_t stands for year fixed effects capturing additional time-specific variation. ε_{ijt} is an i.i.d. error term.

We extend this analysis by specifically studying if Africa is different from other parts of the world and run the following specification:

$$Innov_{ijt} = \alpha_0 + X_{ijt}\alpha_1 + C_{jt}\alpha_2 + \alpha_3 TA_{jt} + \alpha_4 Afr_j + \alpha_5(Afr_j \times TA_{jt}) + \mu_j + k_t + \varepsilon_{ijt} \tag{4}$$

where we control for a dummy Afr which is equal to 1 for African countries and 0 for the rest of the world. The equation includes an interaction term between the Afr dummy and the tourist arrivals variable TA, the rationale behind to see if short term labor mobility has a different effect on innovation in the African context compared to the rest of the world.

6 Results

6.1 OLS estimates

Table 2 presents the main results. The OLS estimates of the effect of short-term labor mobility on innovation in column (1) show that tourism is positively related to innovation in products and services, or processes. More precisely, a 10% increase in mobility, as proxied by tourism arrivals, per 10,000 inhabitants raises the probability of innovation by 0.43%. In column (2), we augment the regression with a specific dummy for Africa and an interaction term between mobility and Afr. While the coefficient of mobility remains positive and significantly different from zero at 1 per cent level, the sign of the interaction term is not statistically different from zero. This may reflect either lacking influence, or conflicting effects occurring as a result of forcing the dependent variable to be varying only between zero and one – in other words, combining innovation in products/services and in process in a single category. To explore this possibility we, therefore allow the dependent variable to vary between zero, for the case of no innovation, one, if either innovation in product or process is present, and two, if innovation is in both product and process. Correspondingly we apply an ordered probit regressor to estimate Eq. (4).

The results, reported in column (3) of Table 2 confirm the positive "effect of tourism arrival on innovation found in column (1). In column (4) the interaction coefficient emerges as being both positive and statistically different from zero, suggesting that the probability that a firm innovates is higher in Africa compared to the rest of the world (RTW) as labor mobility increases.

In the following columns: (5)-(8), we investigate the interaction effect in more detail, by focusing on both types of innovation separately. The results indicate that short-term mobility makes African countries more innovative in products or services compared with non-African countries (column 6), while the rest of the world is more innovating in process than Africa as labor mobility increases (column 8). Short-term mobility is thus a powerful means to foster innovation in products or services (not necessarily in process) in Africa, and actually brings about more new products and services on the continent compared to the rest of the world.

Other control variables such as investment in R&D, size of the firm, quality certification, growth, FDI and trade all have the expected positive sign, and strong statistical significance coefficient, on innovation activity.

Table 2: OLS estimates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Innovation	In products or process		In products and/or process		In products		In process	
	OLS		Oprobit		OLS		OLS	
TA (log)	0.043***	0.050***	0.135***	0.100**	0.029*	0.009	0.012	0.029*
	(0.016)	(0.017)	(0.044)	(0.046)	(0.017)	(0.017)	(0.016)	(0.017)
Afr		0.866***		0.261		-0.331*		0.947***
		(0.196)		(0.550)		(0.196)		(0.191)
TAxAfr		-0.084		0.403**		0.213***		-0.180***
		(0.058)		(0.164)		(0.058)		(0.056)
R&D	0.314***	0.313***	0.953***	0.954***	0.316***	0.317***	0.318***	0.318***
	(0.004)	(0.004)	(0.011)	(0.011)	(0.004)	(0.004)	(0.004)	(0.004)
Size (log)	0.031***	0.031***	0.092***	0.092***	0.023***	0.023***	0.032***	0.032***
	(0.001)	(0.001)	(0.003)	(0.003)	(0.001)	(0.001)	(0.001)	(0.001)
Certification	0.054***	0.054***	0.173***	0.174***	0.056***	0.056***	0.048***	0.048***
	(0.004)	(0.004)	(0.011)	(0.011)	(0.004)	(0.004)	(0.004)	(0.004)
Growth	0.021***	0.020***	0.047***	0.048***	0.018***	0.019***	0.016***	0.016***
	(0.002)	(0.002)	(0.006)	(0.006)	(0.002)	(0.002)	(0.002)	(0.002)
FDI	0.018***	0.017***	0.020**	0.025***	0.008**	0.011***	0.005*	0.003
	(0.003)	(0.003)	(0.009)	(0.009)	(0.003)	(0.003)	(0.003)	(0.003)
Trade	0.003***	0.003***	0.011***	0.011***	0.004***	0.004***	0.003***	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	-0.613***	-0.674***			-0.488***	-0.334***	-0.306***	-0.436***
	(0.067)	(0.079)			(0.069)	(0.082)	(0.069)	(0.082)
Observations	83,097	83,097	83,097	83,097	82,890	82,890	82,466	82,466
R-squared	0.255	0.255			0.219	0.219	0.260	0.260
Country dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: *** p<0.01, ** p<0.05, * p<0.1. All standard errors (in parenthesis) are heteroskedasticity robust.

6.2 Dealing with endogeneity issues: control function approach and gravity-based instrumental variable

The estimates just described are, however, threatened by a number of identification issues. First, the OLS regression coefficients are likely to be inconsistent due to reverse causality: more innovating countries can represent an attractive destination for short-term cross-border flows of people due to the better quality of their products and services. In addition, our regressions may suffer from omitted factors that could jointly affect labor mobility and innovation, which are not captured by the control variables. Furthermore, using tourism arrivals as a proxy for short-term labor movements may be affected by measurement errors inherent to data filling procedures in the different countries. To address these potential identification issues, we apply a control function approach (CFA) to non-linear models, drawing on Wooldridge (2015)[7], and a gravity-based instrumental variable approach.

6.2.1 Obtaining the instrument for tourist arrivals

We rely on a gravity-based instrumental variable drawing on Frankel and Romer (1999) and Feyrer (2019), taking advantage of bilateral tourism inbounds from UN World Tourism Organization (UNWTO) statistics. The instrument is obtained in two steps. First, we estimate a gravity model predicting bilateral tourism inbounds out of exogenous dyadic geographical and cultural variables – i.e., variables which are unlikely to (directly) affect firms innovation (see Eq. (5) below). Then, we generate the predicted bilateral tourism flows, $\widehat{TA_{ijt}}$, which we aggregate over destination country and year, $\widehat{TA_{it}} = \sum_j \widehat{TA_{ijt}}$, to capture an exogenous source of variation in the actual aggregate flow of tourist arrivals. The instrument for our short-term labour mobility variable (the aggregate actual tourist arrivals per 100 inhabitants) is the aggregate predicted inbound of tourists divided by the destination country's population size, multiplied by 100: $(\widehat{TA_{it}}/Pop_i \times 100)$.

Following Frankel and Romer (1999), this gravity model-based method in constructing a reliable instrumental variable has been commonly used in the trade and migration literature: examples include Feyrer (2019), Alesina et al. (2016), and Ortega and Peri (2014). Andersen and Dalgaard (2011) also resorted to this method to obtain an instrument for short term travel flows in their study of the impact of short-term people flows on productivity. The "pseudo" gravity model predicting tourism inbounds is given by the following equation:

$$\begin{aligned} Log(TA_{ijt}) =& \alpha_0 + \alpha_t + \beta_1 Lang_{ij} + \beta_2 Contig_{ij} + \beta_3 \alpha_t Log(Dist_{ij}) + \beta_4 Log(Pop_{it}) + \\ & \beta_5 Log(Pop_{jt}) + \beta_6 Log(Area_i) + \beta_7 Log(Area_j) + \beta_8 Lock_i + \varepsilon_{ijt}, \end{aligned} \tag{5}$$

where $Log(TA_{ijt})$ is the logarithm of tourist arrivals in destination country i from origin

[7] See Appendix A.

country j in year t; α_0 is the constant; and α_t captures year dummies. $Lang_{ij}$ is a dummy variable equal to 1 if a language is spoken by at least 9% of the population in both destination and origin countries: linguistic proximity is expected to favour mobility. $Log(Dist_{ij})$ is the natural logarithm of the geographical distance between countries pairs – in kilometers - which we interact with the year dummies (α_t): distance negatively affects international travel as longer distances are associated with higher transportation costs, the interaction with the year dummies aims at capturing common shocks in communication and technologies which have alleviated physical distance barriers between countries over time. $Contig_{ij}$ is a dummy variable taking a value 1 if countries share a common border: the logic behind this variable is the same as the distance variable. $Log(Pop_{it})$ represents the logarithm of the population size in the destination country, and $Log(Area_i)$, the logarithm of its area in square kilometers: these two variables together proxy for the country size as larger countries are more likely to host tourists. $Log(Pop_{jt})$ and $Log(Area_j)$ are equivalent to the previous two variables for the departure country, and similarly, the number of visitors from a country is expected to increase with its size. $Lock_i$ is a dummy variable for landlocked destination countries. There is little reason to believe that the selected determinants of bilateral tourism flows would directly affect firms' innovative capacity, and therefore they appear to be good exogenous predictors of short-term mobility in a firm's relationship to innovation.

The presence of a large number of zeroes in tourism flow statistics between some pairs of countries likely makes inconsistent the parameters of the gravity equation when the OLS estimator is used. We thus apply a Poisson regression using the pseudo maximum likelihood (PPML) approach[8] to identify and drop regressors that may cause the nonexistence of the (pseudo) maximum likelihood estimates (Silva and Tenreyro, 2011). The estimations are based on yearly data spanning the period 2006–2019. Data on population are from the World Bank's WDI and data for other determinants are sourced from the CEPII database.

The results are reported in Table 3 with robust standard errors clustered by country pairs. They indicate that the geographical and cultural variables are strong predictors of bilateral tourism arrivals as the coefficients are highly statistically and significantly different from zero. Moreover, they have the expected signs. Bilateral tourist flows increase when two countries have a common language and border, with the size of the population of the departure and arrival country, and the area of the destination country. These flows decrease with the distance between two countries, the area of the origin country, and when the destination country is landlocked.

[8] We use the *ppml* command on Stata.

Table 3: PPML estimates of the gravity model

	Bilateral tourist arrivals (log)
Common language	0.622**
	(0.265)
Contiguity	1.830***
	(0.380)
LogDistance_2006	-0.853***
	(0.142)
LogDistance_2007	-0.850***
	(0.141)
LogDistance_2008	-0.860***
	(0.139)
LogDistance_2009	-0.855***
	(0.141)
LogDistance_2010	-0.844***
	(0.139)
LogDistance_2011	-0.837***
	(0.139)
LogDistance_2012	-0.844***
	(0.144)
LogDistance_2013	-0.842***
	(0.143)
LogDistance_2014	-0.833***
	(0.143)
LogDistance_2015	-0.755***
	(0.131)
LogDistance_2016	-0.754***
	(0.131)
LogDistance_2017	-0.846***
	(0.145)
LogDistance_2018	-0.837***
	(0.145)
LogPop_dest	0.392***
	(0.0743)
LogPop_ori	0.744***
	(0.0979)
LogArea_dest	0.135*
	(0.0793)
LogArea_ori	-0.404***
	(0.131)
Landlocked_dest	-0.462*
	(0.236)
Constant	8.012***
	(1.663)
Observations	230,186
Year dummies	Yes

Notes: Standard errors (clustered by country pairs) in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

6.2.2 Control Function Approach-based estimations

The results of the first stage regression in the CFA are provided in Table B1 in the Appendix and show that the gravity-based instrument of short-term flows of people correlates positively and significantly with actual tourist arrivals. The estimates show that the instrument strongly predicts the labor mobility variable. All the above results confirm the reliability of the chosen instrument.

The second-stage regression results are shown in Table 4. The interaction term in column (1) is significant and positive after correcting the endogeneity of the tourist arrivals while it was not statistically different from zero with the OLS estimates in Table 2. Results in columns (2) and (3) confirm the OLS results that short-term mobility has a greater impact in Africa relative to the rest of the world in terms of aggregate innovation (column 2) and innovation in products (column 3). Short-term flows of people increase innovation in Africa compared to the rest of the world; this result is mainly driven by innovation in products and services rather than innovation in new processes as respectively reported in the last two columns of Table 4. Indeed, the results confirm that short-term mobility significantly helps innovation in products and services (column 3), while the effect on process is positive but statistically not different from zero (column 4). This result supports the hypothesis that short-term international mobility in Africa is less capable of bringing innovation to processes relative to simply expanding products and services that already exist. This may however mask constraints in the amount or quality of existing infrastructure and/or costs to produce and distribute locally rather than ineffective labor movements. We further explore these results in the context of the heterogeneity analysis discussed in the next subsection.

Table 4: Instrumental variable results based on the Control Function approach

	(1)	(2)	(3)	(4)
Innovation in:	Product or process	Product and/or process	Product	Process
TA (log)	0.069	0.222**	0.134**	0.096
	(0.056)	(0.097)	(0.061)	(0.061)
Afr	-0.131	-0.419	-0.813***	0.348
	(0.231)	(0.374)	(0.242)	(0.239)
TAxAfr	0.214***	0.387***	0.390***	0.011
	(0.063)	(0.102)	(0.065)	(0.064)
R&D	0.330***	0.671***	0.337***	0.338***
	(0.005)	(0.008)	(0.005)	(0.005)
Size (log)	0.033***	0.059***	0.026***	0.034***
	(0.002)	(0.003)	(0.002)	(0.002)
Certification	0.042***	0.074***	0.042***	0.033***
	(0.006)	(0.011)	(0.007)	(0.007)
Growth	0.042***	0.075***	0.043***	0.033***
	(0.008)	(0.014)	(0.009)	(0.009)
FDI	0.012**	0.012	0.007	0.004
	(0.005)	(0.008)	(0.005)	(0.005)
Trade	0.003***	0.006***	0.004***	0.002*
	(0.001)	(0.002)	(0.001)	(0.001)
Control Function	-0.085*	-0.217***	-0.111**	-0.112**
	(0.045)	(0.079)	(0.049)	(0.051)
Constant	-0.688***	-1.364***	-0.776***	-0.602**
	(0.216)	(0.369)	(0.238)	(0.236)
Observations	77,100	77,100	76,924	76,540
Country dummy	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes

Notes: Bootstrapped standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

6.3 Heterogeneity analysis

Our previous results could vary depending on regions or sectors. We thus carry out some heterogeneity analysis taking care of these differences considering OLS estimates. The results reported in Table 5 (columns 1–4) show that while African regions are less innovative than the EU, short-term labor mobility is associated with more innovation than in the EU. As a result, short-term mobility can be a valuable channel to diffuse and foster innovation in Africa, especially when considering that European economies are already at the frontier of innovation.

Table 5: Short-term mobility and innovation: Comparing Africa with the EU region

	(1)	(2)	(3)	(4)
	OLS	Oprobit	OLS	OLS
Innovation in:	Products or process	Products and/or process	Products	Process
TA (log)	-0.073***	-0.194***	-0.045***	-0.073***
	(0.008)	(0.021)	(0.008)	(0.008)
centr_af	-0.243***	-0.630***	-0.166***	-0.237***
	(0.045)	(0.118)	(0.045)	(0.044)
east_af	-0.275***	-0.655***	-0.172***	-0.212***
	(0.044)	(0.114)	(0.043)	(0.043)
north_af	-0.445***	-1.335***	-0.330***	-0.337***
	(0.047)	(0.129)	(0.046)	(0.046)
south_af	-0.132***	-0.336***	-0.108**	-0.055
	(0.049)	(0.130)	(0.050)	(0.049)
west_af	-0.299***	-0.675***	-0.225***	-0.210***
	(0.045)	(0.117)	(0.044)	(0.044)
Rest of EU	-0.396***	-1.009***	-0.249***	-0.361***
	(0.049)	(0.130)	(0.048)	(0.048)
Mid_East	-0.029	0.088	-0.060	0.030
	(0.072)	(0.194)	(0.067)	(0.069)
LAC	0.062	0.153	0.067	0.006
	(0.046)	(0.119)	(0.045)	(0.045)
East Asia	0.254**	0.266	-0.080	0.234**
	(0.109)	(0.292)	(0.109)	(0.110)
Rest of Asia	-0.339***	-0.935***	-0.325***	-0.245***
	(0.042)	(0.111)	(0.042)	(0.042)
Oceania	-0.020	-0.106	-0.098*	0.071
	(0.050)	(0.127)	(0.052)	(0.051)
TAxCentr_af	0.135***	0.319***	0.093***	0.081***
	(0.015)	(0.039)	(0.015)	(0.013)
TAxEast_af	0.217***	0.595***	0.152***	0.228***
	(0.012)	(0.033)	(0.012)	(0.012)
TAxNorth_af	0.063***	0.214***	0.026**	0.064***
	(0.011)	(0.031)	(0.011)	(0.011)
TAxSouth_af	0.017	0.080**	0.018	0.019*
	(0.012)	(0.032)	(0.012)	(0.011)
TAxWest_af	0.135***	0.325***	0.096***	0.125***

	(0.013)	(0.033)	(0.013)	(0.012)
TAxRest_eu	0.066***	0.165***	0.036***	0.064***
	(0.010)	(0.028)	(0.010)	(0.010)
TAxMid_east	-0.044**	-0.162***	-0.026	-0.045**
	(0.018)	(0.050)	(0.016)	(0.017)
TAxLAC	0.019**	0.054**	0.011	0.014*
	(0.009)	(0.023)	(0.008)	(0.008)
TAxEast_Asia	-0.159***	-0.241**	-0.038	-0.104**
	(0.041)	(0.110)	(0.041)	(0.042)
TAxRest_Asia	0.030***	0.088***	0.024***	0.032***
	(0.008)	(0.021)	(0.008)	(0.008)
R&D	0.333***	0.980***	0.328***	0.335***
	(0.004)	(0.010)	(0.004)	(0.004)
Size (log)	0.030***	0.087***	0.022***	0.031***
	(0.001)	(0.003)	(0.001)	(0.001)
Certification	0.048***	0.152***	0.052***	0.043***
	(0.004)	(0.011)	(0.004)	(0.004)
Growth	0.008***	0.021***	0.007***	0.006***
	(0.001)	(0.003)	(0.001)	(0.001)
FDI	0.002***	0.002*	0.001*	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Trade	0.001***	0.002***	0.000***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
Constant	0.466***		0.386***	0.420***
	(0.045)		(0.045)	(0.044)
Observations	83,097	83,097	82,890	82,466
R-squared	0.227		0.200	0.232
Year dummy	Yes	Yes	Yes	Yes

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

As the preliminary results established that short business trips increase innovation in Africa more than in the rest of the world, in Table 6 we focus on the African sample and explore the sectors that drive this innovation using the classification of low-, medium-low-, and higher- R&D-intensity sectors based on a taxonomy developed by the OECD[9]. The results show that on average in Africa, medium- and higher-R&D-intensity sectors are more innovative than lower-R&D-intensity sectors (column 1). However, the impact of

[9]See Galindo-Rueda and Verger (2016).

Table 6: Labor mobility and innovation: heterogeneity analysis by the level of intensity in R&D

	(1)	(2)	(3)	(4)
Innovation in:	Products or process	Products and/or process	Products	Process
	OLS	Oprobit	OLS	OLS
TA (log)	-0.021	-0.047	-0.027	-0.208***
	(0.026)	(0.079)	(0.026)	(0.025)
High	0.042***	0.098**	0.021	0.043***
	(0.015)	(0.040)	(0.015)	(0.014)
Medium	0.032**	0.061	0.003	0.036***
	(0.014)	(0.038)	(0.014)	(0.014)
TA x High	-0.021***	-0.044**	-0.013*	-0.013*
	(0.007)	(0.021)	(0.007)	(0.007)
TA x Medium	-0.013*	-0.028	-0.005	-0.009
	(0.007)	(0.018)	(0.006)	(0.006)
R&D	0.297***	0.941***	0.305***	0.300***
	(0.008)	(0.025)	(0.009)	(0.008)
Size (log)	0.032***	0.102***	0.031***	0.026***
	(0.003)	(0.008)	(0.003)	(0.002)
Certification	0.042***	0.143***	0.041***	0.037***
	(0.009)	(0.027)	(0.010)	(0.009)
Growth	0.030***	0.097***	0.017***	0.008*
	(0.005)	(0.015)	(0.005)	(0.005)
FDI	-0.005	-0.022	0.010	0.045***
	(0.013)	(0.034)	(0.013)	(0.012)
Trade	-0.002*	-0.008*	-0.000	0.008***
	(0.001)	(0.005)	(0.001)	(0.001)
Constant	0.562***		0.230***	0.174**
	(0.085)		(0.086)	(0.084)
Observations	19,395	19,395	19,363	19,223
R-squared	0.259		0.201	0.308
Country dummy	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes

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

short-term labor mobility in these sectors is lower compared with the low technology sector. This is particularly true for the high-R&D-intensity sector, where the interaction with the mobility variable is significant and negative across all regressions (columns 1 to 4)[10]. Mobility enhances innovation, but predominantly in low-tech industries through improvements in products and services.

6.4 Focusing exclusively on business visits

Our measure of short-term mobility in the previous analyses captures arrivals for various purposes including business, professional, holidays, leisure, and recreation. However, in the linkage between short-term mobility and firm productivity, not all types of travel may be equivalent in their effects on the probability to innovate. One might expect travels with more direct contact with firms' environment to have higher implications for their innovation capacity. In line with that argument, we replicate estimations in Table 2 using an alternative measure of short-term mobility which exclusively captures arrivals for business and professional purposes which we refer to as business visits (BV). The data are sourced from the UNWTO.

Columns (1)–(4) in Table 7 reports the results with the BV variable as a share of the destination country's population, using population data from the WDI. The results provide stronger evidence of the higher probability of African firms to innovate relative to the rest of the world as short-term mobility increases. The coefficient on the interaction term between business visits and the Africa dummy is strongly significant and positive in all regressions whether based on aggregate innovation or type of innovation (products and process). The control variables are also very significant with the expected signs in most estimations. However, the negative coefficient on our travel variable (without interaction) seems to suggest a priori that business visits are negatively related to innovation in non-African countries, on average. In columns (5)–(8), we question this finding by including the BV squared to explore any possible non-linearity in this relationship. The results indeed show a more complex relationship between BV and innovation in the non-Africa region for all levels of flows of people, with some non-linearity. While the coefficient attached to BV is still significant and negative, the positive coefficient on the squared term indicates that short-term business travel is conducive to innovation in the rest of the world as well after a certain threshold, especially for aggregate innovation in column (6) and innovation in process in column (8), where the term is significant at the 5% level. This reinforces the evidence of our prior finding that Africa is more sensitive to the influence of labor mobility to foster innovation than the rest of the world.

[10]For a more detailed analysis focusing on each African region, see Appendix B, where Table 6 is replicated in Table B2 and Table B3 for innovation in products/services and innovation in process, respectively.

Table 7: Business visits and innovation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Baseline estimations				Including business visits squared			
	OLS	Oprobit	OLS	OLS	OLS	Orpobit	OLS	OLS
Innovation in	Product or process	Product or/ and process	Products	Process	Product or process	Product or/ and process	Products	Process
BV (log)	-0.049***	-0.183***	-0.031*	-0.084***	-0.053***	-0.226***	-0.040**	-0.100***
	(0.015)	(0.042)	(0.017)	(0.016)	(0.017)	(0.046)	(0.018)	(0.018)
BV (log) square					0.004	0.038**	0.007	0.014**
					(0.006)	(0.018)	(0.007)	(0.007)
Africa	0.314***	0.556***	0.021	0.204***	0.318***	0.592***	0.028	0.219***
	(0.050)	(0.154)	(0.051)	(0.048)	(0.051)	(0.156)	(0.052)	(0.049)
BV (log)x Africa	0.222***	1.042***	0.304***	0.166***	0.248***	1.261***	0.347***	0.250***
	(0.039)	(0.107)	(0.040)	(0.039)	(0.053)	(0.150)	(0.057)	(0.058)
R&D	0.318***	0.990***	0.329***	0.327***	0.318***	0.990***	0.329***	0.327***
	(0.004)	(0.012)	(0.005)	(0.004)	(0.004)	(0.012)	(0.005)	(0.004)
Size (log)	0.032***	0.096***	0.025***	0.031***	0.032***	0.096***	0.025***	0.031***
	(0.001)	(0.004)	(0.001)	(0.001)	(0.001)	(0.004)	(0.001)	(0.001)
Certification	0.049***	0.161***	0.049***	0.044***	0.049***	0.161***	0.049***	0.044***
	(0.004)	(0.013)	(0.005)	(0.005)	(0.004)	(0.013)	(0.005)	(0.005)
Growth	0.029***	0.066***	0.027***	0.018***	0.029***	0.066***	0.027***	0.017***
	(0.003)	(0.009)	(0.003)	(0.003)	(0.003)	(0.009)	(0.003)	(0.003)
FDI	0.012***	0.018*	0.004	0.005	0.013***	0.020*	0.004	0.006
	(0.004)	(0.011)	(0.004)	(0.004)	(0.004)	(0.011)	(0.004)	(0.004)
Trade	0.002***	0.010***	0.004***	0.003***	0.003***	0.011***	0.004***	0.003***
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
Constant	-0.226***		-0.103	-0.083	-0.242***		-0.131	-0.136*
	(0.074)		(0.079)	(0.077)	(0.079)		(0.084)	(0.081)
Observations	67,414	67,414	67,268	66,963	67,414	67,414	67,268	66,963
R-squared	0.271		0.227	0.274	0.271		0.227	0.274
Country/Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

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

7 Conclusion

We show that an increase in the flow of short-term international visits is associated with an increase in the probability to innovate in products/services or in process. After correcting for endogeneity, we confirm that short-term international labor movements in Africa increase innovation more than in the rest of the world. This outcome is mainly driven by innovation in products and services, rather than innovation in process. Using an alternative measure of short-term mobility that only captures arrivals for business and professional purposes, our findings provide stronger evidence that African firms are more likely than those in the rest of the world to innovate as a result of short-term mobility.

On the methodological front, these results indicate the relevance of disentangling the analysis between innovation for products and services and innovation in process, as labor mobility has differential effects depending on the region of the world and the type of innovation, particularly on the type of employment (i.e., skill and educational level) that it promotes. Investigating possible regional heterogeneity in the mobility-innovation nexus, we find that all African regions are less innovating than those in the EU region when we control for firm- and country-level determinants of innovation. Labor mobility nevertheless positively contributes to more firm innovation capacity in each of the African regions than in the EU. Some heterogeneity in the relationship between labor mobility and innovation in Africa exists, based on the sector of activity. Medium- and higher-R&D-intensity sectors are more innovating, and the impact of short-term mobility in these sectors is lower compared with sectors with lower levels of technology.

Overall, informality in the economy does not remove the ability to create new productive knowledge and innovate, though it makes the measurement of innovation and its effects empirically challenging. Although we rely on data on international tourist flows as a proxy for labor mobility, we find that mobility as a distinct phenomenon from migration matters to innovation in products/services or processes. More and better data to measure peoples' interactions could help better quantify their effects in low- and medium-income countries. Our analysis shows that peoples' talent and skills arising from short-term interactions rather than permanent migrations are economically meaningful, highlighting that labor mobility is an "easy" way to generate innovation and increase productivity, in that it does not require the reallocation of resources that accompanies permanent migrations. Nor it can be analyzed in the traditional zero-sum game that characterizes migration, whereby a country's loss of skilled people and brains is another's gain. The flows of ideas and knowledge associated with inflows and outflows of short-term movements are unlikely to net out, as they compound the stock of knowledge that already exists in places of origin and destination. The temporary visit of an engineer from Africa to North America and the corresponding visit of a North American medical doctor to Africa do not modify the permanent stock of people living in Africa and North America. But, they can lead to knowledge sharing about medical procedures and engineering problems and solutions. These two "knowledges" cannot be netted out, and there is no winner and no loser: both the place of origin and the destination gain new productive knowledge from their citizens' visits. This point is particularly relevant for Africa, as it has often experienced the relocation of highly skilled people to other, generally higher-income countries in other parts of the world. While there is little doubt that such relocation is a physical loss of highly trained workforce, it also gives the opportunity to the countries of origin to tap into the knowledge and skills that those permanent migrants gain in their host country on a regular basis, or to involve them in mentoring and sharing knowledge with those "left behind" throughout face-to-face or virtual interactions, and business visits. Such activity, albeit hard-to-measure, contributes to the stock of productive knowledge used in both origin and destination countries and makes a positive contribution to economic growth.

With a regional perspective, this also suggests innovation would benefit from policymakers' implementing the existing provisions of the Free Movement Protocols within Africa and related labor mobility policies. Labor mobility in Africa is a crucial aspect of the African Continental Free Trade Area (ACFTA). Its adoption could open new opportunities to tap into the knowledge generated around the world through mobility, promote the take-off of activities beyond manufacturing, and affect the choice of technology and the direction of innovation, looking at a broader perspective of industrialization (Stiglitz et al., 2017).

As peoples' circulation is often synonymous with the circulation of ideas and innovation, African countries can take further advantage of development and industrial policies that take into account the positive effect of short-term labor mobility. Put differently, labor mobility could be part of a strategic plan to promote innovation, reduce poverty, and spark growth on the continent.

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Appendix A. Brief presentation of the control function approach (CFA)

Let us rewrite Eq. (4) as

$$Innov_{ijt} = \beta_0 + \beta_1 Afr_j + \beta_2 TA_{jt} + \beta_3 (Afr_j \times TA_{jt}) + X\gamma + u_{ijt}, \tag{6}$$

where X includes both firm-and country-level control variables.
Because TA_{jt} is likely to be endogenous, so is its interaction with the Africa dummy, $Afr_j \times TA_{jt}$, leading to possible inconsistent estimates of β_2, the effect on non-African countries, and β_3, the differential impact between Africa and the rest of the world. Having an instrument for our tourism variable, the standard 2SLS-IV estimator can address the endogeneity issue related to TA_{jt} but not necessarily that related to the interaction term. The CFA developed by Wooldridge (2015)) represents an efficient way to identify both β_2 and β_3 and consistently estimate how the effect of tourism on innovation differs between Africa and the rest of the world.

We denote Z_{jt} an instrumental variable for TA_{jt} and assume that $E(u|X, Z_{jt}) = 0$. The reduced form equation is given by:

$$TA_{jt} = \psi_0 + X\eta + Z\pi + v_{jt} \tag{7}$$

with $E(v_{jt}|X, Z_{jt}) = 0$.
We assume that the structural error, conditioned on the reduced form error does not depend on the controls and the instrument and is a linear function of the reduced form error:

$$E(u_{ijt}|v_{jt}, X, Z_{jt}) = E(u_{ijt}|v_{jt}) = \theta v_{jt} \tag{8}$$

Based on these assumptions, we obtain:

$$\begin{aligned} E(Innov_{ijt}|TA_{jt}, X, Z_{jt}) =& E(Innov_{ijt}|v_{jt}, X, Z_{jt}) \\ &= \beta_0 + \beta_1 Afr_j + \beta_2 TA_{jt} + \beta_3 Afr_j TA_{jt} + X\gamma + \theta v_{jt} \end{aligned} \tag{9}$$

v is called the control function (CF), and as shown by Eq. (9), adding it solves the endogeneity of TA and $Afr \times TA$.

In summary, the estimation procedure is conducted in two steps:

(i) We first obtain the OLS residuals, $\widehat{v_{jt}}$ from the reduced form Eq. (7);

(ii) Then we estimate, using OLS, the structural Eq. (6) augmented with the predicted CF obtained from (i), i.e.:
$Innov_{ijt} = \beta_0 + \beta_1 Afr_j + \beta_2 TA_{jt} + \beta_3 Afr_j \times TA_{jt} + X\gamma + \theta\widehat{v_{jt}} + u_{ijt}$

Appendix B: Tables

Table B1: First-stage regression of the Control Function approach

	Tourist arrivals (Log)
Africa	-0.177***
	(0.013)
R&D	-0.063***
	(0.010)
Size (Log)	-0.022***
	(0.003)
Certification	0.102***
	(0.011)
Growth	-0.157***
	(0.003)
FDI	-0.057***
	(0.002)
Trade	0.019***
	(0.000)
Instrument	0.000***
	(0.000)
Constant	2.493***
	(0.026)
Observations	77,202
R-squared	0.579
Prob > F	0.000
Country dummies	Yes

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

Table B2: Mobility, innovation in products or services, and R&D intensity sector by African region

	(1)	(2)	(3)	(4)	(5)
	Innovation in products or services				
	North	Central	South	West	East
TA (Log)	0.852**	0.045	2.353***	0.016	0.557***
	(0.350)	(0.042)	(0.376)	(0.030)	(0.198)
High	-0.028	-0.010	0.103	-0.036	0.057**
	(0.042)	(0.049)	(0.069)	(0.034)	(0.025)
Medium	0.060	-0.076	0.028	0.089**	0.006
	(0.038)	(0.047)	(0.067)	(0.036)	(0.025)
TA x High	0.012	-0.059	-0.035	0.022	-0.049**
	(0.017)	(0.038)	(0.024)	(0.026)	(0.024)
TA x Medium	-0.007	-0.028	-0.022	-0.073***	-0.058**
	(0.014)	(0.037)	(0.024)	(0.027)	(0.023)
R&D	0.329***	0.253***	0.286***	0.318***	0.302***
	(0.022)	(0.041)	(0.020)	(0.019)	(0.015)
Size (log)	0.014***	0.044***	0.033***	0.032***	0.045***
	(0.004)	(0.016)	(0.007)	(0.007)	(0.006)
Certification	0.079***	0.087*	-0.006	0.043*	0.027
	(0.015)	(0.049)	(0.023)	(0.025)	(0.019)
Growth	0.070	0.020	0.258***	0.071***	0.022
	(0.130)	(0.026)	(0.037)	(0.016)	(0.025)
FDI	0.017		0.878***	0.017*	-0.021
	(0.163)		(0.135)	(0.009)	(0.023)
Trade	-0.025***		-0.114***	-0.002**	0.017***
	(0.010)		(0.017)	(0.001)	(0.003)
Constant	-1.073**	0.128	-2.109***	-0.056	-0.953***
	(0.488)	(0.173)	(0.406)	(0.105)	(0.360)
Observations	5,443	887	3,335	4,496	5,202
Countries	3	3	7	11	7
R-squared	0.139	0.072	0.169	0.094	0.137
Country/Year dummies	Yes	Yes	Yes	Yes	Yes

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

Table B3: Mobility, innovation in process, and R&D intensity sector by African region

	(1)	(2)	(3)	(4)	(5)
	Innovation in process				
	North	Central	South	West	East
TA (log)	1.374***	-0.253***	2.419***	0.063**	-0.335*
	(0.375)	(0.038)	(0.275)	(0.027)	(0.184)
High	-0.026	0.014	0.144**	0.012	0.063**
	(0.040)	(0.041)	(0.062)	(0.031)	(0.025)
Medium	0.014	-0.035	0.067	0.006	0.077***
	(0.037)	(0.044)	(0.059)	(0.033)	(0.025)
TA x High	0.010	-0.042	-0.038*	0.010	-0.026
	(0.017)	(0.032)	(0.021)	(0.023)	(0.022)
TA x Meidum	0.002	0.038	-0.023	0.013	-0.052**
	(0.015)	(0.034)	(0.020)	(0.024)	(0.022)
R&D	0.364***	0.372***	0.250***	0.285***	0.291***
	(0.021)	(0.037)	(0.018)	(0.016)	(0.014)
Size (log)	0.009**	0.027*	0.029***	0.036***	0.037***
	(0.004)	(0.014)	(0.006)	(0.006)	(0.005)
Certification	0.049***	0.106**	0.035*	0.006	0.039**
	(0.014)	(0.045)	(0.020)	(0.024)	(0.018)
Growth	0.138	-0.119***	0.283***	0.113***	-0.124***
	(0.139)	(0.024)	(0.027)	(0.014)	(0.023)
FDI	-0.013		0.939***	0.039***	0.073***
	(0.176)		(0.100)	(0.008)	(0.022)
Trade	-0.040***		-0.119***	-0.007***	0.021***
	(0.010)		(0.013)	(0.001)	(0.003)
Constant	-1.791***	0.949***	-2.269***	-0.115	0.213
	(0.522)	(0.165)	(0.289)	(0.089)	(0.337)
Observations	5,418	882	3,297	4,474	5,152
Countries	3	3	7	11	7
R-squared	0.192	0.248	0.350	0.224	0.223
Country/Year dummies	Yes	Yes	Yes	Yes	Yes

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

Table B4: List of countries

Africa	EU	Rest of Europe	East Asia	Rest of Asia	Latin America & Carrib.	Middle East
Benin	Bulgaria	Albania	China	Armenia	Antigua & Barbuda	Israel
Burundi	Croatia	Belarus	Mongolia	Azerbaijan	Argentina	Jordan
Cameroon	Cyprus	Bosnia and Herz.		Bangladesh	Bahamas	Lebanon
Central Afr. Rep.	Czech Rep.	Georgia		Bhutan	Barbados	West Bank & Gaza
Congo, DR	Estonia	Moldova		Cambodia	Belize	
Côte d'Ivoire	Greece	Montenegro		India	Bolivia	
Egypt	Hungary	North Macedonia		Indonesia	Chile	
Eswatini	Italy	Russia		Kazakhstan	Colombia	
Ethiopia	Latvia	Serbia		Kyrgyz Rep.	Costa Rica	
Gambia	Lithuania	Ukraine		Lao PDR	Dominica	
Ghana	Malta			Malaysia	Dominican Rep.	
Guinea	Poland			Myanmar	Ecuador	
Kenya	Portugal			Nepal	El Salvador	
Lesotho	Romania			Philippines	Grenada	
Malawi	Slovak Rep.			Sri Lanka	Guatemala	
Mali	Slovenia			Tajikistan	Guyana	
Morocco	Sweden			Thailand	Honduras	
Mozambique				Timor-Leste	Jamaica	
Namibia					Mexico	
Niger				Turkey	Nicaragua	
Nigeria				Uzbekistan	Panama	
Rwanda				Vietnam	Paraguay	
Senegal					Peru	
Sierra Leone					St Kitts & Nevis	
Sudan					St Vincent & Grenad.	
Tanzania					Suriname	
Togo					Uruguay	
Tunisia					Venezuela	
Uganda						
Zambia						
Zimbabwe						

Table B5: Description of the variables.

Variable	Measurement and description	Source
Innovation in product/ service	Dummy equal to 1 if a firm has introduced a new product/service over the last 3 years, and 0 otherwise	World Bank Enterprise Survey (WBES), question h1
Innovation in process	Dummy equal to 1 if a firm has introduced a new or significantly improved process over the last 3 years, and 0 otherwise	WBES, question h5
Innovation in product/service or process	Dummy equal to 1 if a firm has introduced either a new product/service or/and a new process over the last 3 years, and 0 otherwise	WBES, combining questions h1 and h5
Innovation in product/service or/and process	Categorical variable: 0 if a firm has introduced neither a new product/service nor a new process; 1 if a firm has introduced either a new product/service or a new process; 2 if a firm has introduced both a new product/service and a new process.	WBES, combining questions h1 and h5
Tourist arrivals	Log of the number of international visitors for a period not exceeding 12 months, and for a purpose not related to a remunerated activity, as a percent of the visited country's population	World Development Indicators (WDI), World Bank
Business visits	Same as tourist arrivals capturing exclusively travel for business and professional purposes	World Tourism Organization (UNWTO)
R&D	Dummy equal to 1 if a firm has invested in research and development during last fiscal year	WBES
Size	Log of the total number of full-time employees, adjusted for temporary workers.	WBES
Certification	Dummy equal to 1 if a firm holds an internationally recognized quality certification	WBES
Growth	Real GDP growth rate	WDI
FDI	FDI inflows in percent of GDP	WDI
Trade	Sum of exports and imports, as a percent of GDP	WDI
Bilateral tourist arrivals	Log of Tourist arrivals in each destination country i in the sample from each origin country j in the world	UNWTO
Language	Dummy equal to 1 if a language is spoken by at least 9% of the population in both destination and origin countries	CEPII database
Distance	Log of geographical distance between countries pairs in kilometre	CEPII database
Contiguity	Dummy taking a value 1 if countries share a common border	CEPII database
Population	Log of population size	WDI
Area	Log of the country's area in kilometre square	CEPII database
Lock	Dummy for landlocked destination countries	CEPII database

Table B6: Share of innovating firms by African country

Country	Innovating firms (percent of all firms)	Region
Rwanda	87.6%	East Arica
Kenya	84.2%	East Arica
Namibia	80.7%	Southern Africa
Uganda	76.2%	East Arica
Mauritania	75.3%	North Africa
Zambia	73.9%	Southern Africa
Central African Rep.	73.3%	Central Africa
Burundi	73.2%	East Arica
Malawi	73.0%	Southern Africa
Ghana	71.8%	West Africa
Nigeria	66.8%	West Africa
Tanzania	66.5%	East Arica
South Sudan	65.5%	East Arica
Senegal	65.4%	West Africa
Sudan	60.3%	East Arica
Ethiopia	54.1%	East Arica
Congo, DRC	52.9%	Central Africa
Zimbabwe	52.5%	Southern Africa
Djibouti	51.9%	East Arica
Morocco	49.6%	North Africa
Mali	47.8%	West Africa
Liberia	47.0%	West Africa
Tunisia	45.1%	North Africa
Cameroon	43.9%	Central Africa
Côte d'Ivoire	41.9%	West Africa
Togo	39.3%	West Africa
Niger	38.0%	West Africa
Sierra Leone	34.9%	West Africa
Guinea	33.3%	West Africa
Benin	30.9%	West Africa
Eswatini	28.9%	Southern Africa
Egypt	23.4%	North Africa
Lesotho	8.7%	Southern Africa