

Formal-Informal Supply Chain Linkages and Firm Productivity in Sub-Saharan Africa

Citation for published version (APA):

Djidonou, R., Foster-McGregor, N., & Mathew, N. (2025). *Formal-Informal Supply Chain Linkages and Firm Productivity in Sub-Saharan Africa: The Role of Human Capital*. UNU-MERIT. UNU-MERIT Working Papers No. 006 <https://doi.org/10.53330/JNER2108>

Document status and date:

Published: 14/02/2025

DOI:

[10.53330/JNER2108](https://doi.org/10.53330/JNER2108)

Document Version:

Publisher's PDF, also known as Version of record

Document license:

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#2025-006

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Published 13 February 2025

DOI:

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UNU-MERIT Working Papers

ISSN 1871-9872

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Formal-Informal Supply Chain Linkages and Firm Productivity in Sub-Saharan Africa: The Role of Human Capital

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Abstract

Micro, Small, and Medium Enterprises (MSMEs) play a crucial role in reducing poverty and inequality by generating the majority of jobs, income, and pathways to better employment opportunities. However, informal enterprises are often characterized by low productivity and significant decent work deficits. In Sub-Saharan Africa, where a large share of the workforce is engaged in informal enterprises, transitioning to formality is essential for enhancing productivity, fostering economic growth, and ensuring decent work for all. A critical pathway for informal firms to formalize is through production and worker linkages with formal firms. Using a sample of 13,626 informal firms from three Sub-Saharan African countries, this study examines the performance effects of informal firms with formal linkages and explores the mediating role of human capital. We find that formal backward linkages—where informal firms source inputs from formal firms—are significantly more common than other types of formal-informal linkages. Employing heteroskedasticity-based identification, our findings reveal that the productivity gains from these linkages are not automatic - higher human capital is essential for firms to benefit from knowledge and technology transfers. This highlights the critical role of absorptive capacity in enabling informal firms to leverage knowledge and technology transferred through formal backward linkages, thereby emphasizing the importance of targeted capacity-building interventions in fostering inclusive economic growth.

Keywords: Formal-informal linkages, supply chains, informal firm, firm productivity, technology transfer, knowledge transfer, absorptive capacity, human capital, Sub-Saharan Africa.

JEL Codes: J46 ; L14 ; L25 ; O12 ; O17 ; O33.

1 Introduction

Informality is a significant cause and symptom of productivity stagnation in modern sectors in developing countries and a major concern for policymakers (Djidonou and Foster-McGregor (2022)). The formalization of informal firms is seen as a means of improving overall productivity, prompting several countries to enact policies aimed at incentivizing informal firms to register. For instance, the West African Monetary Union (WAEMU) has adopted a single electronic enterprise formalization window to reduce the costs and complexity for firms formalizing their activities. However, the results of such policy initiatives have been mixed, partly because informality is often a deliberate economic choice (Meagher (1995, 2013); Bruhn (2013)). This highlights the importance of examining firm dynamics within the informal sector and understanding the factors driving productivity improvements in this sector.

Micro, Small, and Medium Enterprises (MSMEs) in both the formal and informal sectors are one of the main drivers in reducing poverty and inequality by generating the majority of jobs, incomes, and pathways to better employment opportunities. As key drivers of long-term economic growth and development, their role is particularly significant in Africa, where eight out of ten workers are engaged in informal employment (Kanbur (2021)). However, the severe decent work deficits characterizing the informal economy have led to a growing consensus that transitioning to formality is essential for realizing decent work for all, making this transition a priority on policy agendas across Africa.

Informality is also potentially a substantial drag on aggregate productivity across Sub-Saharan Africa (SSA) since informal firms are typically smaller and less productive than their formal counterparts (Ulyssea (2020); Djidonou and Foster-McGregor (2022)). They often lack the managerial and technological capabilities required to expand their activities. One way of alleviating capability gaps and enhancing productivity for informal firms is by

creating links with formal firms that have such capabilities. To access such capabilities, however, informal firms may need to have a certain level of absorptive capacity.

In this paper, supply chain linkages are identified as a main mechanism through which productivity spillovers may occur from formal to informal firms. The primary focus is on the backward linkages that exist from formal to informal firms. These linkages are particularly noteworthy as they can create a positive feedback loop that benefits both types of firms. By providing informal firms with access to new markets, knowledge, and resources, formal firms can help informal firms increase their productivity and competitiveness. Collaboration with formal firms may further improve product quality and compliance with higher standards. Informal firms may also acquire skills and financial support from formal partners, upgrading their operations and expanding capabilities. Participation in the supply chain provides valuable market intelligence, aiding informed decision-making and market adaptation. However, formal firms also benefit from the flexibility, lower costs, local market knowledge, extensive networks, and innovation of informal firms (Ulyssea (2020)).

Productivity spillovers and knowledge transfer from formal to informal firms are not straightforward or automatic. Informal firms with internal competencies are better positioned to benefit from linkages with formal firms. For example, informal firms may need higher levels of absorptive capacity to learn and adopt new techniques and help access the resources required to upgrade their production processes. The concept of absorptive capacity has been used by researchers to explain various organizational phenomena (Cohen et al. (1990)) and is a critical discussion in the Global Value Chain (GVC) literature (Khan et al. (2019); Farole and Winkler (2015)). Absorptive capacity can be understood as the ability to recognize, assimilate, transform, and apply the value of external resources to local economic development (Cohen et al. (1990); Todorova and Durisin (2007)). Previous literature has shown that the level of absorptive capacity is driven by the education and work experience of workers (Spithoven and Knockaert (2011)). Education-based human capital improvement

helps firms enlarge their technological boundaries and absorb new technologies (Faems and Subramanian (2013); Brekke (2021)). In the case of formal-informal supply chains, the absorptive capacities of workers can help informal firms benefit effectively from the linkages. The extent to which linkages with formal firms help in the productivity enhancement of informal firms and the moderating role of complementary assets like human capital in this relationship is under-explored, especially in the context of SSA.

The current study addresses this gap in the existing literature by examining the impact of firm linkages in supply chains on the transfer of practices, technologies, workers, and knowledge from more productive formal firms to less productive informal firms in developing countries and how education mediates this. Recent evidence collected by the International Labour Organization (ILO) in Latin America finds that supplying to and buying from large domestic and foreign-owned firms acts as a vehicle for transmitting managerial practices to small firms, including informal firms embedded in their supply chains, with these effects incentivizing formalization. The main explanation for such results is that purchasing inputs from formal firms can be a source of productivity spillovers. Through these linkages, informal firms may access new and improved product varieties and adopt more recent technologies and practices that improve their productivity.

In this paper, we evaluate the implications of formal linkages for the productivity of informal firms in SSA. Moreover, we study how human capital mediates the impact of formal-informal supply chain linkages on firms' productivity. To achieve this goal, we use a dataset, consisting of phases 1 and 2 of the "Enquêtes 1-2-3" survey (henceforth Survey 1-2-3), which provides detailed information on the linkages between formal and informal firms in Sub-Saharan African countries. The Survey 1-2-3 adopts the definitions of informality suggested by the ILO, defining informal firms as small production units that do not have written formal accounts and/or are not registered with the tax administration¹.

¹Following the International Labour Organization (ILO) definition of informal firms, firms are classified

Our results indicate that formal backward linkages matter for productivity enhancement in informal firms. However, the effects become insignificant when we control for sector and country dummies. We further find that human capital mediates the impact of formal backward linkages on informal firms' productivity in all scenarios considered in our analysis. In other words, informal firms with skilled employees benefit to a greater extent in terms of productivity from linkages with formal firms.

Our approach has several advantages over past studies. Firstly, the results are based on a survey that is nationally representative and comparable across countries. Secondly, our analysis features a critical methodological advance over previous studies by addressing the endogeneity of informal backward linkages, which may arise due to reverse causality and omitted variables. Thirdly, this is the first study we are aware of to examine the drivers of possible linkages and the role of complementary factors like human capital in the effect of linkages on informal firms' productivity. This focus is central to understanding the process of capability accumulation, productivity improvement, and dynamics within informal firms, with relevant policy implications.

The paper is organized as follows: Section 2 outlines the theoretical framework and reviews relevant literature. Section 3 details the dataset used for the empirical analysis. Section 4 offers descriptive evidence on formal and informal linkages. Section 5 explains the econometric methodology. Section 6 presents the results, focusing on the impact of formal backward linkages on informal firms' productivity and the mediating role of human capital. Finally, Section 7 summarizes the key findings and provides conclusions.

as informal firms if they do not comply with all regulations that apply to their activities. For example, informal firms do not officially register their activities, avoid tax payments, do not hold a formal account, or do not respect employment and operating licenses.

2 Theoretical Framework, and Literature Review

2.1 Theoretical Frameworks on Firm Linkages and Spillovers

The study of firm linkages is underpinned by several theoretical frameworks, each providing unique insights into how these relationships influence firm performance and development. One foundational theory relates to knowledge spillovers and posits that firms can improve their performance by absorbing knowledge from more advanced firms. This framework suggests that proximity to innovative firms or foreign actors can facilitate the transfer of technological know-how, management practices, and market intelligence, benefiting less advanced firms and, by extension, the wider economy. Empirical research supports this, with Javorcik (2004) demonstrating how foreign direct investment (FDI) can improve domestic firms' productivity through backward linkages. These linkages enable local firms to learn from foreign firms by engaging in supply chain relationships, adapting to higher standards, and adopting new technologies. The spillover framework highlights the mechanisms through which knowledge flows from multinationals to domestic firms, leading to improved competitiveness and long-term productivity gains. In a broader context, the impact of such spillovers has also been observed by Newman et al. (2015), particularly in developing countries, where firms benefit from interactions with international buyers and suppliers. These interactions not only lead to innovation and skill development but also expose domestic firms to advanced market practices, enabling them to enhance their efficiency and innovation capabilities. Exposure to FDI and participation in global value chains (GVCs) provides local firms with opportunities to upgrade their processes and products, strengthening their position in both domestic and international markets.

Complementing this framework is that of absorptive capacity, which emphasizes the role of firms' ability to recognize, assimilate, and apply external knowledge. Firms with greater absorptive capacity are better equipped to benefit from spillovers, as they possess the nec-

essary capabilities to internalize and use new information effectively (Cohen et al. (1990)). Thus, firm linkages, particularly with more advanced firms or foreign entities, are pivotal in fostering innovation and driving economic development, especially in contexts where domestic firms can leverage external knowledge to improve their competitiveness. Several studies used traditional science indicators like R&D or patenting (Arora and Gambardella (1990); Gambardella (1992); Mathew et al. (2024)) to measure absorptive capacity. Moreover, there are different kinds of knowledge that firms can obtain from external parties, which also relates to the appropriate indicator of absorptive capacity. Mangematin and Nesta (1999) argue that highly educated employees increase the absorptive capacity of firms by facilitating access to external knowledge, with their ability to recognize and understand valuable external knowledge. Recent studies also use human capital as an indicator of absorptive capacity (e.g., Yu et al. (2022); Khan (2022); Bye and Fæhn (2022)). Several studies (see, for example, Spithoven and Knockaert (2011)) have shown that the level of absorptive capacity is driven by the level of education and work experience of workers. Education-based human capital improvement helps firms enlarge their technological boundaries and absorb new technologies (Faems and Subramanian (2013); Brekke (2021)). Furthermore, firms endowed with a certain level of knowledge generally increase their attractiveness to partners and thus increases the firm's collaboration opportunities (Ahuja (2000)) since they are well equipped to assimilate and utilize external knowledge, thus improving payoffs from their interaction activities. This dynamic is equally relevant in the linkages between formal and informal firms.

Informal firms, also known as informal enterprises or informal businesses, are economic units that operate outside a country's formal legal and regulatory frameworks (Alter Chen (2005)). These firms are typically small-scale and unregistered and may operate in various industries such as agriculture, manufacturing, retail, and services. This definition is in line with the definition provided by the ILO, stipulating that firms are categorized as informal

if they fail to meet all the regulations that apply to their operations. Informal firms do not officially register their activities, avoid making tax payments, operate without a formal account, or disregard employment and operating licenses. They also do not operate in isolation.

Three contending schools of thought have discussed the relationships between formal and informal firms: the structuralists, the dualists, and the legalists (Bacchetta and Bustamante (2009)). While structuralists view formal and informal firms as complementary and argue for integration, dualists see them as two separate and parallel economic systems that operate independently of each other. The legalists focus on the legal framework and advocate for reforms to make the economy more inclusive for informal firms. The structuralist school of thought is decomposed into two competing visions: the stagnant and modernist views. This paper discusses mainly the structuralist perspective as it primarily examines the complementarities between formal and informal firms while other schools of thought see them as two separate economic units.

The structuralist school of thought, also called the neo-Marxist approach, believes that informal firms are heavily linked with formal firms (Portes et al. (1989)). Among structuralists, there are two competing views on the relationship between formal and informal segments in an economy. The “stagnant view” is pessimistic about the linkages between formal and informal firms in an economy. It stipulates that informal firms compete with formal firms and, in many cases, lead to the exit of the latter from the market. This competition takes place for several reasons. One reason is the production cost advantage of informal firms. Access to labour at a lower cost and tax payment avoidance are some sources of lower production costs for informal firms, making them more competitive in the production of the labour-intensive goods in which they are specialised. Another source of competition is their propensity to produce goods and services that satisfy the needs of lower-cost consumers (Ranis and Stewart (1999)). For instance, repairing a motorbike in an informal shop is generally

more affordable than repairing it in formally registered firms and is thus an attractive option for low-end consumers.

Furthermore, finding an informal repairer in many parts of developing countries is generally common, making access to such services relatively easy. This combination of low cost and ease of access makes informal firms attractive to consumers. The stagnant view further considers that the linkages between formal and informal firms results in a vicious circle of worsening labour conditions and downward pressure on wages since formal firms subcontract labour activities to informal firms.

On the contrary, the "modernisation view" argues that the linkages between formal and informal firms lead to the modernisation of informal firms (Ranis and Stewart (1999)). Linkages between formal and informal firms can facilitate the modernization of informal firms in various ways. Formal firms can transfer knowledge, technology, and modern management practices to their informal counterparts, leading to increased productivity and efficiency (De Vries (2010)). Informal firms can gain access to formal markets, benefiting from larger customer bases and higher demand, which motivates them to upgrade their products and services to meet higher standards. Moreover, exposure to formal firms can enhance the skills of employees in informal firms, leading to overall improvements in their operations (Djidonou and Foster-McGregor (2022)). Despite challenges, successful interactions between formal and informal firms can lead to the integration of informal firms into formal value chains, boosting their growth and sustainability.

2.2 Linkages Between Formal and Informal Firms: Empirical Evidence and Mechanisms

The relationships between formal and informal firms, known as linkages, represent the interactions and connections within economic systems that include both types of firms. These

linkages, particularly backward and forward linkages, play a significant role in shaping business dynamics, especially in developing countries such as those in Sub-Saharan Africa (Xaba et al. (2002); Böhme and Thiele (2014)). Backward linkages occur when informal firms obtain inputs from other firms, either formal or informal. When inputs are sourced from formal firms, these are considered formal backward linkages, while sourcing from other informal firms constitutes informal backward linkages. Forward linkages, on the other hand, involve informal firms supplying goods or services to other firms. These are classified as formal when informal firms supply to formal firms and informal when they supply to other informal firms.

Empirical studies indicate the prevalence and importance of these linkages, especially in SSA, where formal and informal firms frequently engage in economic exchanges. For instance, Xaba et al. (2002) document significant interlinkages in the final output market, with formal and informal firms acting as key suppliers to each other. However, Hugon (1990) notes that while formal firms frequently supply inputs to informal firms, reverse flows from informal to formal firms are minimal. Using the Survey 1-2-3 dataset, Böhme and Thiele (2014) further explore these dynamics, showing that formal backward linkages, where informal firms purchase intermediate goods from formal firms, are far more common than formal forward linkages. Their findings also reveal that the prevalence of these linkages varies with the scale of informality at the macro level.

In India, similar patterns emerge. Majumdar and Borbora (2015) find that over 52% of surveyed informal firms in Assam maintain backward linkages with formal firms, primarily for sourcing raw materials and intermediate goods. However, these relationships are typically concentrated among larger informal firms. Formal backward linkages, which involve formal firms supplying resources such as raw materials, technology, or financial support to informal firms, can play a crucial role in improving the productivity and competitiveness of informal firms. These linkages provide informal firms with access to resources they might otherwise lack, thus boosting their operations and market access.

The importance of these linkages for informal firms is well-supported by empirical evidence. Studies show that backward linkages with formal firms can significantly enhance the productivity of informal firms. For example, Kraemer-Mbula et al. (2010) find that informal manufacturing firms in Kenya experience productivity improvements through backward linkages with formal firms, particularly through subcontracting, supply chain interactions, and technology transfer. Similarly, McKenzie and Woodruff (2014) highlight improved business performance among informal firms in Mexico with formal linkages, while Schmitz and Nadvi (1999) document how informal firms in industrial clusters in Pakistan and Brazil benefit from increased profitability and knowledge-sharing facilitated by backward linkages.

While much of the existing research has relied on qualitative assessments, such as case studies or interviews, this paper aims to contribute a quantitative analysis of formal backward linkages and their impact on firm performance, focusing specifically on SSA. Although informal firms also engage in informal backward linkages—interactions with other informal firms—this study prioritizes formal linkages because of their potential to transfer critical knowledge, technology, and managerial expertise from formal firms, which could lead to productivity and competitiveness gains for informal firms.

The collaboration between informal and formal firms through formal backward linkages also facilitates knowledge and skill transfers. Formal firms often possess more advanced systems, technologies, and expertise in areas such as production processes, quality control, and marketing (Bloom et al. (2013); Buera and Oberfield (2020)). Through these interactions, informal firms can adopt best practices and learn new skills, leading to significant improvements in productivity. In addition, formal firms tend to operate under stricter quality and regulatory standards, which can help informal firms enhance product quality and meet formal market demands (Böhme and Thiele (2014)). This leads to better market access, expanded customer bases, and ultimately, increased sales and productivity.

Furthermore, formal backward linkages expose informal firms to more efficient business

practices, such as better inventory management and optimized production processes. These changes result in operational improvements that drive productivity growth. Our **first** research question seeks to empirically assess whether informal firms with formal linkages exhibit higher productivity or profitability compared to those with only informal linkages.

However, the extent to which informal firms benefit from formal backward linkages depends on their human capital and absorptive capacity. Research shows that firms with more skilled labor or higher absorptive capacity—defined as the ability to understand and utilize external knowledge—are better equipped to capitalize on formal linkages. For example, Van Biesebroeck (2005) finds that informal firms with skilled labor are more likely to experience productivity gains from formal backward linkages. Similarly, Görg and Strobl (2005) demonstrate that firms with greater absorptive capacity are more effective at utilizing the knowledge transferred from formal firms.

Studies document the role of human capital in enhancing productivity through formal linkages highlighting the critical function of education and training (Schultz, 1961) and (Becker, 2009). Informal firms with a more educated workforce are better positioned to adopt new technologies and practices, thereby improving productivity. Sonobe and Otsuka (2006) shows that informal firms in developing countries with better-trained employees benefit more from formal linkages. Absorptive capacity then plays a moderating role in the effectiveness of technology transfer through formal-informal linkages. Firms with higher absorptive capacity can effectively assimilate and apply knowledge gained from formal firms, resulting in stronger innovation and performance outcomes. Conversely, firms with low absorptive capacity may struggle to fully benefit from formal linkages, leading to incomplete technology transfer.

To date, empirical research has yet to fully explore how absorptive capacity moderates the impact of formal-informal linkages on the performance of informal firms. Therefore, our **second** research question aims to investigate whether absorptive capacity, as reflected by human capital, mediates the relationship between firm linkages and the productivity of

informal firms.

3 DATA

We use data from the Survey 1–2–3 collected in 2015 for this study. Survey 1–2–3 is the first nationally representative household and informal firm survey conducted in seven WAEMU countries and some other selected African countries, including Senegal, Togo, Burkina Faso, Mali, Benin, Niger, Côte d’Ivoire, Cameroon, the Democratic Republic of Congo, and Morocco. Survey 1–2–3 adopts the definitions suggested by ILO and Alter Chen (2005), defining informal firms as small production units that do not have written formal accounts and/or are not registered with the tax administration.

The Survey 1–2–3 employs a standardized questionnaire and was conducted simultaneously in the WAEMU countries, ensuring comparability across datasets. The surveys are reliable due to technical support from the Observatoire Economique et Statistique d’Afrique Subsaharienne (AFRISTAT)² and Développement, Institutions et Mondialisation (DIAL)³, and financial backing from the World Bank, the European Commission, the French Ministry of Foreign Affairs, the African Development Bank (AfDB), the United Nations Development Program (UNDP), the Department for International Development (DFID), and the governments of each participating country. The surveys were classified as official data (Böhme and Thiele (2014)).

The Survey 1–2–3 extends the principle of mixed surveys on the informal sector to better understand its role in each economy. It comprises three nested surveys involving different statistical populations: individuals, production units, and households, and covered all provinces, communes, and cities, making the sample nationally representative. The first phase of this survey consists of employment, unemployment, and household activity con-

²<https://www.afristat.org/>

³<https://dial.ird.fr/recherche/enquetes/enquetes-1-2-3/>

ditions (phase 1: employment survey). The second phase consists of surveying heads of production units on their conditions of activity, economic performance, mode of integration into the production structure, and prospects (phase 2: informal production units survey). Finally, the third phase is a household consumption survey, which aims to estimate household welfare, measure the weight of the formal and informal sectors in their consumption, and analyze the determinants of the choice of different places of purchase (phase 3: investigation of consumption and poverty).

The employment survey fulfills a dual objective: to provide the main indicators to describe the situation of individuals and households in the labor market and to serve as a filter survey for phase 2 on informal production units. It provides the information necessary to identify all informal units surveyed during the first phase. In 2015, 21,454 were surveyed in the DRC, 38,599 in Cameroon, and 32,393 in Burkina Faso.

During the second phase, 13,626 firms were randomly selected from the informal firms identified in the first phase (Brilleau et al. (2005)). Heads of informal production units were interviewed and were asked questions about their conditions of activity, their economic performance, the mode of insertion into the production and supply chains, and their prospects. The second phase allows us to have specific information on variables such as turnover, production costs, profits, and product quality information, the size of the entity, the human capital of workers, the intensity of inputs, the characteristics of entrepreneurs of informal firms, and their linkages with other firms. The 1–2–3 surveys define informal enterprises as small production units that do not have written formal accounts and/or are not registered with the tax administration.

Moreover, the 1–2–3 surveys allow us to define the linkages between formal and informal firms. For example, formal backward linkages pertain to the supply of raw materials, equipment/machinery, finance, and consumer goods from formal to informal firms. In the Survey 1–2–3, informal firms are asked the sector of activity of their main suppliers and clients.

In our dataset, formal backward linkages occur when informal firms purchase intermediate inputs from the public and para-public sector, large commercial private enterprises, or large non-commercial private enterprises. Similarly, informal backward linkages occur when informal firms buy from small production units that do not have written formal accounts and/or are not registered with the tax administration. This paper mainly relies on the second phase of the survey, with the sample covering 4,504 firms in the DRC, 4,598 firms in Cameroon, and 4,524 firms in Burkina Faso. The random selection of firms from the first phase of the survey is nationally representative.

Several studies have utilized data from the Survey 1–2–3 to analyze various aspects of informal economies in Sub-Saharan Africa. For example, Grimm et al. (2012) used the Survey 1–2–3 data to investigate the performance of informal enterprises in West Africa, highlighting the heterogeneity within the informal sector. Nordman and Vaillant (2014) employed the survey data to study gender disparities in earnings within the informal sector. Additionally, Benjamin and Mbaye (2012) utilized the Survey 1–2–3 to explore the impact of informality on economic development in Sub-Saharan Africa.

4 Descriptive Statistics on Formal and Backward Linkages

In the realm of the firm linkages literature, two primary types are often discussed: consumption and production linkages, as elucidated by Hirschman (1985). Consumption linkages pertain solely to sales directed towards final demand, while production linkages can be further categorized into forward and backward linkages. In Survey 1-2-3, forward linkages occur when informal firms sell their goods and services to other firms, whether formal or informal. Specifically, a forward linkage is formal when an informal firm sells its goods and services

to a formal firm. Conversely, a forward linkage is informal when informal firms sell their goods and services to other informal firms. Backward linkages occur when informal firms buy their goods and services from other firms. In this context, a backward linkage is informal when informal firms buy their goods and services from other informal firms. Conversely, a backward linkage is formal when informal firms buy their goods and services from formal firms.

The assumption that firms cannot simultaneously have both backward and forward linkages, or both formal and informal backward linkages, stems from the design of the survey, which is structured to capture only the primary suppliers or buyers of each firm. The survey focuses on the most significant transactional relationships, prioritizing the main suppliers or clients rather than detailing the full spectrum of interactions a firm may have. The survey's coding system categorizes a firm's primary buyers or suppliers, based on the entity that represents the highest value of transactions. Each code corresponds to a different type of buyer or supplier, helping to classify the firm's relationships within its supply chain⁴. Consequently, firms are categorized based on their dominant supply chain relationships, either as having formal backward linkages (sourcing from formal firms) or informal backward linkages (sourcing from other informal firms), without room for overlap between the two categories.

This approach presents a limitation, as it overlooks secondary or less prominent rela-

⁴DESTINATION / ORIGIN CODES OF PRODUCTS: For a firm, we seek the main destination/source (in terms of Sales), meaning the one that represents the highest value. 1 = Public or Parastatal Sector: government, public or parastatal enterprises; 2 = Large Private Commercial Enterprise: private commercial establishment, registered, employing more than 5 people; 3 = Small Commercial Enterprise: private commercial establishment employing up to 5 people; 4 = Large Private Non-Commercial Enterprise: private production or service establishment, registered, employing more than 5 people; 5 = Small Private Non-Commercial Enterprise: private production or service establishment employing up to 5 people; 6 = Household/Individual: This category applies to individuals purchasing for their final consumption. For example, in the case of a business making clothes and delivering them to neighbors to wear, the destination is coded as "Household" (code 6). However, if the customer is an individual purchasing for resale, it should be coded as "Small Commercial Enterprise" (code 3). 7 = Direct Export: sales to a foreign partner; 8 = Self-Consumption: This code captures the amount of production from the informal production unit (UPI) that is consumed by the household of its promoter. For a UPI producing and selling donuts, this code indicates the amount of donuts consumed by all members of the promoter's household. 9 = Association/NGO.

tionships that could provide a more nuanced understanding of a firm’s position within the broader economic network. For example, an informal firm might source most of its inputs from other informal firms (classified as having informal backward linkages) but could also occasionally source specialized inputs from formal firms. These secondary formal linkages, though not captured in the survey, may still influence the firm’s performance and development. Similarly, while the survey assumes that firms cannot engage in both backward and forward linkages at the same time, in practice, informal firms may operate in both directions, acting as suppliers to other firms while simultaneously sourcing inputs.

By focusing only on the primary suppliers or buyers, the survey limits the scope of the analysis, potentially underrepresenting the complexity of the interactions between formal and informal firms. This restricted view of firm linkages can lead to an incomplete understanding of how firms integrate into larger supply chains, and how these interactions affect their productivity and growth. Despite this limitation, our analysis remains relevant by shedding light on the core dynamics of formal-informal backward linkages and their influence on informal firm performance. Future research could benefit from more comprehensive data collection that includes multiple tiers of suppliers and buyers to better capture the multifaceted nature of firm relationships.

Descriptive statistics reveal that households are the predominant consumers of informal goods, with 11,759 households reporting demand for products from informal firms. Moreover, informal firms often rely on households not only as consumers but also as suppliers of intermediary goods within their production chains. Specifically, 2,764 informal firms integrate inputs sourced directly from households. This study, however, deliberately excludes any analysis of linkages between households and informal firms. Instead, it aims to elucidate the dynamics of formal and informal backward linkages among firms only.

To provide insights into the dataset, Table 1 presents detailed information on the number of informal firms involved in both formal and informal backward linkages. It highlights that

approximately 85 percent of the total linkages observed are backward linkages, underscoring their significance for informal firms in Sub-Saharan Africa. Additionally, the table presents comparative details on the number of informal firms participating in formal and informal forward linkages, highlighting the role of informal firms as suppliers to other entities. The findings demonstrate that only a minority of informal firms are involved in forward linkages, constituting 15 percent of total linkages. Only, 3.03 percent of total linkages are formal forward linkages, while 11.87 percent are informal forward linkages.

This paper excludes the analysis of both formal and informal forward linkages from its scope, as its primary focus is to juxtapose formal backward linkages against informal ones. Given this, we define the backward linkage variable as a binary outcome, with the formal backward linkage variable taking the value 1 if the suppliers to informal firms are formal firms and 0 if the suppliers are informal firms. As such, the analysis focuses only on informal firms with a backward linkage to either formal or informal firms. The data indicates that around 16 percent of total linkages are formal backward linkages, while the majority, over 69 percent, are informal backward linkages, indicating that a substantial proportion of informal firms source their inputs and final goods from other informal firms. This trend can be attributed to the preference of informal firms for affordable input sources (Ranis and Stewart (1999)).

Despite informal backward linkages being prevalent, the current paper focuses on the potential for interactions with formal firms through backward linkages to impact performance through spillover effects. In this sense and given the focus on informal firms with backward linkages only, the informal firms with backward linkages to other informal firms serve as the control group.

To provide an initial comparison between informal firms with formal and informal backward linkages, Table 2 provides information on the average values (and the standard deviation) of a set of key firm performance indicators for firms with formal backward and with informal backward linkages (see Table 3 for a full definition of the variables). The findings

indicate that informal firms with formal backward linkages tend to be, on average, more capital-intensive and to employ a higher-skilled workforce relative to informal firms with informal backward linkages. Additionally, these firms tend to be larger in terms of value-added, enjoy better access to electricity and credit facilities, and exhibit higher profits.

To examine whether there are differences in productivity (defined as sales per worker) and profitability (defined as profit per worker) between informal firms with formal and informal backward linkages, Figure 1 compares the productivity distribution of these two types of informal firms. The figure demonstrates that informal firms with formal backward linkages tend to exhibit higher productivity levels than those with informal backward linkages. Figure 2 reports similar information, but uses data on profitability rather than productivity, with a similar outcome. While such results are suggestive of the role of formal backward linkages in enhancing the productivity of informal firms, it could also be that formal firms display a preference for engaging in supply chains with informal firms that possess stronger capabilities. This raises the issue of reverse causality, which will be addressed subsequently.

Table 1: Frequency and Share of Informal Firms with Different Linkage Types

	Backward	Forward	Total
Formal	1795 (15.93%)	342 (3.03%)	2137 (18.97%)
Informal	7792 (69.16%)	1337 (11.87%)	9129 (81.03%)
Total	9587 (85.09%)	1679 (14.90%)	11266 (100%)

Note: The figures represent the number of informal firms with backward and forward linkages. The figures in parentheses represent the share of the linkages in total linkages.

Source: Authors' calculation based on 1-2-3 survey.

Table 2: Comparison of performance measures between informal firms with formal and informal backward linkages

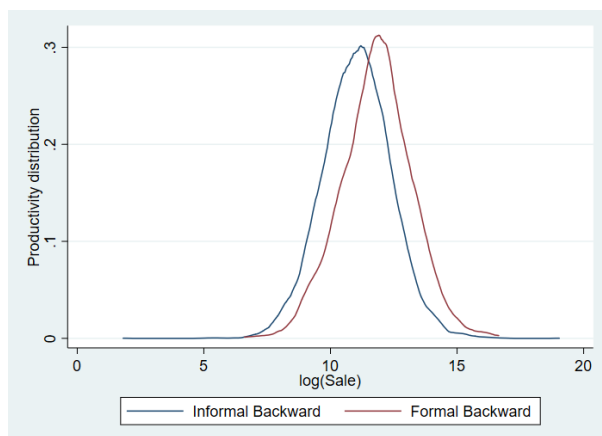
	Formal Backward					Informal Backward				
	Obs	Mean	Std. dev.	Min	Max	Obs	Mean	Std. dev.	Min	Max
Productivity	1759	11.8	1.40	6.5	16.6	7648	11.088	1.33	1.79	19.0
Profitability	1759	11.4	1.69	3.7	16.6	7645	10.766	1.50	3.26	19.0
Education	1795	6.73	4.85	0	18	7792	5.243	4.44	0	20
Capital	1560	10.5	2.17	3.3	17.7	7010	9.687	1.9	2.67	16.5
Value Added	1790	10.7	1.49	4.4	15.9	7758	10.055	1.46	0.996	16.7
Number of workers	1795	1.49	1.10	1	12	7792	1.311	0.893	1	17
Access to Credit	1795	0.065	0.246	0	1	7792	0.037	0.19	0	1
Age of workers	1794	19.1	27.5	0	94	7786	20.361	28.3	0	94
Firm Age	1795	36.5	11.1	12	77	7792	36.734	12.5	7	89
Gender of Workers	1792	0.084	0.277	0	1	7782	0.047	0.212	0	1
Belong to Association	1795	0.607	0.488	0	1	7792	0.336	0.472	0	1
Access to Support	1236	0.453	0.498	0	1	5175	0.449	0.497	0	1
Experience	1794	18.2	25.9	0	89	7787	19.433	26.9	0	89
Access to Water	1795	0.059	0.236	0	1	7792	0.025	0.156	0	1

Source: Authors' calculation based on 1-2-3 survey.

Table 3: Definition of Variables

Variable	Definition
Backward Linkage	A binary variable that equals 1 if the firm has a formal backward linkage and 0 if the firm has an informal backward linkage.
Productivity	Log of total sales per worker
Profitability	Log of total profit per worker
Education	Average number of years of schooling of workers
Capital	Log of capital stock of firms
Value Added	Log of total value added
Number of workers	Total number of workers
Access to Credit	A binary variable equal to 1 if firm has access to finance and 0 otherwise
Age of workers	Average age of workers in years
Firm Age	Number of years of firm existence
Gender of Workers	The share of workers that are male.
Belonging to Association	A binary variable equal to 1 if the firm belongs to an association and 0 otherwise. Firms were asked whether they were members of professional associations or received help from professional associations.
Access to Support	A binary variable equal to 1 if the firm has access to professional support from associations and 0 otherwise.
Experience	Average number of years spent by workers in a firm
Access to Water	A binary variable equal to 1 if firm has access to water and 0 otherwise.

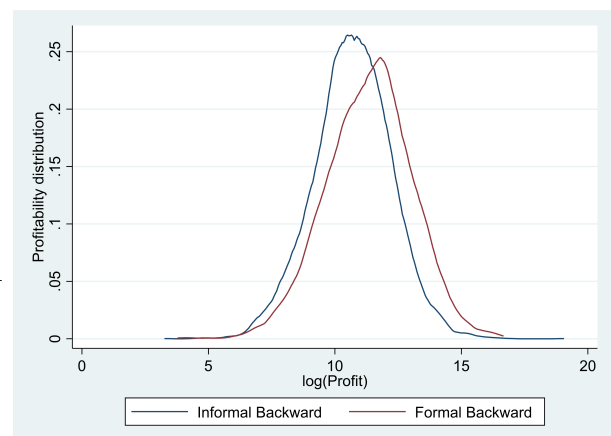
Figure 1: Productivity distribution of informal firms with formal and informal backward linkages



Source: Authors' calculation based on

1-2-3 survey

Figure 2: Profitability distribution of informal firms with formal and informal backward linkages



Source: Authors' calculation based on

1-2-3 survey

5 Econometric Methodology

In order to investigate our first research question of whether informal firms with formal linkages have higher productivity (or profitability) than those with informal linkages, we begin by estimating a linear regression model. The econometric model takes the following form:

$$Y_{ic} = \beta_1 + \beta_2 BL_{ic} + X\lambda + \alpha_j + \alpha_c + \epsilon_{ic} \quad (1)$$

where Y_{ic} is the indicator measuring informal firm productivity or profitability, BL_{ic} is the binary variable capturing the presence of formal backward linkages for firm i in country c , and X is a vector of additional control variables that are discussed below. The regression specification further includes both country (α_c) and sector (α_j) dummies to control for unobserved heterogeneity across sectors and countries. The measure of productivity that we adopt is sales per worker, which is an estimate of labour productivity. Sales per worker is a commonly used measure in economic and business research to assess the efficiency and output generated by each worker within a firm (Syverson (2011)). Higher sales per worker indicate that a firm is generating more revenue relative to the number of workers employed, suggesting a higher level of output efficiency and productivity (Hsieh and Klenow (2009)).

However, it is important to acknowledge that sales alone may not capture the full picture. One limitation of sales per worker is its inability to account for changes in inventories, which can affect the accuracy of productivity estimates. Changes in inventories, such as fluctuations in stock levels, can influence the overall efficiency and productivity of a firm (Olley and Pakes (1992)).

As a robustness check, we use profit per worker to measure firm profitability. The inclusion of profit per worker as a measure of firm performance provides valuable insights into the potential cost-saving effects and output enhancements resulting from spillovers received

from formal firms. By considering profitability, it is reasonable to expect that informal firms benefiting from linkages with formal firms may experience cost reductions due to improved access to resources, technology, knowledge, or economies of scale (Bloom et al. (2013)). Additionally, these linkages may lead to increased output, as the informal firms can tap into new markets, expand their customer base, or access higher-value supply chains (Newman et al. (2015)).

Following Böhme and Thiele (2014), we include a set of control variables, X , that are expected to affect firm productivity and profitability. We initially control for firm age (firm age is measured as the number of years the firm has existed). Firm age is an important control variable when studying the relationship between formal-informal linkages and the productivity of informal firms. It allows us to consider whether factors like experience, knowledge, resources, reputation, adaptability, resilience, and industry dynamics are associated with firm performance. We further control for informal firms' endowments, including primary production factors (capital stock levels, number of workers), infrastructure (access to electricity, access to a telephone, access to water), and access to credit. The expectation is that firms with higher levels of capital and infrastructure are likely to have higher productivity and profitability. The expected coefficient on the number of workers is ambiguous: while we may expect that productivity and employment are positively related, the number of workers is also the denominator of the dependent variable, labour productivity, which may result in a negative relationship. We also control for worker characteristics (gender of workers measured by the share of male workers, years of education, years of experience, and the age of workers) to account for differences in the human capital of the firm's workforce beyond the number of workers. Finally, we control for membership in professional associations and support from such associations. Contact with associations may facilitate networking and positively affect informal firm productivity and profitability (Böhme and Thiele (2014)). Further details of the measurement of these variables are provided in Table 8 in the appendix.

Spillovers from formal to informal firms can significantly enhance the productivity and profitability of informal firms by providing access to resources, learning opportunities, innovation, networking, and capacity building, among other benefits (Newman et al. (2015); Gorodnichenko and Peter (2007)). This learning process, however, depends on whether the workers in informal firms possess adequate absorptive capacities, such as education and skills, to effectively utilize these opportunities (Cohen et al. (1990)).

Our **second** research question investigates whether absorptive capacity, proxied by human capital, mediates the relationship between firm linkages and the productivity of informal firms. Understanding this mediation effect is crucial as it sheds light on the mechanisms through which formal-informal linkages translate into productivity gains in the informal sector (Thoumrungroje and Racela (2022)). To do this, we introduce an interaction variable, which is the product of variable BL_{ic} and a human capital variable HC_{ic} . The estimating equation thus becomes:

$$Y_{ic} = \beta_1 + \beta_2 BL_{ic} + \beta_3 HC_{ic} + \beta_4 BL_{ic} \times HC_{ic} + \beta_5 X_{ic} + \alpha_j + \alpha_c + \epsilon_{ic} \quad (2)$$

where HC_{ic} is the human capital variable, measured as the average number of years of education of workers in the firm. We begin our analysis by estimating an OLS regression, further including country and sector dummies in the regression model.

The OLS estimation of Equations 1 & 2 is likely to suffer from omitted variables and reverse causality problems. Unobserved effects such as ability, entrepreneurship, or risk-taking characteristics of the workers of a given firm may drive the omitted variables problem. These effects cannot be measured by the data but can affect both the ability of firms to enter in the same value chain and firm performance simultaneously. Unobserved differences in aspects such as ability, entrepreneurship and risk-taking are likely to impact directly on productivity and profitability but may also make it more likely for an informal firm to enter

a supply chain and to form linkages with formal firms. Reverse causality may also be an issue with the data used. On the one hand, an informal firm's productivity may affect their probability of participating in a supply chain with a formal firm, especially when those activities require a certain level of human capital. On the other hand, informal firms may have a greater incentive to enter in a supply chain with formal firms to seek better and more stable profits. Both omitted variables and reverse causality underlie the perennial problem of endogeneity.

5.1 Identification through Heteroskedasticity

To address the challenge of finding appropriate external instruments for formal backward linkages, we employ an alternative identification approach known as identification through heteroskedasticity, following the methodology proposed by (Lewbel (2012)). This identification strategy provides an alternative means to address endogeneity concerns in our analysis and involves utilising the heteroskedasticity present in the data to generate a set of instruments (Baum et al. (2012)). This offers a practical solution when finding suitable external instruments is challenging, with Newey (1987) and Rigobon (2003) highlighting the effectiveness of using heteroskedasticity to address endogeneity.

A main advantage of this identification method is that it bypasses some of the stringent conditions associated with standard instrumental variable (IV) estimation, such as the requirement of excludability. By relying on second-order variation that is orthogonal to the exclusion-restriction assumptions, the approach further allows for statistically robust over-identification tests.

This approach allows us to generate instruments that address our concerns about potential reverse causality and omitted variable bias. In so doing, it provides a more accurate and reliable assessment of the relationship between formal backward linkages and firm per-

formance. The methodology also allows for testing the validity of our findings by ensuring that the instruments are uncorrelated with the error term, as confirmed by statistically insignificant Hansen J p-values in our over-identification tests.

The Lewbel approach involves constructing residuals from an ordinary least-squares regression of the endogenous variable on exogenous variables and then using these residuals to generate instruments for the two-stage least squares estimation. To describe Lewbel’s model in more detail, let’s consider the equation $Y = BL\beta + X\gamma + e$, where Y is the dependent variable, BL is the endogenous explanatory variable, and X is the vector of exogenous variables. The Lewbel (2012) estimator can be summarized as the following two steps (Baum and Lewbel (2019)):

1. In an initial stage, we construct the residuals, \hat{v} , from an ordinary least-squares regression of BL on X . The residual is obtained as $\hat{v} = BL - X\hat{\delta}$. Using these residuals, we calculate $(Z - \bar{Z})\hat{v}$.
2. Using the constructed instrument $(Z - \bar{Z})\hat{v}$, we then estimate a standard two-stage least squares model. In the first stage, BL is regressed upon the elements of X and the constructed instrument, with the fitted values from this first stage then used in the second stage regression of Y on BL and the X ’s.

Identification through heteroskedasticity, as proposed by Lewbel (2012), offers a powerful and flexible solution for addressing endogeneity in empirical research. Its successful application in various studies, such as those by Baum and Lewbel (2019), Emran and Shilpi (2012), and Gorodnichenko and Peter (2007), validates its effectiveness and practicality.

6 Empirical Analysis and Results

6.1 OLS with and without Country and Sector Dummies

This section presents the initial results examining the relationship between formal backward linkages and the performance of informal firms using Ordinary Least Squares (OLS) regression, both with and without country and sector dummies. We estimate Equation (1) with firm productivity and profitability as the dependent variables, as defined in the previous section. Table 4 displays the regression outcomes. Columns 1 and 2 report the OLS results for productivity and profitability, respectively, controlling for firm characteristics. Columns 3 and 4 add employee characteristics to the control variables, while columns 5 and 6 incorporate sector and country dummies.

The estimated coefficients for formal backward linkages on productivity and profitability are consistently positive and statistically significant at the 1% level. This indicates that informal firms with backward linkages to formal firms experience higher productivity and profitability than those with linkages to informal firms. Specifically, when controlling only for firm characteristics, having a formal backward linkage is associated with a 34% increase in labour productivity and a 13% increase in profitability compared to having informal backward linkages. Including employee characteristics marginally increases these coefficients. However, incorporating firm and country dummies slightly reduces the coefficients, suggesting that productivity is 23% higher and profitability 14% higher for informal firms with formal backward linkages.

These results suggest that backward linkages with formal firms play a significant role in enhancing the managerial and organizational skills of informal firms, thereby boosting their productivity and profitability. Nevertheless, it is crucial to note that causality cannot be established from these results alone, as reverse causality remains a potential issue.

Regarding control variables, most firm characteristics, such as worker experience and

education level, capital stock, access to credit, access to electricity, access to water, and membership in informal firm associations, are positively and significantly associated with firm performance. Higher education and greater work experience are significantly associated with better firm performance, as more educated and experienced workers are better equipped to adopt practices that enhance sales and profitability. The importance of human capital in driving productivity is well-documented in economic literature, which highlights that a highly educated labour force contributes to higher productivity levels (Lucas Jr (1988); Romer (1990)). Educated and experienced workers are better at developing and transferring new ideas, particularly in technically complex industries (Nelson and Phelps (1966)).

Furthermore, access to essential resources like electricity, water, and credit positively impacts productivity and profitability. These resources are vital for production, marketing, and management processes. For instance, credit can be utilized to invest in newer capital, expand firm activities, and increase production capacity (Beck et al. (2005)). The negative coefficient on the number of workers is likely due to the way productivity and profitability are measured, with the number of employees in the denominator—either sales per worker or profits per worker—resulting in a negative correlation between both productivity and profitability and the number of workers.

These findings align with existing literature, which underscores the importance of firm characteristics and resource access in determining firm performance. For example, access to credit is widely recognized for its role in enabling firms to invest in capital and expand operations, thereby improving productivity and profitability (Beck et al. (2005)). Similarly, infrastructure access, such as electricity and water, is critical for efficient production and operational activities, further supporting firm performance (Eifert et al. (2008)).

In summary, our analysis highlights the significant positive association between formal backward linkages and the performance of informal firms, alongside the critical relationship between firm characteristics and resource access and productivity and profitability. However,

Table 4: Effects of Formal Backward Linkages on Informal Firms' Productivity: OLS and Sector and Country Dummies

	(1) Productivity	(2) Profitability	(3) Productivity	(4) Profitability	(5) Productivity	(6) Profitability
Formal Backward	0.343*** (0.036)	0.133*** (0.033)	0.357*** (0.036)	0.146*** (0.031)	0.228*** (0.035)	0.145*** (0.028)
log (Value Added)	0.768*** (0.011)	0.899*** (0.010)	0.769*** (0.011)	0.894*** (0.010)	0.745*** (0.015)	0.839*** (0.011)
log (Capital Stock)	0.066*** (0.009)	0.155*** (0.008)	0.067*** (0.009)	0.135*** (0.008)	0.075*** (0.009)	0.067*** (0.008)
Number of workers	-0.478*** (0.021)	-0.463*** (0.019)	-0.476*** (0.021)	-0.471*** (0.018)	-0.438*** (0.030)	-0.459*** (0.028)
Access to Credit	0.193*** (0.054)	-0.018 (0.049)	0.191*** (0.054)	0.003 (0.047)	0.218*** (0.050)	0.106*** (0.037)
Firm Age	-0.002*** (0.001)	-0.001** (0.000)	-0.002 (0.002)	-0.002 (0.002)	-0.000 (0.001)	-0.000 (0.001)
Access to Support	-0.061** (0.031)	0.048* (0.028)	-0.067** (0.031)	0.028 (0.026)	-0.049* (0.028)	-0.031 (0.022)
Association membership	0.042 (0.055)	-0.020 (0.050)	0.061 (0.055)	0.012 (0.048)	0.041 (0.046)	0.017 (0.039)
Access to Electricity	0.083* (0.043)	0.231*** (0.039)	0.081* (0.043)	0.182*** (0.037)	-0.017 (0.042)	-0.074* (0.038)
Access to Water	-0.081 (0.065)	-0.176*** (0.058)	-0.086 (0.065)	-0.092* (0.056)	0.081 (0.056)	0.082* (0.047)
Education of workers			0.015*** (0.003)	0.050*** (0.003)	0.001 (0.004)	0.003 (0.002)
Age of workers			0.002 (0.001)	-0.000 (0.001)	0.002 (0.001)	0.002** (0.001)
Sex of Workers			-0.100*** (0.033)	0.104*** (0.028)	-0.083*** (0.030)	0.063*** (0.024)
Experience			0.001 (0.002)	0.000 (0.002)	0.001 (0.001)	0.001 (0.001)
Exports			0.216 (0.181)	0.347** (0.156)	0.264 (0.252)	0.387* (0.219)
Country and Sector Dummies					YES	YES
Constant	3.472*** (0.111)	0.608*** (0.100)	3.509*** (0.123)	1.112*** (0.107)	3.727*** (0.360)	2.741*** (0.179)
Observations	3,028	3,027	3,024	3,023	3,023	3,022
R-squared	0.689	0.808	0.692	0.826	0.748	0.878

Notes: The first 2 columns control only for firm characteristics, columns 3 and 4 control for both firm and worker characteristics, and the last 2 columns present the results, including firm and country dummies alongside firm and worker characteristics. Figures in parenthesis are clustered robust standard errors; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

establishing causality requires further investigation, considering the potential for reverse causality in these relationships.

6.2 Identification through Heteroskedasticity

In this section, we report the results of the impact of formal backward linkages on the performance of informal firms using the identification approach known as identification through

heteroskedasticity, following the methodology proposed by (Lewbel (2012)). As discussed above, we might face the issue of reverse causality when estimating the impact of formal backward linkages on firm performance. For example, it could be that more productive and profitable informal firms are more likely to establish formal backward linkages, rather than these linkages driving the performance improvements. To address this endogeneity issue, we use the identification through heteroskedasticity method developed by Lewbel (2012), which utilizes the heteroskedasticity present in the data to generate a set of instruments (Baum et al. (2012)).

Table 5 presents the results, with columns 1 and 2 showing the outcomes when controlling for firm characteristics, columns 3 and 4 when controlling for both firm and worker characteristics, and columns 5 and 6 when further including country and sector dummies. The outcomes of our variable of interest remain consistent with those obtained using OLS without country and sector dummies, thus confirming our previous findings that formal backward linkages are positively and significantly associated with higher productivity and profitability of informal firms. However, when controlling for country and sector dummies, the impact of formal backward linkages on the performance of informal firms is no longer significant, although the coefficients remain positive.

The results indicate that informal firms with formal backward linkages exhibit productivity and profitability levels that are 31% and 49% higher, respectively, compared to firms with informal backward linkages when only firm characteristics are controlled. Similar results are found when controlling for both firm characteristics and worker characteristics, with significance at the 1% level. However, when additionally controlling for country and sector dummies, the impacts become lower and insignificant, suggesting that formal backward linkages alone are not sufficient for firms to achieve higher productivity and profitability.

The Hansen J test's p-value is statistically insignificant at all conventional significance levels, indicating that the internally generated instruments used in the models are uncor-

related with the error term. This result supports the validity of our instruments. Formal backward linkages can provide informal firms with access to better managerial practices, higher quality inputs, and more stable demand, which in turn can boost their productivity and profitability (McKenzie and Woodruff (2014)). These linkages facilitate knowledge transfer and can lead to the adoption of more efficient production techniques and improved business strategies. However, the reduction in significance when controlling for country and sector dummies suggests that contextual factors play a critical role. This finding highlights the necessity of considering the broader economic and institutional environment in which firms operate. For instance, countries with stronger regulatory frameworks and better infrastructure might enhance the effectiveness of formal backward linkages (Bennett and Estrin (2007)). Conversely, in environments with weak institutions and poor infrastructure, the benefits of these linkages may be less pronounced.

Additionally, the positive but non-significant results after controlling for country and sector dummies may imply that informal firms need more than just formal linkages to thrive. Access to, skilled labour for example, as well as supportive government policies, are crucial for sustaining growth and improving performance (Beck et al. (2005)). Therefore, policy interventions aimed at strengthening formal-informal firm linkages should be complemented by broader efforts to improve the business environment and provide direct support to informal firms. The following section examines the role of human capital in comparing formal backward linkages with informal backward linkages.

6.3 Backward Linkages, Firm Performance, and Human Capital

Improvements in human capital are essential for generating a workforce capable of creativity and innovation, which significantly impacts business development in Sub-Saharan Africa. A low level of human capital hinders firms from performing effectively and efficiently. Or-

Table 5: Effects of Formal Backward Linkages on Informal Firms' Productivity: Identification using the Lewbel (2012) method

	(1) Productivity	(2) Profitability	(3) Productivity	(4) Profitability	(5) Productivity	(6) Profitability
Formal Backward	0.308** (0.136)	0.489*** (0.125)	0.292** (0.123)	0.375*** (0.107)	0.007 (0.085)	0.029 (0.068)
log (Value Added)	0.769*** (0.012)	0.889*** (0.011)	0.771*** (0.012)	0.889*** (0.010)	0.750*** (0.011)	0.843*** (0.009)
log (Level Capital)	0.066*** (0.009)	0.149*** (0.008)	0.068*** (0.009)	0.132*** (0.008)	0.081*** (0.009)	0.071*** (0.007)
Number of workers	-0.477*** (0.021)	-0.468*** (0.020)	-0.475*** (0.021)	-0.474*** (0.018)	-0.433*** (0.020)	-0.456*** (0.016)
Access to Credit	0.195*** (0.054)	-0.039 (0.050)	0.195*** (0.054)	-0.010 (0.047)	0.229*** (0.049)	0.114*** (0.040)
Firm Age	-0.002*** (0.001)	-0.001* (0.000)	-0.001 (0.002)	-0.002 (0.001)	-0.000 (0.002)	-0.001 (0.001)
Access to Support	-0.061** (0.031)	0.055* (0.028)	-0.068** (0.031)	0.032 (0.027)	-0.050* (0.028)	-0.031 (0.022)
Association membership	0.044 (0.056)	-0.045 (0.051)	0.064 (0.055)	-0.002 (0.048)	0.052 (0.050)	0.026 (0.040)
Access to Electricity	0.085* (0.044)	0.204*** (0.041)	0.086* (0.044)	0.166*** (0.038)	0.000 (0.041)	-0.060* (0.033)
Access to Water	-0.079 (0.065)	-0.197*** (0.060)	-0.082 (0.065)	-0.108* (0.057)	0.099* (0.060)	0.096** (0.048)
Level of Education			-0.015*** (0.003)	-0.050*** (0.003)	0.001 (0.004)	0.003 (0.003)
Age of workers			0.002 (0.001)	-0.000 (0.001)	0.002 (0.001)	0.002* (0.001)
Sex of Workers			-0.095*** (0.034)	0.088*** (0.029)	-0.065** (0.031)	0.077*** (0.025)
Experience			-0.001 (0.002)	0.000 (0.001)	-0.001 (0.001)	-0.000 (0.001)
Exports			0.228 (0.182)	0.306* (0.158)	0.304* (0.165)	0.418*** (0.132)
Country and Sector Dummies	No	No	No	No	Yes	Yes
Constant	3.464*** (0.114)	0.688*** (0.106)	3.495*** (0.126)	1.161*** (0.110)	2.956*** (0.125)	1.385*** (0.101)
Observations	3,028	3,027	3,024	3,023	3,023	3,022
R-squared	0.688	0.800	0.692	0.823	0.744	0.876
Hansen J Statistic	0.292	0.538	0.171	0.131	0.106	4.140
Hansen J Statistic p-value	0.5888	0.4633	0.6794	0.7173	0.7444	0.0419

Notes: The first 2 columns control only for firm characteristics, columns 3 and 4 control for both firm and worker characteristics, and the last 2 columns present the results obtained by adding firm and country dummies. Figures in parenthesis are clustered robust standard errors; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

ganizational value creation, fostered by knowledge, skills, competency, and innovation, is critical for both entrepreneurs and workers. The literature argues that a minimum level of education, technology, infrastructure, and health is necessary for informal firms to benefit from potential spillovers (Thoumrungroje and Racela (2022)). Many informal firms with low levels of education suffer from this knowledge gap, which may explain their relatively poor

performance compared to productive formal firms.

The results in the previous section show that backward linkages alone are insufficient for firms to be productive and generate more profit while controlling for sector and country dummies. This suggests that while formal backward linkages provide potential channels for knowledge and technology transfer, these channels need to be coupled with adequate human capital to realize their benefits. Without a skilled and educated workforce, informal firms may not fully capitalize on the opportunities presented by their linkages with formal firms. For instance, an informal firm might have access to high-quality inputs from formal firms, but without the necessary skills and knowledge, it cannot utilize these inputs efficiently to enhance productivity and profitability.

In this section, we examine the role played by education in the learning process generated by linkages between formal and informal firms and its impact on the performance of informal firms in Sub-Saharan Africa. Table 6 summarizes the results from OLS regression with an interaction between formal backward linkages and the average level of education of workers. Columns 1 and 2 of Table 6 show the results of this interaction by considering both firm and worker characteristics, while columns 3 and 4 add sector and country dummies to the control variables.

The regression results demonstrate that education mediates the learning process from formal backward linkages and significantly affects the performance of informal firms in Sub-Saharan Africa. For firms with formal backward linkages, each additional year of education is associated with a 10.7% increase in productivity and a 7% increase in profitability while controlling for both firm and worker characteristics. These findings indicate a similar positive effect of an additional year of worker education on firm performance when they maintain formal backward linkages.

Table 7 presents the results of the mediated role of education on firm performance through formal backward linkages using an identification strategy via heteroskedasticity, following

the approach proposed by (Lewbel (2012)). We apply Lewbel (2012) method to both the backward linkage variable and its interaction with education. This method aims to enhance the reliability of coefficient estimates by addressing reverse causality problems. Columns 1 and 2 show results using identification through heteroskedasticity, considering both firm and worker characteristics, while columns 3 and 4 add sector and country dummies. The impact of formal backward linkages on informal firm performance, mediated by education, is consistent with previous regressions. The results show that if workers in informal firms have an additional year of education, having backward linkages with formal firms increases their productivity by 3.2% and profitability by 7%. These results remain consistent when controlling for sector and country dummies. The Hansen J p-value, reported in the last row of both columns, is statistically insignificant at all conventional significance levels, indicating that the internally generated instruments used in these models are uncorrelated with the error term. This confirms the validity of our internally generated instruments.

Similarly, Lund Vinding (2006) found that the share of highly educated employees is positively correlated with a firm's ability to produce efficiently. This finding supports the idea that informal firms with highly educated workers can experience productivity spillovers by purchasing inputs from formal firms. Through these linkages, informal firms might access new and improved product varieties, adopt more recent technologies and practices, and enhance their productivity (Newman et al. (2015)). Furthermore, Ratten et al. (2017) emphasize that innovation and entrepreneurial capabilities, which are often higher in more educated workforces, are crucial for firm performance and competitiveness.

Our findings suggest that education plays a crucial role in mediating the learning process from formal backward linkages and significantly impacts the performance of informal firms in Sub-Saharan Africa. The positive relationship between education and both productivity and profitability underscores the importance of investing in human capital and fostering linkages between formal and informal sectors for economic development. Enhancing the educational

Table 6: Formal Backward Linkages and Informal Firms' Productivity Using OLS: Mediating Role of Human Capital

	(1) Productivity	(2) Profitability	(3) Productivity	(4) Profitability
Formal Backward	0.528*** (0.063)	0.326*** (0.066)	0.324*** (0.056)	0.325*** (0.052)
Formal Backward × Education	0.027*** (0.007)	0.028*** (0.007)	0.016** (0.006)	0.028*** (0.005)
Education (in years)	0.008** (0.004)	0.042*** (0.003)	0.005 (0.004)	0.010*** (0.003)
log (Value Added)	0.769*** (0.015)	0.891*** (0.012)	0.745*** (0.014)	0.837*** (0.011)
log (Level Capital)	0.063*** (0.009)	0.133*** (0.008)	0.072*** (0.009)	0.065*** (0.008)
Number of workers	-0.396*** (0.025)	-0.393*** (0.023)	-0.366*** (0.023)	-0.372*** (0.022)
Access to Credit (1=yes)	0.189*** (0.053)	0.001 (0.043)	0.217*** (0.050)	0.105*** (0.037)
Firm Age	-0.002 (0.001)	-0.002** (0.001)	-0.001 (0.001)	-0.000 (0.001)
Access to Support	-0.076** (0.031)	0.020 (0.027)	-0.056** (0.028)	-0.037 (0.023)
Association membership	0.055 (0.052)	0.001 (0.043)	0.036 (0.046)	0.004 (0.039)
Access to Electricity	0.063 (0.045)	0.162*** (0.044)	-0.022 (0.042)	-0.088** (0.038)
Access to Water	-0.066 (0.059)	-0.065 (0.056)	0.094* (0.056)	0.109** (0.048)
Age of workers	0.002 (0.001)	-0.000 (0.001)	0.002* (0.001)	0.002** (0.001)
Sex of Workers	-0.101*** (0.033)	0.102*** (0.029)	-0.080*** (0.030)	0.064*** (0.024)
Experience	-0.000 (0.002)	0.000 (0.001)	-0.001 (0.001)	-0.001 (0.001)
Exports	0.221 (0.269)	0.337 (0.242)	0.275 (0.246)	0.385* (0.202)
Country and Sector Dummies			Yes	Yes
Constant	3.409*** (0.135)	1.021*** (0.109)	3.617*** (0.362)	2.585*** (0.176)
Observations	3,063	3,062	3,062	3,061
R-squared	0.693	0.826	0.747	0.876

Notes: Included country and sector dummies are not reported. Figures in parenthesis are cluster robust standard error; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

attainment of the workforce can enable informal firms to better absorb and implement the knowledge and technologies accessed through formal backward linkages, thereby driving improvements in firm performance and contributing to broader economic growth.

Table 7: Formal Backward Linkages and Informal Firms' Productivity Using Lewbel (2012): Mediating Role of Human Capital

	(1) Productivity	(2) Profitability	(3) Productivity	(4) Profitability
Formal Backward	0.535*** (0.068)	0.372*** (0.059)	0.267*** (0.062)	0.278*** (0.050)
Formal Backward × Education	0.023*** (0.007)	0.028*** (0.006)	0.009 (0.007)	0.021*** (0.005)
Education (in years)	0.009** (0.004)	0.042*** (0.003)	0.003 (0.004)	0.008* (0.003)
log (Value Added)	0.768*** (0.011)	0.890*** (0.010)	0.746*** (0.011)	0.837*** (0.009)
log (Level Capital)	0.063*** (0.009)	0.132*** (0.008)	0.072*** (0.009)	0.065*** (0.007)
Number of workers	-0.396*** (0.015)	-0.393*** (0.013)	-0.365*** (0.013)	-0.371*** (0.011)
Access to Credit (1=yes)	0.187*** (0.053)	-0.001 (0.046)	0.216*** (0.049)	0.104*** (0.039)
Firm Age	-0.002 (0.002)	-0.002 (0.001)	-0.000 (0.002)	-0.000 (0.001)
Access to Support	-0.075** (0.030)	0.021 (0.026)	-0.055** (0.028)	-0.036 (0.022)
Association membership	0.053 (0.055)	-0.002 (0.047)	0.037 (0.050)	0.005 (0.040)
Access to Electricity	0.063 (0.043)	0.158*** (0.037)	-0.019 (0.041)	-0.085*** (0.033)
Access to Water	-0.071 (0.064)	-0.067 (0.056)	0.090 (0.059)	0.105** (0.047)
Age of workers	0.002 (0.001)	-0.000 (0.001)	0.002 (0.001)	0.002** (0.001)
Sex of Workers	-0.103*** (0.033)	0.098*** (0.028)	-0.079*** (0.030)	0.065*** (0.024)
Experience	-0.001 (0.002)	0.000 (0.001)	-0.001 (0.001)	-0.000 (0.001)
Exports	0.216 (0.181)	0.330** (0.156)	0.278* (0.164)	0.388*** (0.132)
Country and Sector Dummies	No	No	Yes	Yes
Constant	3.424*** (0.123)	1.030*** (0.106)	2.963*** (0.121)	1.359*** (0.098)
Observations	3,063	3,062	3,062	3,061
R-squared	0.693	0.826	0.747	0.876
Hansen J Statistic	7.976	11.969	40.549	44.004
Hansen J Statistic p-value	0.018	0.002	0.359	0.387

Notes: Included country and sector dummies are not reported. Figures in parenthesis are cluster robust standard error; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

7 Conclusion

This paper examines the effects of formal-informal supply chain linkages on the performance of informal firms and investigates how human capital mediates the impact of these linkages on the performance of informal firms. Our study first explores the presence of both formal

and informal forward and backward linkages. We find that formal backward linkages, - where informal firms use inputs produced by formal firms - are significantly more prevalent than formal forward linkages, where formal firms source inputs from informal firms.

We then assess the impact of formal backward linkages on informal firms' performance, measured both by productivity and profitability. Our findings indicate that informal firms participating in supply chains with formal firms exhibit significantly higher productivity. This paper is among the first in the informal economy literature to address the endogeneity of formal backward linkages, which can arise due to omitted variables and reverse causality. Using identification through heteroskedasticity, we demonstrate that informal firms with backward linkages to formal firms experience enhanced productivity. However, the impacts turn insignificant when we account for sector and country dummies.

Furthermore, we examine how human capital mediates the impact of these backward linkages on the productivity of informal firms in Africa. Our findings underscore that informal firms with workers possessing higher absorptive capacities benefit more from backward linkages in terms of productivity gains. This underscores the crucial role of human capital in maximizing the benefits derived from external linkages with formal firms.

Our findings have significant implications both at the organizational level and for policy formulation. We highlight the importance of complementary assets, such as an educated workforce, in leveraging external linkages with formal firms to enhance productivity. However, merely having an educated workforce is not sufficient; firms must actively engage in knowledge transfer and expansion strategies. Building linkages with firms closer to the efficiency and knowledge frontier is essential for achieving sustained productivity improvements.

At the firm level, the results highlight the importance of complementary assets, particularly human capital, in maximizing the benefits of formal-informal linkages. However, simply having an educated workforce is not sufficient; firms must also actively engage in knowledge acquisition, and process upgrading to sustain productivity improvements. Building stronger

linkages with firms at the efficiency and knowledge frontier is essential for long-term capability development.

At the policy level, our study suggests that interventions aimed at enhancing skills development and absorptive capacities among informal workers can significantly amplify the productivity gains from formal-informal linkages. This calls for targeted vocational training programs, business development services, and incentives for formal-informal collaboration to foster inclusive economic growth. More broadly, policy efforts should not only focus on formalization but also on creating enabling conditions for productivity enhancement within the informal sector.

By shedding light on the interaction between formal and informal firms and the pivotal role of human capital, this study contributes to a deeper understanding of how supply chain linkages can be leveraged to drive productivity growth in the informal economy. Strengthening these linkages through policy support, capacity-building initiatives, and strategic firm interactions can enhance the potential of informal firms as engines of sustainable development and economic transformation.

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