

Sodokin, Koffi; Djafon, Joseph Kokouvi; Couchoro, Mawuli; Kounetsron, Yao Mensah; Agbodji, Akoété Ega

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*Corresponding author: Koffi Sodokin,
Research Center for Applied
Economics and Management of
Organisations (CREAMO), University
of Lome, Lome 1515, Togo
E-mail: ksodokin@univ-lome.tg

Reviewing editor:
Goodness Aye, Agricultural
Economics, University of Agriculture,
Makurdi Benue State, Nigeria

Additional information is available at
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DEVELOPMENT ECONOMICS | RESEARCH ARTICLE

Technological change, the productivity of formal and informal businesses, and the impact on labor market

Koffi Sodokin *, Joseph Kokouvi Djafon , Mawuli Kodjovi Couchoro , Yao Mensah Kounetsron and Akoété Ega Agbodji

ABOUT THE AUTHORS

Koffi Sodokin is an Associate Professor at the Faculty of Economics of the University of Lome and member of the Research Center for Applied Economics and Management of Organisations (CREAMO). He has over ten years of experience teaching and supervising MSc students. His research focuses on money, finance, macroeconomics, and microeconomics of development.

Joseph Kokouvi Djafon is a research assistant in the Research Center for Applied Economics and Management of Organisations (CREAMO) at the University of Lome-Togo. He has over 1 years of experience in field research focused on African countries. His research area includes Micro economics, Development Economics, Banks and Finance. Mawuli K. Couchoro is a Full Professor and the Dean of the Faculty of Economics at the University of Lome and member of the Research Center for Applied Economics and Management of Organisations (CREAMO). He has over 15 years of teaching and research experience and supervision of Ph.D. and MSc students. His research interests include money, finance, macroeconomics, and microeconomics of development.

Yao Kounetsron is a Full Professor at the Institute of Enterprise Administration (IAE) of the University of Lome and member of the Research Center for Applied Economics and Management of Organisations (CREAMO). He has over 20 years of teaching and research experience and supervision of Ph.D. and MSc students. His research interests include accounting, finance and management of organisations.

Akoété Ega Agbodji is a Full Professor at the Faculty of Economics of the University of Lome and member of the Research Center for Applied Economics and Management of Organisations (CREAMO). He has over 20 years of teaching and research experience and supervision of Ph.D. and MSc students. His research interests include microeconomics of development.

PUBLIC INTEREST STATEMENT

Technological innovations, such as e-commerce, are transforming economies worldwide, but their impacts can be complex and uneven across sectors. This study provides valuable insights into how online business adoption affects companies and employment in Togo, focusing on the differences between the formal and informal sectors. This research reveals that engaging in online commerce substantially increases productivity, especially in informal enterprises. This highlights the potential of digital tools to enhance competitiveness. However, the study also shows that online businesses can reduce labor demand, thereby threatening job losses. These findings have important policy implications. They indicate that online platforms and mobile technology can empower informal businesses and promote inclusive growth as Internet access expands in developing countries. However, the research also underscores the need for strategies to smooth economic transition through training programs and social protection. As commerce moves online globally, understanding its multifaceted impact is crucial. This study advances the knowledge on how e-commerce adoption influences productivity, employment, and inequality across the formal and informal sectors. Evidence can guide policies to maximize the benefits of digital transformation and ensure that its gains are broadly shared.

Abstract: Digital transformation, both omnipresent and influential, has deeply impacted various sectors with a particular focus on the economy. The introduction and adoption of tools that facilitate technological changes and online business practices have emerged as game changers. They have endowed corporations with enhanced internal agility and improved employee communications. Online business, with its vast potential, is becoming increasingly crucial in developing countries, where Internet accessibility is steadily growing. This study explores the impact of e-commerce on company productivity by considering both formal and informal sectors. It leverages data from the 2018 General Business Census of Togo. By applying endogenous switching regression and smoothed instrumental variable quantile regression tools, this study demonstrates that online businesses can significantly increase productivity, particularly in firms within the informal sector. However, this finding highlights the potential risk of job loss. This study concludes that support strategies are essential for promoting the integration of online companies, increasing productivity, and protecting jobs.

Subjects: Development Studies; Economics and Development; Economics

Keywords: online business; productivity; digital transformation, employment

JEL Classification: L25; O33; M15; O55

1. Introduction

In recent decades, Information and Communication Technology (ICT) has significantly affected various sectors including the economy. However, quantifying its effect on competitiveness and performance remains challenging (Keček et al., 2019; Neirrotti & Pesce, 2019; OECD, 1998). The impact of ICT on various sectors, including the economy, has been widely recognized. However, quantifying its effect on competitiveness and performance remains a challenge (Barsoum & Elfeky, 2017; Frank et al., 2018; OECD, 1998; Swamy, 2020). With the rapid increase in internet usage and online business adoption, digital transformation has become crucial to Africa's economy, especially in the informal sector. Automation and digitalization have the potential to affect employment and exacerbate inequalities, particularly among low-skilled workers (Frank et al., 2018). Although the influence of digital transformation is acknowledged in global economies, its implications for the African informal sector remain largely unexplored. Frank et al. (2018) examine the impact of automation on employment in urban areas. They found that small cities may face greater adjustments, such as worker displacement and job content substitutions, whereas large cities exhibit increased occupational and skill specialization, reducing the potential impact of automation (Frank et al., 2018). Frank et al. (2018) also demonstrated the connection between urban agglomeration and automation's influence on employment, providing empirical evidence for this relationship. Another study by Autor and Salomons (2018) investigated the labor-displacing effects of automation and productivity growth. They find that the labor share-displacing effects of productivity growth have become more pronounced over time, suggesting that automation has become less labor-augmenting and more labor-displacing (Autor & Salomons, 2018). However, comprehensive evidence of the labor-displacing channel of automation remains limited (Autor & Salomons, 2018). In terms of methodology, Frank et al. (2018) use task groups to assess the resilience of different tasks to job displacement from automation in cities (Frank et al., 2018). They also utilized alternative estimates for the probability of job automation provided by the Organization for Economic Cooperation and Development (OECD) (Frank et al., 2018). Autor and Salomons (2018) employed data on industries and countries to estimate the employment and labor share impacts of productivity growth and automation (Autor & Salomons, 2018).

With the rapid increase in internet usage (World-Bank, 2016, 2020) and online business adoption (Swamy, 2020), digital transformation has become crucial in Africa's formal and informal sector (Hootsuite, 2019). Arntz et al. (2016) argue that automation and digitalization may not destroy many jobs in the Organization for Economic Co-operation and Development (OECD) countries but could exacerbate inequalities and disproportionately affect low-skilled workers. While the influence of digital transformation is clearly recognized in global economies, its specific implications for the African informal sector remain largely unexplored. Rapid technological changes in Internet use and the adoption of online businesses have raised critical questions regarding the potential impact of digital transformation on business performance and employment.

This study investigates the impact of ICT on business productivity and employment in Togo by asking how online activities affect companies and labor in the formal and informal sectors.

The study presents four key findings. First, online operations increase productivity in informal sector firms, with permanent employees having a negligible impact. Second, firms that do not engage in online marketing experience negative turnover variations, thus emphasizing the need for greater online adoption. Third, the impact of online business varies across sectors and productivity variations, with informal sector firms benefiting from higher productivity. Internet access plays a critical role in a firm's productivity, particularly in the informal sector. Finally, additional investigations show that companies operating online require fewer jobs than those that do not. The adoption of online business had a minimal impact on labor supply across all firms and sectors. This was also the case for informal sector enterprises, where formal sector enterprises recorded a substantial increase.

This study offers three main contributions. First, it establishes a connection between the adoption of online business and the stages of innovation diffusion (Rogers, 1962), outlining potential impacts on productivity and employment. This perspective provides a theoretical framework for understanding the dynamics of the link between new technology adoption and the economy using survey data from Togo. Second, it underscores the role of e-commerce in promoting inclusive growth and narrowing the digital divide, highlighting the significance of mobile and digital technologies for business productivity and the labor market. Third, by examining both the formal and informal sectors, this study deepens our understanding of online business adoption and its impact on firm productivity, especially in the informal sector and employment, offering valuable insights for policymakers and business leaders.

2. A brief review of the literature

Previous studies have analyzed the impact of online business adoption on company productivity from different perspectives. Some researchers have focused on economic functions, with Dewan and Min (1997) and Konana et al. (1999) exploring how online businesses can enhance efficiency and lower costs. Others, such as Raymond and Bergeron (1996) and Kekwaletswe (2015), have examined the effects of information and communication technology (ICT) investments on company productivity and organizational change. Two major research streams have emerged: one centered on organizational change and productivity improvements enabled by ICTs (Jorgenson & Stiroh, 1999), and another investigating how ICT investments drive organizational change within companies (Leavitt & Whisler, 1958).

2.1. Online business and its impact on firm productivity

Numerous studies have investigated the relationship between online business adoption and productivity gains. Research shows that enhancing website performance (Bilgic & Duan, 2019) and utilizing automation (Păvăloaia & Necula, 2023) can reduce costs and improve the user experience. Advanced technologies such as the Internet of Things (IoT), big data, and artificial intelligence (AI) can optimize supply chains (Misra et al., 2020) and streamline business processes (Daskalakis & Golowich, 2022). Further productivity improvements stem from innovations in urban logistics (Cano et al., 2022; Rai & Dablanc, 2022), blockchains (Taherdoost & Madanchian, 2023), website accessibility (Najadat et al., 2021), and rural e-commerce opportunities (Ballerini et al.,

2023). User interfaces and usability are critical components (Lesage, 2015). The rapid growth of e-commerce (Eurostat, 2019), highlighted during the COVID-19 pandemic (WTO, 2020), provides opportunities for traditional retailers (Xia & Monroe, 2010) and enables enhanced business performance (Cosgun & Dogerlioglu, 2012) through improved information management (Damanpour & Damanpour, 2001). Consumers benefit from greater product variety, time savings, and lower prices (Khan, 2016), whereas society benefits from reduced traffic, lower air pollution, and increased rural access (Shahriari et al., 2015).

Digital transformation influences several aspects of business and company management (Kraus et al., 2022). Digital innovation and the adoption of management software are significant drivers of this evolution (Endres et al., 2022). The influence of digital transformation extends to enhancing an organization's ability to respond to market turbulence through the establishment of a digital technology infrastructure (Li et al., 2021). The success of digital transformation is also closely tied to business and management commitments, with IT departments playing a supporting role (Ko et al., 2021). Investments in digital technologies, employee digital skills, and digital transformation strategies have been identified as vital for improving performance and sustainability, especially in small and medium-sized enterprises (SMEs) (Teng et al., 2022). Furthermore, digital transformation has been shown to promote green innovation in enterprises, reflecting its broader societal and environmental impacts of digital transformation (Feng et al., 2022). The journey of digital transformation is not without challenges, and organizations face various obstacles in becoming digitally transformed. These challenges can be addressed through a clear understanding of the meaning of digital transformation and implementation of potential solutions (Shahi & Sinha, 2020).

Hypothesis 1: The adoption of online business activities has a positive effect on company productivity (Damanpour & Damanpour, 2001; Xia & Monroe, 2010; Kraus et al., 2022).

2.2. Potential limitations of online business influence on business productivity

The literature presents mixed findings regarding the effects of online business adoption on firm productivity. Some studies suggest potential obstacles, with Leavitt and Whisler (1958) noting that the Internet and ICTs could harm small businesses. Other research points to challenges such as management issues (Farooq et al., 2019; Thaichon et al., 2018), the need for digital transformation (Hategan et al., 2021), sustainability concerns (Oláh et al., 2018), privacy risks (Maseeh et al., 2021; Rita & Ramos, 2022), data management (Aker & Wamba, 2016), and various consumer attitudes (Alrousan & Jones, 2016; Rosário & Raimundo, 2021). Additional barriers include adoption challenges for SMEs (Abed et al., 2015; Sila, 2015; Sin et al., 2016; Viu-Roig & Alvarez-Palau, 2020), differing levels of customer loyalty (Mangiaracina et al., 2015; Wang et al., 2020) and emotional intelligence (Huang et al., 2021). However, business performance can be significantly improved through commercial websites and online marketplaces (Davies et al., 2019). Retail innovation continues (Pantano & Priporas, 2016), although research on social media marketing effectiveness remains mixed (Kapoor et al., 2018; Kartika, 2021).

The transition to online commerce can disrupt consumer habits and destabilize companies during the adaptation period. This disruption is multifaceted and can be understood through various lenses. First, the perceived risk associated with online shopping, especially during unprecedented events such as the COVID-19 pandemic, can create a barrier to consumer acceptance of online commerce, leading to disruptions in traditional shopping habits (Habib & Hamadneh, 2021). Second, the virtual store environment itself can alter consumer behavior, as real consumers may react differently in online settings than in physical stores, leading to unexpected changes in purchasing patterns (Dahlen & Lange, 2002). Third, factors such as product type and individual consumer characteristics can significantly influence the intention to shop online, adding complexity to the transition from offline commerce to online commerce (Chiang & Dholakia, 2003). Fourth, the equilibrium between offline and online selling channels can be affected, as altering consumer

preferences for online purchasing shows a shift in traditional supply chain dynamics, posing challenges to companies in maintaining balance (Yu et al., 2015). Fifth, the strategic behavior of e-commerce businesses, particularly in industries such as electronics, can influence factors such as price competition and service quality, further contributing to the destabilization of traditional business models (Svobodová & Rajchlová, 2020). Together, these factors paint a complex picture of the transition to online commerce, in which both consumer habits and business stability can be significantly affected during the adaptation period (Wang et al., 2020).

Hypothesis 2: The adoption of online commerce may have a negative or limited effect on the productivity of certain companies (Abed et al., 2015; Endres et al., 2022) and a disruptive effect of social networks (Qu et al., 2013; Song et al., 2022).

2.3. The effect of internet and online business on labor market

The impact of online businesses on the labor market has been a major research focus. Studies have revealed structural changes in retail, job losses, and the need to adapt to e-commerce (Terzi, 2011). Research has found mixed effects, with some studies emphasizing job creation (Américo & Veronico, 2018; Paul et al., 2022) and others highlighting the displacement and importance of retraining. Employment effects vary across developing countries (Gherghina et al., 2021), and are heavily dependent on the local context and policies in place (Li et al., 2023). Training workers is essential for adapting to the evolving labor market driven by e-commerce expansion. Some scholars caution that digital transformation through online business and Internet adoption could negatively impact informal sectors in developing economies (Leavitt & Whisler, 1958). Despite these potential benefits, adopting digital technologies may render some traditional roles obsolete or require significant change (Autor et al., 2003). Trends in automation, artificial intelligence, and machine learning can displace human workers, particularly in roles susceptible to automation (Frey & Osborne, 2017). This may result in job loss and higher unemployment, particularly among workers with limited skills and education (Acemoglu & Restrepo, 2018). Comparative analyses of OECD countries further highlight the need to understand comprehensively how digital transformation can impact employment (Arntz et al., 2016).

The rise of interconnected entrepreneurial ecosystems offers new opportunities in the context of digital transformation (Barykin et al., 2020; Candelo et al., 2021). According to Bouncken and Kraus (2022), this evolution is characterized by an interconnection between various stakeholders in an ecosystem, such as governments, the private sector, society, universities, and entrepreneurs. These actors work together to create a social and economic environment conducive to innovation and entrepreneurship (Hernández-Chea et al., 2021; Komninou et al., 2021). This means that companies are no longer solely focused on distinguishing themselves individually from their competitors but also rely on shared resources, network externalities, knowledge transfers, and government support.

Digital transformation plays a key role in the interconnection of entrepreneurial ecosystems (Stroumpoulis & Kopanaki, 2022). Technological advancements, such as increased internet connectivity and high-speed broadband connections, facilitate the design and testing of new technologies (Feng et al., 2022; Xue et al., 2022). Moreover, information and communication technologies enable stronger links between resources and actors at the local, regional, and international levels (Shahi & Sinha, 2020; Soto-Acosta, 2020). The digitization of business processes offers new opportunities and imposes new challenges for companies, such as the need to develop digital knowledge and rethink business models (Furr et al., 2022; Ritala et al., 2021). Digitization promotes collaboration and complementarity between companies within ecosystems while allowing for rapid feedback and autonomous digital processes (Secundo et al., 2020). It also enables customers to play a more active role in defining the demand. However, some traditional sectors may be destabilized, requiring adaptation (Song et al., 2022).

Hypothesis 3a: Online commerce leads to job losses in certain sectors (Frey & Osborne, 2017; Bouncken & Kraus, 2022).

Hypothesis 3b: Online commerce creates new jobs in other sectors (Américo & Veronico, 2018; Kusi-Appiah & Essandoh, 2023).

This brief literature review clearly shows that online businesses can enhance their business productivity. However, this study has several limitations. The impact on employment can also be mixed and context dependent. Therefore, the present study was conducted. Additional investigations using microdata from Togo better understand the ins and outs of these modern facts in the African context, where economies are characterized by the coexistence of formal sectors and many economic microstructural activities (the so-called informal sector) (Sodokin, 2007; Sodokin et al., 2023).

3. Methodological approach

3.1. Theoretical model and assumptions

Drawing from Rogers (1962) innovation diffusion model, companies adopting online business as innovation are risk-takers, aiming to enhance competitiveness. Online business speed depends on factors, such as the complexity of the online sales process, setup costs, and market competition. Early adopters may gain a competitive advantage, whereas latecomers may face market-share losses and higher entry costs. To model the impact of online business on productivity and the labor market, we include in the Rogers(1962) innovation diffusion model a binary variable OP (online business), which takes the value of one if the company has adopted online business and zero otherwise. Based on Rogers (1962) innovation diffusion model, we formulate a theoretical model of the link between online commerce and productivity, as follows:

$$\Delta C = (1 - OP)C_t - C_{t-1} + OPC'_t - C_{t-1} \quad (1)$$

where C'_t represents the productivity of the company after adopting online business.

To model a company's decision to adopt a digital tool for online business, we use the following logistic function:

$$P = \frac{1}{1 + \exp(-X\beta)} \quad (2)$$

where P represents the probability that a company adopts an online business, X represents the factors that influence the adoption decision, such as the complexity of online sales, the cost of setting up an online business website, and competition in the market, and β is a regression coefficient that measures the impact of these factors on the adoption probability.

Finally, we combined these two formulations to obtain an expression for the variation in productivity depending on the online business decision. To combine the two formulations, we express productivity change as a function of the binary variable OP, the probability of adoption (P), and factors that influence the adoption decision (X). We introduce parameter α , which represents the impact of online business on productivity changes. The combined expression can be written as

$$\Delta C = \alpha OP + (1 - OP)[\alpha P + (1 - P)C_{t-1}] - C_{t-1} \quad (3)$$

Substituting the logistic function for P, we get:

$$\Delta C = \alpha OP + (1 - OP) \left[\alpha \left(\frac{1}{1 + \exp(-X\beta)} \right) + \left(1 - \left(\frac{1}{1 + \exp(-X\beta)} \right) \right) C_{t-1} \right] - C_{t-1} \quad (4)$$

To simplify, the expression of ΔC by grouping the terms C_{t-1} , equation (4) becomes:

$$\Delta C = \alpha OP + (1 - OP) \left[\alpha \left(\frac{1}{1 + \exp(-X\beta)} \right) - \left(\left(\frac{1}{1 + \exp(-X\beta)} \right) C_{t-1} + C_{t-1} \right) \right] \quad (5)$$

This expression shows the changes in productivity (ΔC) as a function of the binary variable OP , the factors that influence adoption decision (X), the impact of these factors on adoption probability (β), and the effect of adoption on changes in productivity (α). By analyzing the values of α and β and the specific factors in X , a company can better understand how its productivity may change based on its decision to adopt an online business. In summary, the model incorporates a binary variable, OP to model the impact of e-commerce adoption on revenue variation. The combined expression represents productivity variation as a function of OP , the probability of adopting P , and the factors influencing the decision to adopt an online business.

To analyze the changes in labor productivity (ΔC) as a function of the binary variable, we first take the partial derivatives of equation (5) with respect to OP . Taking the partial derivative with respect to OP , we treat the other variables as constants.

$$\begin{aligned} \partial(\Delta C)/\partial(OP) &= d(\alpha OP)/dOP \\ &+ d \left[(1 - OP) \left(\alpha \left(\frac{1}{1 + \exp(-X\beta)} \right) - \left(\left(\frac{1}{1 + \exp(-X\beta)} \right) C_{t-1} + C_{t-1} \right) \right) \right] / dOP \end{aligned} \quad (6)$$

Equation (6) calculates the partial derivative with respect to OP . This allowed for the analysis of the marginal effect of the variation in OP on ΔC .

The derivative of αOP with respect to OP is α :

$$d(\alpha OP)/dOP = \alpha \quad (7)$$

Equation (7) is the derivative of a linear function, which is constant and equal to coefficient α . This simplifies the first term in Equation (6). For the second term, we use the chain rule for derivatives:

$$d[(1 - OP)F]/dOP = -F + (1 - OP)/dOP \quad (8)$$

Equation (8) is the composite function derivation rule for the second term in Equation (6), where F is the following function:

$$F = \alpha \left[\frac{1}{1 + \exp(-X\beta)} \right] - \left[\left(\frac{1}{1 + \exp(-X\beta)} \right) C_{t-1} + C_{t-1} \right] \quad (9)$$

Equation (9) defines the composite function F for applying the derivation rule of Equation (8). Because F does not depend on OP , its derivative with respect to OP is zero:

$$dF/dOP = 0 \quad (10)$$

In equation (10), the derivative of the constant is zero, and Because F does not depend on OP , its derivative with respect to OP is zero:

Thus, the derivative of the second term is simply:

$$d[(1 - OP)F]/dOP = -F \quad (11)$$

The result of (10) is used to simplify the derivative of the second term via the composite function derivation rule to obtain equation (11).

Combining these results, we obtain the partial derivative of ΔC with respect to OP :

$$\partial(\Delta C)/\partial(OP) = \alpha - F \quad (12)$$

Substituting F (equation 9) into (12), we obtain

$$\partial(\Delta C)/\partial(OP) = \alpha - \left[\alpha \left(\frac{1}{1 + \exp(-X\beta)} \right) - \left(\left(\frac{1}{1 + \exp(-X\beta)} \right) C_{t-1} + C_{t-1} \right) \right] \quad (13)$$

Equation (13) represents the final derivative parameters. We make the following assumptions.

Assumption 1. $\partial(\Delta C)/\partial(OP) > 0$

For the partial derivative to be positive, these conditions must be satisfied:

$$\alpha - \left[\alpha \left(\frac{1}{1 + \exp(-X\beta)} \right) - K \right] > 0 \quad (14)$$

$$\text{With } K = \left(\left(\frac{1}{1 + \exp(-X\beta)} \right) C_{t-1} + C_{t-1} \right)$$

Rearranging the terms, we get:

$$\alpha > K - \alpha \left[\frac{1}{1 + \exp(-X\beta)} \right] \quad (15)$$

Or

$$\alpha > K / \left[1 + \left(\frac{1}{1 + \exp(-X\beta)} \right) \right] \quad (16)$$

In this case, the adoption of online businesses has a positive impact on productivity. We associate this assumption with the context of this study in that even the adoption of online business has a positive impact on changes in productivity, and the transition to task automation can displace labor, particularly in positions involving tasks that can be automated (Frey & Osborne, 2017). Consequently, this may cause job reduction and heightened unemployment, predominantly affecting workers with limited skill sets and education (Acemoglu & Restrepo, 2018). In practice, Assumption 1 assumes that the partial derivative of productivity variation with respect to the adoption of an online business is positive. In other words, the transition to online business has led to an increase in company productivity. Several mechanisms can explain this positive impact. First, digital tools and online commerce make it possible to automate certain tasks, optimize processes, reduce costs, and increase operational efficiency (Arntz et al., 2016; Frey & Osborne, 2017). Second, the Internet broadens access to new markets and consumers, thereby increasing business volumes and sales (Aker & Mbiti, 2010). Third, data analytics applied to online transactions improves customer knowledge and facilitates tailored offerings, boosting demand (Aker & Wamba, 2016). However, as Acemoglu and Restrepo (2018) point out, digital automation can also destroy some low-skilled jobs, exacerbating inequalities.

Assumption 2. $\partial(\Delta C)/\partial(OP) < 0$

For the partial derivative to be negative, the following condition must be satisfied:

$$\alpha - \left[\alpha \left(\frac{1}{1 + \exp(-\chi\beta)} \right) - K \right] < 0 \quad (17)$$

Rearranging the terms, we get:

$$\alpha < K - \alpha \left[\frac{1}{1 + \exp(-\chi\beta)} \right] \quad (18)$$

Or

$$\alpha < K / \left[1 + \left(\frac{1}{1 + \exp(-\chi\beta)} \right) \right] \quad (19)$$

In this case, the adoption of online business has a negative impact on productivity. By adopting online services, social activities involving advice-seeking may have a negative impact on online retailers' business productivity and labor demand (Qu et al., 2013; Stephen & Toubia, 2010). Assumption 2 assumes that the partial derivative of the productivity variation with respect to the adoption of online operations is negative. In other words, the transition to e-commerce led to a decrease in company productivity. Several mechanisms can explain this negative impact. First, the adoption of digital tools and e-commerce can entail significant transition costs that undermine short-term productivity (e.g., investments, employee training, process reorganization) (Levy & Murnane, 2004). Second, social activities involving advice-seeking, increased by Internet use, can have a disruptive and distracting effect on employees, reducing their individual productivity and, therefore, that of the company (Qu et al., 2013). Third, the transition to digital technology can destabilize consumer habits and benchmarks and therefore negatively impact companies' commercial activity during the adaptation period (Wang et al., 2020).

Assumption 3. $\partial(\Delta C)/\partial(OP) = 0$

For the partial derivative to be zero, these conditions must be satisfied:

$$\alpha - \left[\alpha \left(\frac{1}{1 + \exp(-\chi\beta)} \right) - K \right] = 0 \quad (20)$$

Rearranging the terms, we get:

$$\alpha = K - \alpha \left[\frac{1}{1 + \exp(-\chi\beta)} \right] \quad (21)$$

Or

$$\alpha = K / \left[1 + \left(\frac{1}{1 + \exp(-\chi\beta)} \right) \right] \quad (22)$$

In this case, the adoption of online business has no impact on the variation in companies' productivity. Assumption 3 supposes that the partial derivative of productivity variation with respect to the adoption of online business is zero. This means that in this case, the transition to online business operations has no impact on companies' productivity changes. There are several possible explanations for this observation: First, some companies may adopt online business without changing their internal processes or models. They are content with an online presence without in-depth exploitation (Sin et al., 2016). Second, initial efforts to develop e-commerce may have been undertaken but proved unsuccessful or unprofitable, leading to a return to the status quo ante (Terzi, 2011). Third, it is possible that a company's industry does not lend itself to the potential benefits of digital technology, thus limiting productivity gains (Leavitt & Whisler, 1958).

3.2. Empirical method

Sample selection models were used to achieve the study's objectives. Since firms have not been randomly assigned to groups that do or do not conduct business on the Internet, the estimation of our primary sample could lead to a serious bias (Roy, 1951). In cases where our sample is predominantly composed of firms that conduct business on the Internet, we could overestimate or underestimate the causal effect depending on whether the firms experience positive or negative changes in productivity. In addition, certain unobservable characteristics such as pressure from a firm's shareholders or employees may induce firms to conduct business online. In this sense, several observable and unobservable characteristics may bias the composition of our sample, and hence, our estimates. The bias in the composition of our sample is selection bias (Cameron & Trivedi, 2005; Sodokin, 2021; Sodokin et al., 2023) and sample selection models allow us to address this bias (Cameron & Trivedi, 2005; Maddala, 1983). Specifically, we use the endogenous switching regression method by first estimating the probability that a firm conducts Internet business and then the impact of the Internet business on firm productivity (Roy, 1951). We use the instrumental variable method with quantile regression (Kaplan, 2022; Kaplan & Sun, 2017) to check the robustness of the results obtained through endogenous switching regression (Cameron & Trivedi, 2005) and explore the impact of online business on the quantile of firm productivity.

3.2.1. Computation of the formal and informal firm productivity

The starting point is the Cobb-Douglas production function (Cobb & Douglas, 1928) which is typically written as follows:

$$Y = AK^{\alpha}L^{1-\alpha}$$

where Y is the total output, A is a constant parameter representing the level of technology, K is the amount of capital, L is the amount of labor, and α is the capital elasticity, which measures the sensitivity of the output to a variation in capital while holding labor constant.

Average factor productivity is defined as the total output divided by the number of production factors used. Focusing on average labor productivity, we divide the Cobb-Douglas production function by the amount of labor as follows:

$$\bar{L} = Y/L = AK^{\alpha}L^{-\alpha}$$

Where $\bar{L}$ is average labor productivity. We then derive the changes in labor productivity by taking the difference in the average labor productivity for the two periods.

3.2.2. Endogenous switching regression model

Inspired by Roy's (1951) model, we define the latent variable OP_i^* as the opportunity to conduct business online. If OP_i^* can be expressed in terms of a vector of firm characteristics, we can formalize the model as follows:

$$\begin{cases} OP_i^* = X_i^T \beta + \varepsilon_{0i} \\ OP_i = 1 \text{ if } OP_i^* > 0 \\ OP_i = 0 \text{ if } OP_i^* \leq 0 \end{cases} \quad (23)$$

where i refers to a given firm; ε_{0i} is the error term; X_i^T is the transposed vector of explanatory variables; β is the vector of coefficients associated with X_i^T and OP_i is a categorical variable taking the value 1 if the firm performs business operations on the Internet and 0 otherwise. Based on the work of Goldfeld and Quandt (1973) and Maddala and Nelson (1975), we define two regimes 1 and 2, where regime 1 groups firms operating on the Internet and regime 2 includes companies that do not operate on the Internet. These two models are described as follows:

$$\begin{cases} \text{Regime1} : \Delta \bar{L}_i = Z_{1i}^T \theta_1 + \varepsilon_{1i} \text{ if } X_{1i}^T \beta \geq \varepsilon_{0i} \\ \text{Regime2} : \Delta \bar{L}_i = Z_{2i}^T \theta_2 + \varepsilon_{2i} \text{ if } X_{1i}^T \beta < \varepsilon_{0i} \end{cases} \quad (24)$$

Where $\Delta \bar{L}_i$ means the change in labor productivity for company i , ε_{1i} is the error term, Z_{1i}^T is the transposed vector of explanatory variables for regime 1, and θ_1 the vector of the associated coefficients. We assume that the joint distribution of error terms follows a normal distribution.

$$\begin{bmatrix} \varepsilon_{0i} \\ \varepsilon_{1i} \\ \varepsilon_{2i} \end{bmatrix} \sim \mathcal{N} \left[\begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \begin{bmatrix} 1 & \sigma_{01} & \sigma_{02} \\ \sigma_{01} & \sigma_1^2 & \sigma_{12} \\ \sigma_{02} & \sigma_{12} & \sigma_2^2 \end{bmatrix} \right] \quad (25)$$

where the variance of the error term of the selection model $V(\varepsilon_{0i})$ is normalized to 1. However, the assumption of normality of the joint distribution was strong. Nevertheless, given our sample size, we can rely easily on asymptotic properties to mitigate the significance of this assumption. The sample maximum likelihood function in equation (5) is expressed as follows:

$$L(\theta_1, \theta_2, \sigma_1^2, \sigma_2^2, \sigma_{01}, \sigma_{02}) = \prod_{i=1}^N \left[\int_{-\infty}^{\beta^T X_i} f(\Delta \bar{L}_i - Z_{1i}^T \theta_1, \varepsilon_{0i}) d\varepsilon_{0i} \right]^{OP_i} \left[\int_{\beta^T X_i}^{+\infty} g(\Delta \bar{L}_i - Z_{2i}^T \theta_2, \varepsilon_{0i}) d\varepsilon_{0i} \right]^{1-OP_i} \quad (26)$$

where f and g are the joint normal density functions of $(\varepsilon_{1i}, \varepsilon_{0i})$ and $(\varepsilon_{2i}, \varepsilon_{0i})$. However, maximizing L (.) were tedious and unfeasible. The two-step method of Heckman (1979) was used to estimate model parameters. By expressing the expected values of the error terms ε_{1i} and ε_{2i} in terms of the Mills ratio, we can write:

$$E(\varepsilon_{1i} | \varepsilon_{0i} \leq X_{1i}^T \beta) = -\sigma_{01} W_{1i} \text{ with } W_{1i} = \frac{\phi(X_{1i}^T \beta)}{\Phi(X_{1i}^T \beta)} \quad (27)$$

$$E(\varepsilon_{2i} | \varepsilon_{0i} \geq X_{1i}^T \beta) = \sigma_{02} W_{2i} \text{ with } W_{2i} = \frac{\phi(X_{1i}^T \beta)}{1 - \Phi(X_{1i}^T \beta)} \quad (28)$$

where $\phi(\cdot)$ and $\Phi(\cdot)$ Mean, standard normal density function, and standard normal cumulative distribution function. We can then rewrite equations (24) for the two regimes as follows:

$$\begin{cases} \text{Regime1} : \Delta \bar{L}_i = Z_{1i}^T \theta_1 - \sigma_{01} W_{1i} + \mu_{1i} \text{ for } OP_i = 1 \\ \text{Regime2} : \Delta \bar{L}_i = Z_{2i}^T \theta_2 + \sigma_{02} W_{2i} + \mu_{2i} \text{ for } OP_i = 0 \end{cases} \quad (29)$$

where μ_{1i} and μ_{2i} are the residuals corrected for selection bias with zero conditional expectation. The two-step estimation involves using the maximum likelihood method to estimate, through a probit, the vector of coefficients β in equations (23). From vector $\hat{\beta}$ we express the values of $\hat{W}_{1i}$ and $\hat{W}_{2i}$ to estimate equations (29) using ordinary least squares. Thus, we obtain consistent estimates of the parameters of the model (Maddala, 1983).

3.2.3. Instrumental variable method

As mentioned earlier, potential biases due to the non-random assignment of firms to Internet business operations can be addressed by endogenous switching regression method, which provides robust estimators (Maddala, 1983). However, this method assumes a trivariate normal distribution of the error terms. The instrumental variables method helps test the robustness of the results obtained through endogenous switching regression method while considering endogeneity problems (Cameron & Trivedi, 2005; Wooldridge, 2015).

Consider the following model:

$$\Delta \bar{L}_i = f(OP_i; W_i) + V_i \quad (30)$$

Where $\Delta \bar{L}_i$ represents changes in the labor productivity of firm i , OP_i is the indicator variable of the variable of interest that defines whether firm i conducts business on the Internet, W_i and is a set of variables used to control the effect of the indicator variable on labor productivity changes. Note that in a regression, the coefficients of the control variables are not interpretable because of their correlation with the error term (Stock & Watson, 2022). If the hypothesis of conditional mean independence is not satisfied, the instrumental variable Z_i is excluded from equation (30), such that

$$\text{Cov}(Z_i, OP_i | W_i) \neq 0 \text{ and} \quad (31)$$

$$\text{Cov}(Z_i, V_i | W_i) = 0. \quad (32)$$

Condition (31) imposes a non-null correlation between instrumental variable Z_i and instrumented OP_i . This is the principle behind relevance. The instrumental variable must be able to explain variations in the instrumented variables. Condition (32) implies that the instrumental variable is uncorrelated with the error term in equation (30). This is the principle of exclusion. In other words, Z_i explains only the exogenous part of the variable OP_i . Under the principle of relevance and exclusion, Z_i is a valid instrument of OP_i and the instrumental variable method leads to robust estimators (Sodokin, 2021; Stock & Watson, 2022). Based on this premise, we distinguish the quantiles of productivity to derive the smoothed instrumental variable quantile regression estimator (Kaplan, 2022; Kaplan & Sun, 2017; Sodokin et al., 2023)

3.3. Rationale, selection of variables and descriptive statistics

3.3.1. Rationale and selection of variables

We chose managers' age and education as variables based on human capital theory, which posits that a manager's skills, experience, and education can significantly influence a company's performance (Becker, 1964). Contingency theory suggests that a company's size can impact its ability to effectively leverage the Internet (Donaldson, 2001). The selection of a company's age as a variable draws on organizational life cycle theory, indicating that older companies might be more stable and better positioned to generate revenue (Lester et al., 2003). Access to technology and the internet was included as a proxy for digital transformation. This decision was guided by the technology acceptance model, which states that access to technology and the Internet can shape a company's adoption and usage of Internet technologies (Davis, 1989). Environmental factors, such as competition, transportation, and access to credit, are considered critical for a company's performance, according to resource dependence theory (Pfeffer & Salancik, 1978). Changes in productivity are considered a measure of a company's performance, and a metric frequently employed in management and business economics research (Geroski et al., 1993). Furthermore, the differentiation between formal and informal companies is a common distinction in economic development research for understanding the variations in performance and operations between these two categories of companies (La Porta & Shleifer, 2008). We selected the "permanent employment" variable to encapsulate the influence of digital transformation on a company's employment level. This choice is underpinned by Schumpeter's model of creative destruction, a theoretical framework employed to examine the repercussions of internet adoption and e-commerce on employment. According to this model, technological innovation, embodied here by the adoption of the Internet and e-commerce, can act as a double-edged sword, eliminating jobs in certain sectors and fostering job creation in others. For instance, the adoption of e-commerce may curtail the necessity for workers in traditional brick-and-mortar retail, yet

simultaneously catalyze job creation in areas such as logistics, digital marketing, and online customer service (Schumpeter, 1942).

3.3.2. Descriptive statistics and data

The data used in this study were obtained from the latest General Census of Enterprises conducted in Togo in 2018 by the National Institute of Economics and Development Studies (INSEED, 2019). This census was born out of the need to update the directory of resident businesses in Togo, and to have a recent statistical system that allows for an assessment of the contribution of informal and formal sector businesses to the economic system. A total of 119,318 economic units were surveyed throughout Togo, 62.9% of which were located in the “Grand Lomé” region. This census population includes single establishments, headquarters enterprises, and secondary establishments (INSEED, 2019). Table 1 presents the descriptive statistics for all the variables selected for the estimates. Through standard errors, we observe strong dispersion in turnover among firms. This indicates significant disparities in turnover among the firms in Togo. Table 1 also shows that the economic landscape is largely composed of firms operating in the informal sector, with the majority of their managers having an average education level below the secondary school level. Despite minor difficulties in accessing technology, very few companies in Togo conduct business operations on the internet. However, many of them face difficulties related to increased competition within the country. In this sense, online business may appear as a missing scheme that allows companies to respond to their current difficulties and to reduce performance disparities between resident companies in Togo.

In Table 2, we conduct t-tests on the difference in means between the characteristics of firms that conduct business operations on the internet and those that do not. Furthermore, we first conduct an analysis for all firms without distinction, and then distinguish between firms in the formal and informal sectors. The results reveal that firms conducting business operations on the Internet have, on average, significantly higher changes in labor productivity than those that do not. These results are also confirmed when we distinguish between firms in formal and informal sectors. Moreover, Internet-active firms experienced greater changes in productivity from one year to the next. However, other firm characteristics may influence productivity levels. Indeed, as Table 2 shows, there are significant differences between the firms. In this sense, the differences in productivity may not be solely due to internet business operations. In particular, managers of firms conducting business on the Internet have higher average education. Similarly, these firms have more permanent employees and fewer difficulties in accessing credit. The estimation methods used in the remainder of this study allow us to account for these potential biases and isolate the effects of online business operations on labor productivity changes.

4. Results

4.1. Determinants of online business operation and firms change in productivity

Table 3 presents the characteristics that motivate firms to conduct business online, and the impact of specific explanatory variables on changes in firms' labor productivity. The likelihood ratio was significant at all levels in the error independence test, indicating a substantial correlation between the error terms in regimes 1 and 2. This justifies the use of a selection model to correct selection bias. The Wald statistic indicates that the characteristics of the firms retained in our models significantly explain changes in labor productivity. The model suggests that past turnover incentivizes firms to engage in online businesses. Specifically, a 1% increase in past turnover raises the likelihood of a firm conducting Internet operations by 0.28% for informal-sector firms and 0.20% for formal-sector firms. Considering all firms, without distinguishing between formal and informal sectors, the number of permanent employees seems to encourage online business engagement. However, one might assume that firms with fewer employees have greater incentives to operate online. This finding is corroborated by the difference between formal and informal firms. For informal firms, the effect of permanent workforce on the probability of conducting online business operations is negative and insignificant. Additionally, the results reveal that older managers are

Table 1. Descriptive statistics

Variables	Description	Mean	Stand. Dev	Minimum	Maximum
Changes in labor productivity	Changes in turnover between 2017 and 2016 per worker	-.1011	2.5576	-29.3199	24.8385
*Turnover in 2017	The logarithm of the turnover in 2017	12.2888	3.4768	0	26.1230
*Turnover in 2016	The logarithm of the turnover in 2016	12.8632	3.0965	0	25.4499
Formal	Formal (1 if the firm operates in informal sector and 0 if it operates in the informal sector)	.1491	.3561	0	1
Online business operation	Online business operation (1 if the company performs business operations on the internet and 0 otherwise)	.0562	.2303	0	1
Internet	Detention of an internet connection (one if the company owns one and 0 otherwise)	.0690	.2535	0	1
Age of the firm	Age of the firm	5.3391	7.1584	0	206
Age of the manager	Age of the manager	39.0494	15.1499	12	99
Instruction of the manager	Education of the manager (one for primary, 2 for secondary, 3 for superior, and 0 otherwise)	1.5728	.8525	0	3
Region	An area where the firm is located (1 for Lomé and 0 otherwise)	.6289	.4831	0	1
Bookkeeping	Bookkeeping (one if the firm has bookkeeping and 0 otherwise)	.2365	.4249	0	1
Permanent staff	The permanent staff (logarithm of permanent staff)	.9043	.4717	0	7.2896
Weekly work hours	The logarithm of the weekly work hours	3.9076	0.6818	0	5.1240
The size of firm in 2016	The size of the firm in 2016 (2 for large firm, 1 for medium firm, and 0 for small firm)	.0369	.2110	0	2
Access to technology issue	Access to the technology issue if the firm has issued to access to technology and 0 otherwise)	.1778	.3823	0	1
Concurrence issue	The concurrence issue (1 if firm ha issues with competition and 0 otherwise)	.6201	.4854	0	1
Transport infrastructure issues	The transport infrastructure issue (one if the firm has issues with transport infrastructure and 0 otherwise)	.2591	.4382	0	1

(Continued)

Variables	Description	Mean	Stand. Dev	Minimum	Maximum
Issue to access credit	Issue to access credit (one if the firm has issue of access to credit and 0 otherwise)	.3652	.4815	0	1
Age of the firm * Instruction of the manager	Crossed variable between age of the firm and instruction of the manager	8.5809	15.2813	0	525
Instruction * Technology	Crossed variable between Instruction of the manager and access to technology issue	.3150	.7639	0	3
Region * Infrastructure	Crossed variable between region and transport infrastructure issue	.1574	.3642	0	1
Bookkeeping * Technology	Crossed variable between bookkeeping and access to technology issue	.0438	.2046	0	1
Staff * Concurrence	Crossed variable between permanent staff and concurrence issues	.5499	.5586	0	7.2027

Note. * We took the log (1+X) to deal with zero values.

less likely to steer their firms toward online businesses, as are large- and medium-sized companies. Thus, conducting business transactions online is predominant in the domain of small companies and this phenomenon is most pronounced among firms operating in the informal sector.

4.2. The impact of online business adoption on changes in firm productivity

Table 4 summarizes the firms' marginal gains when conducting online businesses. We examine these gains at the firm level and separately for firms in formal and informal sectors. Column (1) of Table 4 presents the treatment effects for firms conducting online business. Column (2) displays the treatment effects for firms that do not engage in online business. Finally, Column (3) estimates the treatment effects for all firms regardless of their online business activities. Considering the Average Treatment Effects on the Treated (ATTs), informal sector firms benefit the most from online business, as their changes in labor productivity have more than tripled. Formal-sector firms nearly tripled their labor productivity. This result demonstrates that online business operations have varied impacts depending on whether a firm operates in the formal or informal sector, which is corroborated by other treatment effects.

There are several possible explanations for this observation. One possibility is that online businesses allow firms to reach a wider audience and sell their products and services to a larger number of customers. This can lead to increased sales and profits (Benner & Waldfogel, 2020). Another possibility is that online business allows firms to operate more efficiently. For example, firms can use the internet to automate tasks, communicate with suppliers and customers, and manage their inventories. This could lead to lower costs and higher profits. The findings of this study suggest that the Internet is a valuable tool for businesses (Munirathinam, 2019; Wang et al., 2020). Firms that use the internet to conduct business may be able to increase their productivity and profits. Furthermore, the study finds that the impact of online business transactions on productivity is greater for informal enterprises than formal enterprises. This is likely to be because informal firms are small and have limited resources.

Table 2. Difference in means results

Variables	All firms				Formal firms				Informal firms			
	Online business operation (1)	No Online business operation (2)	Diff mean (2)-(1)		Online business operation (1)	No Online business operation (2)	Diff mean (2)-(1)		Online business operation (1)	No Online business operation (2)	Diff mean (2)-(1)	
	Mean				Mean				Mean			
Changes in labor productivity	.134	-.123	-0.257***		.111	-.002	-0.113		.157	-.141	-0.297**	
Turnover in 2017	13.420	11.823	-1.597***		15.624	13.826	-1.798***		12.331	11.685	-0.645***	
Turnover in 2016	14.117	12.538	-1.579***		15.778	14.173	-1.605***		13.029	12.387	-0.642***	
Formal	.341	.067	-0.275***		-	-	-		-	-	-	
Internet	.565	.039	-0.525***		.746	.156	-0.589***		.471	.031	-0.440***	
Age of the firm	6.975	5.219	-1.756***		1.207	7.974	-2.233***		5.305	5.023	-0.282**	
Age of the manager	4.990	38.926	-2.064***		48.192	46.129	-2.063***		37.275	38.413	1.138***	
Instruction of the manager	2.307	1.530	-0.777***		2.706	2.132	-0.574***		2.101	1.487	-0.614***	
Region	.781	.585	-0.197***		.836	.781	-0.055***		.753	.571	-0.182***	
Bookkeeping	.544	.150	-0.394***		-	-	-		.283	.087	-0.196***	
Permanent staff	1.322	.871	-0.451***		1.870	1.324	-0.547***		1.039	.838	-0.200***	
Weekly work hours	3.876	3.911	0.035***		3.840	3.895	0.055***		3.890	3.912	0.022**	
The size of firm in 2016	.199	.015	-0.184***		.439	.124	-0.316***		.016	.004	-0.012***	
Access to technology issue	.320	.168	-0.152***		.318	.215	-0.103***		.321	.164	-0.156***	

(Continued)

Table 2. (Continued)

Variables	All firms				Formal firms				Informal firms			
	Online business operation (1)	No Online business operation (2)	Diff mean (2)-(1)		Online business operation (1)	No Online business operation (2)	Diff mean (2)-(1)		Online business operation (1)	No Online business operation (2)	Diff mean (2)-(1)	
	Mean				Mean				Mean			
Concurrence issue	.658	.617	-0.041***		.740	.714	-0.026*		.618	.610	-0.008	
Transport infrastructure issues	.349	.253	-0.096***		.337	.288	-0.049***		.354	.250	-.104***	
Issue to access credit	.459	.359	-0.101***		.475	.405	-0.070***		.451	.355	-0.096***	
Age of the firm * Instruction of the manager	17.362	8.063	-9.300***		28.181	17.585	-10.596***		11.799	7.386	-4.412***	
Instruction of the manager * Technology	.762	.283	-0.478***		.879	.505	-0.374***		.705	.267	-0.438***	
Region * Infrastructure	.275	.149	-0.126***		.299	.217	-0.083***		.264	.144	-0.120***	
Bookkeeping * Technology	.181	.034	-0.147***		.318	.215	-0.103***		.113	.021	-0.093***	
Staff * Concurrence	.858	.528	-0.331***		1.411	.950	-0.461***		.588	.496	-0.092***	

Notes. *** p < 0.01, ** p < 0.05, * p < 0.1

Table 3. Estimates of the endogenous switching regression model. Determinants of online business operation and firms change in labor productivity										
Variables	All firms			Formal firms			Informal firms			
	Selection	No Online business operation	Online business operation	Selection	No Online business operation	Online business operation	Selection	No Online business operation	Online business operation	
Turnover in 2016	0.2402*** (0.0069)			0.1933*** (0.0089)						
Permanent staff	0.1984*** (0.0339)			0.1468*** (0.0371)			0.4855*** (0.0745)			
Age of the manager	-0.0052*** (0.0012)			-0.0038*** (0.0015)			-0.0076*** (0.0019)			
The size of firm in 2016	-0.4721*** (0.0599)			-0.3849*** (0.0596)			0.1227 (0.3676)	-1.1084** (.5404)		-0.0603 (2.6653)
Age of the firm		.0405 (.0269)	.1045 (.0712)		.0319 (.0423)	.0766 (.0740)		.1379** (.0653)		.0211 (.2739)
Instruction of the manager		.0994** (.0484)	.4470** (.1974)		.1542 (.1570)	.1663 (.2540)		.1858** (.0752)		.5144 (.4859)
Age of the firm * Instruction of the manager		-.0078	-.0283		-.0066	-.0201		-.0632**		-.0322
Region		(.0107)	(.0246)		(.0168)	(.0256)		(.0300)		(.1881)
		.0952	-.3142		-.7800	1.0247		.0796		-.5834
		(.0698)	(.3596)		(.5025)	(.8443)		(.0696)		(.4642)
Access to technology issue		-.4575*** (.1705)	.7989 (.6762)		-1.0963 (.7076)	.5113 (1.1537)		-.4186** (.1781)		1.7384* (.9781)
Internet		.1518 (.1240)	.3911** (.1939)		.4992** (.2445)	.0528 (.2506)		-.1887 (.1592)		.6473** (.3032)
Concurrence issue		-.2342**	.0776		-.1872	.2224		.0870		-1.3682**

(Continued)

Table 3. (Continued)

Variables	All firms			Formal firms			Informal firms		
	Selection	No Online business operation	Online business operation	Selection	No Online business operation	Online business operation	Selection	No Online business operation	Online business operation
Bookkeeping		(.0972)	(.2609)		(.2904)	(.3427)		(.1336)	(.6036)
		.3010***	-.0196					.0338	-.7159
		(.0815)	(.2679)					(.1148)	(.4549)
Transport infrastructure issues		-.0392	-.1767		-.2631	1.0827		-.0644	-.2196
		(.1096)	(.5292)		(.7312)	(1.2473)		(.1084)	(.6512)
Access to credit		-.0515	-.0396		.0041	.1214		-.0592	-.1948
		(.0582)	(.1857)		(.1767)	(.2235)		(.0616)	(.3012)
Instruction of the manager * Technology		.1843**	-.6877**		.4456	-.2097		.1648*	-1.1096**
		(.0936)	(.2996)		(.2855)	(.4121)		(.0999)	(.4607)
Region * Infrastructure		-.1233	.2919		.1575	-1.4049		-.1473	.6966
		(.1330)	(.5684)		(.7579)	(1.2710)		(.1369)	(.7398)
Staff * Concurrence		.3577***	.2664**		.3773**	.1218		-.0426	2.0901***
		(.0875)	(.1277)		(.1516)	(.1235)		(.1489)	(.6003)
Bookkeeping * Technology		.0998	.8824**					.2821	1.5016**
		(.1770)	(.4419)					(.2553)	(.6996)
Constant	-4.2753***	-.0878	-3.5286***	-3.3635***	1.4594**	-3.1940***	-1.7607***	-.4102**	-9.4308***
	(0.0890)	(.1080)	(.5941)	(0.1468)	(.6278)	(1.0972)	(0.0878)	(.1627)	(1.2069)
Rho 0		.833			.919			.181	
Rho 1			.527			.518			.861
Sigma 0		2.857			3.992			2.524	

(Continued)

Table 3. (Continued)									
Variables	All firms			Formal firms			Informal firms		
	Selection	No Online business operation	Online business operation	Selection	No Online business operation	Online business operation	Selection	No Online business operation	Online business operation
Sigma 1			2.943			2.453			5.032
LR independence test of the equation		$\chi^2 = 698.44$	Pvalue=.000		$\chi^2 = 287.23$	Pvalue = .000		$\chi^2 = 30.31$	Pvalue = .000
The overall significance test (Wald chi2)		$\chi^2 = 146.45$	Pvalue = .000		$\chi^2 = 40.55$	Pvalue = .000		$\chi^2 = 33.84$	Pvalue = 0.004
Observations	9,835	9,835	9,835	1,719	1,719	1,719	8,116	8,116	8,116
Notes. The standard deviations are shown in parentheses. *** p< 0.01, ** p< 0.05, * p< 0.1.									

Table 4. The impact of online business on changes in firm productivity

			Impacts		
			(1)	(2)	(3)
Categories	Online business operation	No Online business operation	ATT	ATU	ATE
All firms	889	8,946	3.068*** (0.058)	-1.856*** (0.004)	-1.524*** (0.008)
Formal firms	466	1253	3.194*** (0.060)	-1.422*** (0.006)	-1.110*** (0.009)
Informal firms	7693	423	1.175*** (0.026)	-8.590*** (0.006)	-7.923*** (0.013)

Notes. The standard deviations are shown in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

When evaluating the Average Treatment Effects on the Untreated (ATUs), there is a negative average variation in labor productivity for firms not conducting business online. This effect is strongest for informal sector firms, as they have lost more than twice the change in productivity compared to previous years. Finally, when estimating the impact of online business operations on all firms, a negative average treatment effect (ATE) is observed. Thus, although many firms conduct business online, their gains do not offset the losses incurred by firms that do not engage in online businesses. This highlights the need to encourage more formal and informal sector firms to conduct business online as the potential gains indicated by ATTs are substantial.

These results highlight the overall positive influence of online business operations on changes in firms' productivity in Togo. However, the impact varies across formal and informal businesses and their initial productivity levels. To further analyze this, it is appropriate to examine the distribution of productivity gains across different quantiles in more detail using instrumental variable quantile regressions.

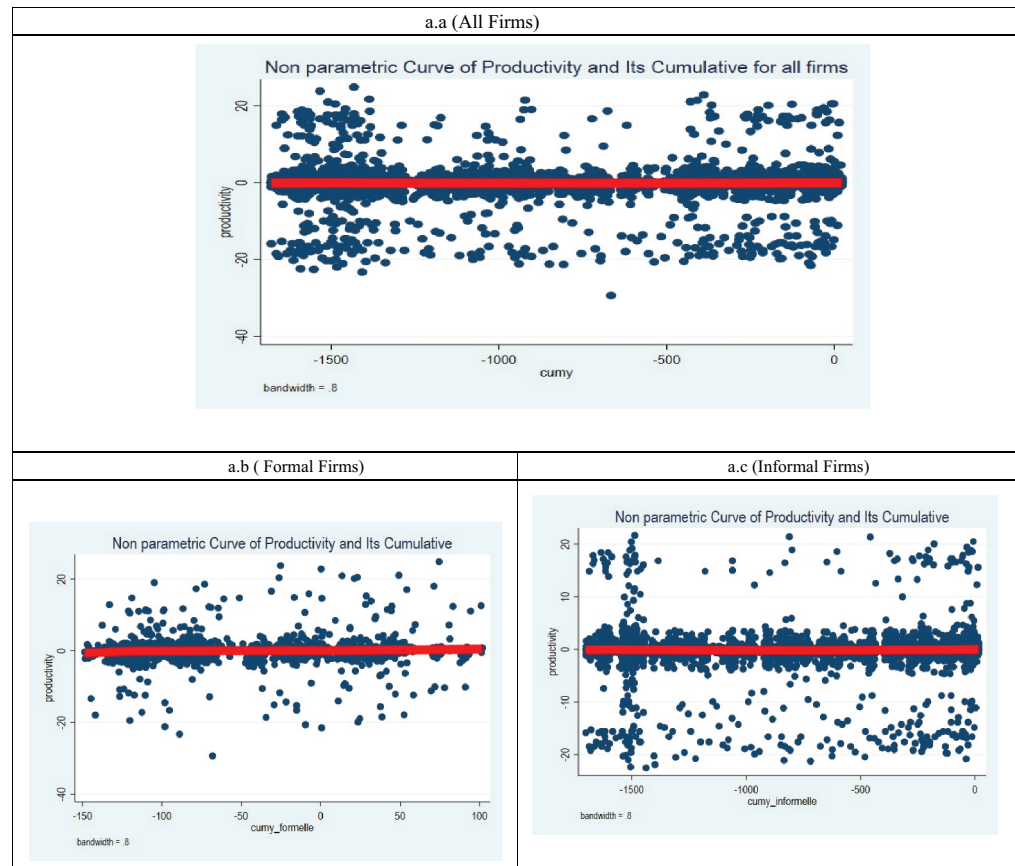
4.3. Smoothed instrumental variable quantile regression of the impact of online business operations on firm's productivity

4.3.1. Lorenz curve of the distribution of changes in productivity

Figure 1(a.d) represents the dynamics of productivity dispersion across all companies; the blue points seem to fluctuate around zero. This suggests that the individual productivity of all companies varies considerably, and is negative for some. This could be due to factors such as variations in company performance, economic shocks, management issues, or seasonal fluctuations. The red curve, representing cumulative productivity, shows a general upward trend for all the companies in the sample, although it seems to have struggled to exceed zero. This suggests that the total productivity of businesses increases over time; however, this increase is slowed by the presence of companies with negative productivity. This could reflect a compensation effect in which productivity gains from some companies are offset by productivity losses from others. In Figure 1(a.b), individual productivity appears to have a greater dispersion in formal companies than in all companies, indicating greater variability in individual productivity. As for cumulative productivity, the curve seems to be flatter and closer to zero for formal businesses than for all businesses, indicating slower growth in cumulative productivity compared with the entire group. In Figure 1.a.c, which represents the dynamics of productivity in informal businesses, the curve of individual productivity fluctuates around zero. However, dispersion appears to be slightly lower than in the case of formal businesses, indicating slightly lower variability in individual productivity. The

Figure 1a. Non parametric curve of firms' productivity and its cumulative.

Source. Authors' computation based on the 2018 General Business Census data of Togo (INSEED, 2019).



cumulative productivity curve also shows an upward trend, but the curve seems to be slightly farther from zero compared to that in the case of formal businesses, indicating slightly faster growth in cumulative productivity.

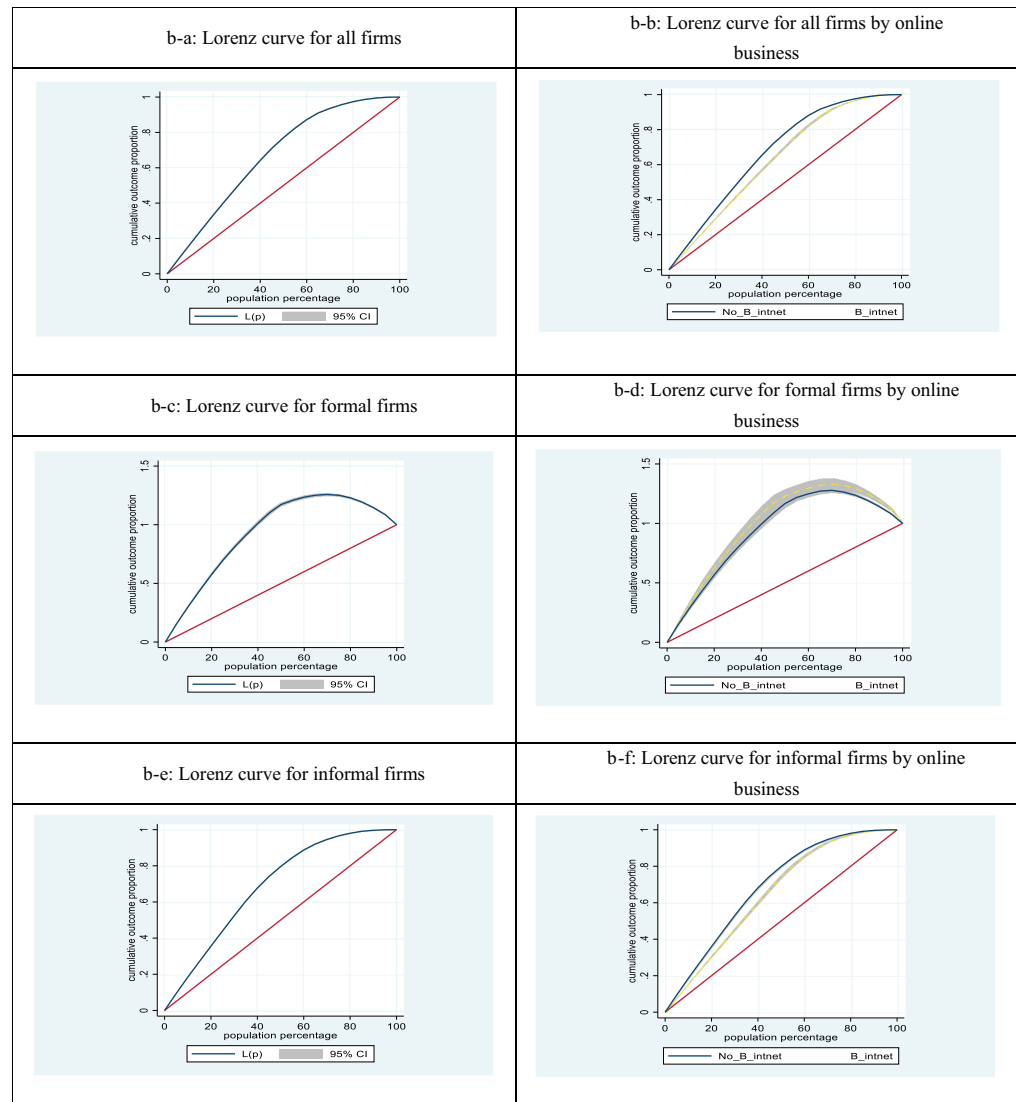
Figure 1 (b) presents the Lorenz curve for companies, categorizing them based on their engagement in online business and operations in the informal sector. First, when examining all firms, a distinct difference in productivity can be observed between those involved in online commerce and those who are not (Figure 1(b-b)). From the 30th quantile onward, the dotted yellow curve surpasses the solid blue curve, signifying a lower productivity gap among companies conducting online businesses. However, if we distinguish between firms, this pattern is the opposite for firms in formal sectors (Figure 1(b-d)), whereas it is the same for firms in informal sectors (Figure 1(b-f)). Consequently, the Lorenz curve diagrams highlight the uneven impact of online business operations across the examined productivity quantiles.

4.3.2. Instruments validity test

In Table 5, we perform econometric tests on the instruments used to account for endogeneity. We employed permanent workforce, firm size, access to credit, firm bookkeeping, and crossed variables for bookkeeping and technology access issues as the instruments. Firms are more inclined to operate online to compensate for a lack of staff. However, a company's permanent workforce rarely changes from one year to the next, and thus has little effect on changes in productivity. Similarly, access to credit can have long-term effects on firm performance. However, in the short run, the impact on changes in firm productivity was limited (see Tables 6, 7). Nonetheless, this may be synonymous with an environment that is conducive to infrastructure development, particularly

Figure 1b. Lorenz curves for all samples and by participation variable.

Source. Authors' computation based on the 2018 General Business Census data of Togo (INSEED, 2019).



in telecommunications. Good bookkeeping may be a sign of efficient business management; however, it is only relevant if the gains from good management are invested well. This reinvestment involves increasing the number of online businesses by controlling for other variables that can affect firm productivity.

The econometric tests carried out in Table 5 are in line with our a priori assumptions about the instruments and endogenous nature of the online business variable. The tests confirm the endogeneity of the online business variable, because we reject the null hypothesis that the standard and instrumented regressions are not significantly different. Fischer's statistics show that these instruments correlate with our endogenous variables. Nevertheless, as Nelson and Startz (1990) show through a simple Monte Carlo experiment, the properties of our estimator can be problematic in a finite sample (Nelson & Startz, 1990). Particularly at certain quantiles, when we compare the standard errors of the standard regression with those of the regression with instruments, we notice that the latter is much higher. This may be a sign of the weakness of the instruments and the presence of bias in instrumented regressions (Cameron & Trivedi, 2005). However, the simulations conducted by Staiger and Stock (1997) in their study show that, if the Fischer statistic

Table 5. Instrument validity test

		(1)	(3)	(3)
Test	Null hypothesis	All firms	Formal firms	Informal firms
Online business				
The test of endogeneity	H0: Variable can be considered as exogenous	$\chi^2 = 116.161$	$\chi^2 = 62.077$	$\chi^2 = 26.369$
		p-value = 0.000	p-value = 0.000	p-value = 0.000
Kleibergen-Paap : test of Sub-identification	H0: The model is under identified	$\chi^2 = 196.517$	$\chi^2 = 38.002$	$\chi^2 = 50.873$
		p-value = 0.000	p-value = 0.000	p-value = 0.000
Hansen J : over-identification test	H0: The principle of exclusion is satisfied	$\chi^2 = 3.699$	$\chi^2 = 0.234$	$\chi^2 = 5.343$
		p-value = 0.448	p-value = 0.890	p-value = 0.254
Cragg-Donald Wald (weakness test of the instruments)	H0: The principle of relevance is satisfied	F = 100.623	F = 19.141	F = 28.563
The critical values of the test low Stock-Yogo ID	10% maximal IV size	26.87	22.30	26.87
	15% maximal IV size	15.09	12.83	15.09
	20% maximal IV size	10.98	9.54	10.98
	25% maximal IV size	8.84	7.80	8.84
Internet access				
The test of endogeneity	H0: Variable can be considered as exogenous	$\chi^2 = 118.652$	$\chi^2 = 57.198$	$\chi^2 = 30.125$
		p-value = 0.000	p-value = 0.000	p-value = 0.000
Kleibergen-Paap : test of Sub-identification	H0: The model is under identified	$\chi^2 = 264.827$	$\chi^2 = 131.369$	$\chi^2 = 31.822$
		p-value = 0.000	p-value = 0.000	p-value = 0.000
Hansen J : over-identification test	H0: The principle of exclusion is satisfied	$\chi^2 = 3.916$	$\chi^2 = 0.684$	$\chi^2 = 3.555$
		p-value = 0.417	p-value = 0.710	p-value = 0.470
Cragg-Donald Wald (weakness test of the instruments)	H0: The principle of relevance is satisfied	F = 183.706	F = 69.754	F = 13.675
The critical values of the test low Stock-Yogo ID	10% maximal IV size	26.87	22.30	26.87
	15% maximal IV size	15.09	12.83	15.09
	20% maximal IV size	10.98	9.54	10.98
	25% maximal IV size	8.84	7.80	8.84

is above 10, the level of bias does not exceed that of the standard regression estimator by 10%. This result shows that the instruments are valid, because the Fischer statistic is greater than 10. Furthermore, the exclusion principle was sufficient for consistency in the instrument's regression estimator. This was confirmed by our failure to reject the null hypothesis of instrumental validity. Furthermore, as a robustness check, we perform a second regression using internet connection access as a variable to approximate the tendency of firms to conduct online business.

4.3.3. The impact of online business on changes in productivity with smoothed instrumental variable quantile regression

Tables 6–8 display the quantile regression results for the impact of online business on firm productivity, with a robustness check using Internet connection access as a proxy for online commerce. The results in both tables point in the same direction, showing that the implementation of online commerce enables firms to increase their productivity. Moreover, the quantile regression shows that not all firms benefit equally from the opportunities offered by online businesses. Indeed, although the Lorenz curve shows that productivity inequalities are lower among firms engaged in online trading, the results in Table 6 show that firms with high levels of productivity benefit more from online operations than firms with lower levels of productivity. This result reflects the crucial role of the initial productivity conditions and suggests that productivity does not converge over time between high- and low-productivity firms, at least not through online businesses. This trend was confirmed, even in the case of both formal and informal firms (Tables 7 and 8). In Table 8, informal firms in the 60th quantile do not experience significant variations in productivity as a result of e-commerce, and firms in the 90th quantile benefit the most. Therefore, even if we can foresee a slight convergence in productivity between low and medium productivity, this will not be realized at very high productivity. However, a robustness check using Internet connection access as a proxy for online business adoption reveals that medium-productivity firms in the informal sector experience the highest levels of productivity. This reinforces the expectation of eventual productivity convergence and leads to nuanced conclusions regarding the role of e-commerce adoption in productivity convergence among informal sector firms.

4.4. Impact of online business on labor market

Using the endogenous switching regression model, we estimated the impact of online business on labor supply, captured through weekly working hours (Becker, 1965; Blundell & MaCurdy, 1999; Keane, 2011) and labor demand (Azariadis, 1975; Hamermesh, 1993) represented by the number of permanent employees within firms. Tables 9, 10, and 11 present the results. The findings in Tables 9 and 10 suggest that the endogenous switching regression model is appropriate for assessing the impact of Internet business operations and Internet adoption on Togo's labor market.

Table 11 summarizes the main findings of the impact analysis. In terms of labor demand, Table 11 reveals that the Average Treatment Effect on the Treated (ATT) for internet business operations is negative and significant for all firms, whereas the Average Treatment Effect on the Untreated (ATU) and Average Treatment Effect (ATE) are positive. This implies that firms with online business operations require less employment than those without. This finding is consistent with those reported by Autor et al. (2003) and Américo and Veronico (2018), who explore how recent technological changes affect job skills and potentially displace certain types of labor. This conclusion was confirmed by distinguishing between formal and informal firms. In contrast to ATT, the ATU for Internet business operations is positive and significant, suggesting that informal firms that lack online business operations could benefit from employment if they adopt these online business operations. Brynjolfsson and McAfee (2014) proposed similar ideas, suggesting online business operations as a vehicle to increase labor demand from informal sector enterprises. This aligns with other studies indicating that online business operations can lead to job losses in some industries but can also create new jobs in others (Terzi, 2011).

Table 6. Online business and internet access impact on changes in productivity using smoothed instrumental variable quantile regression

Variables	All firms (Online business)						All firms (Robustness check: internet access)					
	Standard quantile regression			Smoothed instrumental variable regression			Standard quantile regression			Smoothed instrumental variable quantile regression		
	0.30	0.60	0.90	0.30	0.60	0.90	0.30	0.60	0.90	0.30	0.60	0.90
Internet business operation	0.032 (0.029)	0.026 (0.027)	0.110 (0.189)	0.543*** (0.060)	6.764*** (1.589)	5.343*** (0.572)						
Internet access							0.020 (0.029)	0.015 (0.027)	0.065 (0.185)	0.561*** (0.056)	0.352*** (0.095)	7.262*** (1.138)
Age of the firm	-0.025*** (0.008)	0.013* (0.007)	0.116** (0.049)	-0.026** (0.013)	0.022 (0.016)	0.088*** (0.032)	-0.025*** (0.008)	0.011 (0.007)	0.117** (0.048)	-0.025** (0.011)	0.015 (0.014)	0.200*** (0.040)
Age of the manager	0.001 (0.001)	0.000 (0.001)	0.003 (0.004)	0.001* (0.000)	0.000 (0.001)	0.003** (0.001)	0.001 (0.001)	0.000 (0.001)	0.003 (0.004)	0.001 (0.001)	0.000 (0.000)	0.004** (0.002)
Instruction of the manager	0.007 (0.013)	0.031*** (0.012)	0.216*** (0.083)	-0.021 (0.015)	0.039* (0.022)	-0.017 (0.048)	0.006 (0.013)	0.030** (0.012)	0.218*** (0.081)	-0.033** (0.017)	0.036*** (0.009)	0.274*** (0.055)
Age of the firm * Instruction of the manager	0.008*** (0.003)	-0.004* (0.003)	-0.038** (0.018)	0.007* (0.004)	-0.011 (0.008)	-0.030** (0.012)	0.008*** (0.003)	-0.004 (0.003)	-0.038** (0.018)	0.006 (0.004)	-0.006 (0.004)	-0.086*** (0.018)
Region	-0.038* (0.020)	-0.034* (0.018)	0.049 (0.130)	-0.078*** (0.021)	-0.042** (0.018)	-0.227*** (0.058)	-0.038* (0.020)	-0.034* (0.018)	0.048 (0.127)	-0.049*** (0.016)	-0.029*** (0.011)	0.118*** (0.041)
Access to technology issue	-0.029 (0.025)	0.004 (0.023)	0.047 (0.163)	-0.044*** (0.013)	-0.007 (0.040)	-0.519*** (0.086)	-0.029 (0.025)	0.004 (0.023)	0.076 (0.160)	-0.021 (0.016)	0.015 (0.012)	-0.147** (0.065)
Concurrence issue	-0.015 (0.016)	-0.002 (0.015)	0.033 (0.106)	-0.005 (0.014)	-0.003 (0.011)	0.172*** (0.051)	-0.019 (0.016)	-0.002 (0.015)	0.030 (0.104)	-0.009 (0.016)	-0.003 (0.006)	0.076** (0.034)
Transport infrastructure issues	0.072** (0.031)	-0.005 (0.029)	0.068 (0.203)	0.032 (0.037)	-0.005 (0.025)	-0.060 (0.075)	0.069** (0.031)	-0.006 (0.029)	0.038 (0.199)	-0.018 (0.036)	-0.021 (0.018)	-0.094 (0.062)
Region * Infrastructure	-0.103*** (0.031)	-0.005 (0.029)	-0.101 (0.203)	-0.083* (0.037)	-0.017 (0.025)	-0.124 (0.075)	-0.098*** (0.031)	-0.002 (0.029)	-0.071 (0.199)	-0.037 (0.036)	0.006 (0.018)	-0.017 (0.062)

(Continued)

Table 6. (Continued)

Variables	All firms (Online business)						All firms (Robustness check: internet access)					
	Standard quantile regression			Smoothed instrumental variable quantile regression			Standard quantile regression			Smoothed instrumental variable quantile regression		
	0.30	0.60	0.90	0.30	0.60	0.90	0.30	0.60	0.90	0.30	0.60	0.90
Turnover in 2016	(0.038)	(0.035)	(0.244)	(0.043)	(0.052)	(0.134)	(0.038)	(0.035)	(0.240)	(0.036)	(0.017)	(0.084)
	-0.021***	-0.025***	-0.428***	-0.026***	-0.033	-0.367***	-0.020***	-0.025***	-0.429***	-0.026***	-0.034***	-0.553***
	(0.003)	(0.003)	(0.018)	(0.001)	(0.047)	(0.024)	(0.003)	(0.003)	(0.018)	(0.001)	(0.008)	(0.040)
Permanent staff	0.140***	0.006	0.116				0.140***	0.006	0.114			
	(0.021)	(0.020)	(0.139)				(0.022)	(0.020)	(0.138)			
The size of the firm in 2016	-0.089**	0.045	1.130***				-0.083*	0.045	1.136***			
	(0.042)	(0.039)	(0.273)				(0.043)	(0.039)	(0.270)			
Issue to access credit	0.015	0.013	-0.006				0.015	0.013	-0.005			
	(0.016)	(0.015)	(0.106)				(0.016)	(0.015)	(0.104)			
Bookkeeping	-0.016	0.067***	0.810***				-0.017	0.067***	0.812***			
	(0.023)	(0.021)	(0.149)				(0.023)	(0.021)	(0.147)			
Bookkeeping * Technology	0.030	0.024	-0.033				0.040	0.027	-0.102			
	(0.044)	(0.041)	(0.284)				(0.044)	(0.040)	(0.279)			
Constant	-0.054	0.300***	5.613***	0.158***	0.405	56.829***	-0.053	0.303***	5.620***	0.158***	0.424***	12.293***
	(0.049)	(0.045)	(0.318)	(0.041)	(0.600)	(0.348)	(0.049)	(0.045)	(0.313)	(0.045)	(0.102)	(0.391)
Observations	9,835	9,835	9,835	9,835	9,835	9,835	9,835	9,835	9,835	9,835	9,835	9,835

Notes. The standard deviations are shown in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 7. Online business and internet access impact on changes in productivity using smoothed instrumental variable quantile regression

	Formal firms (Online business)				Formal firms (Robustness check: internet access)				
	Standard quantile regression		Smoothed instrumental variable quantile regression		Standard quantile regression		Smoothed instrumental variable quantile regression		
Variables	0.30	0.60	0.90	0.30	0.60	0.90	0.30	0.60	0.90
Internet business operation	0.074 (0.073)	0.057 (0.073)	0.118 (0.274)	4.903*** (1.787)	6.587** (2.773)	9.453*** (1.855)			
Internet access							0.176** (0.074)	0.101 (0.079)	0.205 (0.283)
Age of the firm	-0.010 (0.016)	0.026* (0.015)	0.057 (0.058)	-0.046 (0.034)	0.067 (0.044)	0.041 (0.047)	-0.012 (0.015)	0.024 (0.016)	0.054 (0.057)
Age of the manager	0.003 (0.002)	0.001 (0.002)	0.005 (0.007)	0.004 (0.005)	0.009** (0.004)	0.012* (0.007)	0.002 (0.002)	0.001 (0.002)	0.007 (0.007)
Instruction of the manager	0.081 (0.053)	0.098* (0.053)	0.242 (0.200)	-0.887** (0.347)	0.013 (0.155)	-0.738*** (0.274)	0.062 (0.052)	0.090 (0.055)	0.243 (0.199)
Age of the firm * Instruction of the manager	0.003 (0.006)	-0.008 (0.006)	-0.017 (0.022)	0.014 (0.012)	-0.025 (0.020)	-0.013 (0.021)	0.003 (0.006)	-0.008 (0.006)	-0.017 (0.021)
Region	-0.081 (0.183)	0.137 (0.182)	0.143 (0.684)	-1.193** (0.481)	-0.264 (0.279)	-1.201* (0.624)	-0.098 (0.175)	0.116 (0.187)	0.123 (0.673)
Access to technology issue	0.070 (0.077)	-0.005 (0.077)	-0.179 (0.289)	-0.587 (0.381)	-0.219 (0.198)	-0.935*** (0.277)	0.083 (0.074)	-0.014 (0.079)	-0.205 (0.284)
Concurrence issue	0.037 (0.069)	0.026 (0.069)	0.268 (0.259)	0.058 (0.225)	0.217 (0.150)	0.186 (0.278)	0.044 (0.066)	0.038 (0.071)	0.237 (0.255)
Transport infrastructure issues	0.005 (0.283)	0.251 (0.281)	0.653 (1.058)	-0.080 (0.363)	0.293 (0.509)	0.553 (0.761)	-0.055 (0.271)	0.243 (0.289)	0.615 (1.041)
Region * Infrastructure	-0.021	-0.254	-0.626	-0.157	-0.452	-0.800	0.071	-0.238	-0.571
							0.012	0.034	-1.049
(Continued)									

(Continued)

Table 7. (Continued)

Variables	Formal firms (Online business)						Formal firms (Robustness check: internet access)					
	Standard quantile regression			Smoothed instrumental variable regression			Standard quantile regression			Smoothed instrumental variable quantile regression		
	0.30	0.60	0.90	0.30	0.60	0.90	0.30	0.60	0.90	0.30	0.60	0.90
Turnover in 2016	-0.044*** (0.009)	-0.138*** (0.009)	-0.734*** (0.034)	-0.337* (0.179)	-0.396*** (0.080)	-0.604*** (0.083)	-0.050*** (0.009)	-0.138*** (0.009)	-0.728*** (0.034)	-0.321*** (0.101)	-0.388*** (0.113)	-0.706*** (0.070)
Permanent staff	0.150*** (0.046)	0.052 (0.046)	0.065 (0.174)				0.147*** (0.045)	0.044 (0.048)	0.033 (0.173)			
The size of the firm in 2016	-0.003 (0.079)	0.359*** (0.079)	2.105*** (0.297)				-0.015 (0.077)	0.350*** (0.082)	2.039*** (0.295)			
Issue to access credit	-0.016 (0.063)	0.041 (0.063)	-0.027 (0.237)				-0.031 (0.061)	0.010 (0.065)	-0.011 (0.233)			
Constant	-0.106 (0.259)	1.627*** (0.258)	11.254*** (0.971)	5.671* (3.011)	5.282*** (1.485)	39.992*** (1.659)	0.027 (0.249)	1.654*** (0.266)	11.155*** (0.957)	5.393*** (1.880)	5.375*** (1.564)	11.417 (9.223)
Observations	1,719	1,719	1,719	1,719	1,719	1,719	1,719	1,719	1,719	1,719	1,719	1,719

Notes. The standard deviations are shown in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 8. Online business and internet access impact on changes in productivity using smoothed instrumental variable quantile regression												
Variables	Informal firms (Online business)				Informal firms (Robustness check: internet access)				Standard quantile regression			
	0.30	0.60	0.90	Smoothed instrumental variable regression	0.30	0.60	0.90	Smoothed instrumental variable regression	0.30	0.60	0.90	Smoothed instrumental variable regression
Online business operation	0.007 (0.037)	0.037 (0.027)	0.172 (0.187)	1.330* (0.745)	2.191 (1.814)	4.305*** (1.025)						
Internet access									-0.028 (0.035)	-0.002 (0.026)	0.096 (0.184)	2.131 (1.671)
Age of the firm	-0.025 (0.018)	-0.001 (0.013)	0.058 (0.090)	-0.024 (0.036)	0.009 (0.041)	0.099 (0.088)			-0.025 (0.018)	0.000 (0.013)	0.058 (0.092)	-0.022 (0.036)
Age of the manager	0.000 (0.001)	-0.000 (0.000)	-0.000 (0.003)	0.001*** (0.001)	-0.000 (0.001)	0.000 (0.002)			0.000 (0.001)	-0.000 (0.000)	-0.000 (0.003)	0.001 (0.001)
Instruction of the manager	0.000 (0.020)	-0.005 (0.015)	0.169 (0.104)	-0.018 (0.053)	0.027 (0.044)	0.071 (0.092)			0.002 (0.020)	-0.002 (0.015)	0.172 (0.106)	-0.028 (0.053)
Age of the firm * Instruction of the manager	0.009 (0.008)	0.005 (0.006)	-0.025 (0.042)	0.008 (0.027)	-0.002 (0.020)	-0.041 (0.038)			0.009 (0.008)	0.004 (0.006)	-0.026 (0.043)	0.004 (0.022)
Region	-0.023 (0.020)	-0.043*** (0.014)	-0.023 (0.100)	-0.057*** (0.020)	-0.046 (0.042)	-0.163* (0.086)			-0.025 (0.020)	-0.042*** (0.014)	-0.013 (0.102)	-0.024 (0.023)
Access to technology issue	-0.025 (0.024)	0.002 (0.018)	0.067 (0.122)	-0.084*** (0.029)	-0.034 (0.083)	-0.441*** (0.109)			-0.023 (0.024)	0.003 (0.018)	0.096 (0.124)	-0.076** (0.033)
Concurrence issue	-0.017 (0.017)	-0.002 (0.012)	-0.003 (0.085)	-0.013 (0.016)	-0.018 (0.034)	0.149** (0.075)			-0.021 (0.017)	-0.001 (0.012)	-0.014 (0.087)	-0.005 (0.022)
Transport infrastructure issues	0.069** (0.030)	-0.033 (0.022)	0.044 (0.153)	0.034 (0.029)	0.004 (0.032)	-0.074 (0.084)			0.068** (0.030)	-0.031 (0.022)	0.032 (0.157)	-0.116*** (0.043)
Region * Infrastructure	-0.113*** (0.030)	0.027 (0.022)	-0.039 (0.153)	-0.128*** (0.029)	-0.061 (0.032)	-0.103 (0.084)			-0.110*** (0.030)	0.027 (0.022)	-0.028 (0.157)	0.010 (0.043)
												0.035 (0.130)

(Continued)

Table 8. (Continued)

Variables	Informal firms (Online business)						Informal firms (Robustness check: internet access)					
	Standard quantile regression			Smoothed instrumental variable quantile regression			Standard quantile regression			Smoothed instrumental variable quantile regression		
	0.30	0.60	0.90	0.30	0.60	0.90	0.30	0.60	0.90	0.30	0.60	0.90
Turnover in 2016	(0.038) -0.019***	(0.028) -0.006**	(0.192) -0.337***	(0.043) -0.024***	(0.043) -0.049	(0.172) -0.316***	(0.038) -0.019***	(0.028) -0.005**	(0.197) -0.329***	(0.045) -0.051***	(0.095) -0.105**	(0.175) -0.313***
Permanent staff	(0.003) 0.161***	(0.002) 0.005	(0.016) 0.215	(0.007) 0.168***	(0.064) 0.005	(0.028) 0.197	(0.003) 0.005	(0.002) 0.005	(0.016) 0.197	(0.009) 0.005	(0.050) 0.005	(0.030) 0.005
The size of the firm in 2016	(0.032) -1.676***	(0.024) -0.127	(0.165) 1.489**	(0.032) -1.679***	(0.024) -0.124	(0.169) 1.446*	(0.032) -1.679***	(0.024) -0.124	(0.169) 1.446*	(0.032) -1.679***	(0.024) -0.124	(0.169) 1.446*
Issue to access credit	(0.017) 0.023	(0.013) 0.004	(0.087) -0.055	(0.017) 0.022	(0.013) 0.004	(0.089) -0.045	(0.017) 0.022	(0.013) 0.004	(0.089) -0.045	(0.017) 0.022	(0.013) 0.004	(0.089) -0.045
Bookkeeping	(0.031) 0.052*	(0.023) 0.044*	(0.159) 0.270*	(0.031) 0.050	(0.023) 0.044*	(0.163) 0.275*	(0.031) 0.050	(0.023) 0.044*	(0.163) 0.275*	(0.031) 0.050	(0.023) 0.044*	(0.163) 0.275*
Bookkeeping * Technology	(0.063) -0.027	(0.047) 0.034	(0.324) -0.100	(0.064) -0.020	(0.047) 0.044	(0.331) -0.084	(0.064) -0.020	(0.047) 0.044	(0.331) -0.084	(0.064) -0.020	(0.047) 0.044	(0.331) -0.084
Constant	(0.064) -0.072	(0.047) 0.109**	(0.325) 4.609***	(0.064) 0.112	(1.108) 0.705	(0.416) 75.320***	(0.064) -0.073	(0.047) 0.105**	(0.332) 4.517***	(0.101) 0.141	(0.858) 1.715**	(0.398) 111.992***
Observations	8,116	8,116	8,116	8,116	8,116	8,116	8,116	8,116	8,116	8,116	8,116	8,116

Notes. The standard deviations are shown in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 9. Estimates of the endogenous switching regression model. Determinants of online business and labor demand

Variables	All firms			Formal firms			Informal firms		
	Selection	No Online business operation	Online business operation	Selection	No Online business operation	Online business operation	Selection	No Online business operation	Online business operation
Turnover in 2016	0.0341*** (0.0026)			0.0282*** (0.0044)			0.0035** (0.0014)		
Age of the manager	0.0001 (0.0005)			0.0025*** (0.0008)			-0.0027*** (0.0004)		
The size of firm in 2016	1.2878*** (0.0322)			0.7977*** (0.0367)			0.4221*** (0.0715)		
Age of the firm		-.0016*** (.0005)	.0006 (.0052)		-.0012 (.0037)	.0341** (.0172)		.0006 (.0005)	-.0018 (.0023)
Instruction of the manager		.0088*** (.0032)	.1250*** (.0258)		.1036*** (.0190)	.2171*** (.0735)		.0176*** (.0030)	.0186* (.0105)
Age of the firm * Instruction of the manager		.0043*** (.0003)	.0087*** (.0020)		.0071*** (.0015)	-.0031 (.0060)		.0019*** (.0003)	.0010 (.0011)
Region		.0070* (.0039)	.0820*** (.0312)		-.0780** (.0335)	-.1519 (.1071)		-.0002 (.0036)	.0363*** (.0136)
Access to technology		-.0296*** (.0103)	.0158 (.0734)		.0034 (.0890)			-.0151 (.0094)	.0394 (.0278)

(Continued)

Table 9. (Continued)

Variables	All firms			Formal firms			Informal firms		
	Selection	No Online business operation	Online business operation	Selection	No Online business operation	Online business operation	Selection	No Online business operation	Online business operation
Concurrence issue		-.0002 (.0035)	-.0191 (.0244)		.0277 (.0227)	-.0638 (.0609)		-.0008 (.0032)	-.0035 (.0087)
Bookkeeping		.1765*** (.0049)	.4323*** (.0322)					.1301*** (.0056)	-.0019 (.0139)
Transport infrastructure issues		-.0128**	.0380		.0384	.0696		-.0185***	.0406**
Access to credit		(.0060)	(.0367)		(.0479)	(.1690)		(.0054)	(.0173)
		-.0016	-.0242		-.0141	-.0362		-.0041	.0037
		(.0035)	(.0229)		(.0209)	(.0546)		(.0033)	(.0084)
Instruction of the manager * Technology		.0360***	-.0025		.0640*	.1517		.0251***	-.0153
		(.0058)	(.0366)		(.0365)	(.1048)		(.0054)	(.0136)
Region * Infrastructure		.0018	-.0139		-.0996*	-.0069		.0184**	-.0571***
		(.0078)	(.0469)		(.0535)	(.1784)		(.0072)	(.0198)
Bookkeeping * Technology		.0540***	.0099			-.4392		.0267**	.0358*
		(.0105)	(.0576)			(.2909)		(.0121)	(.0209)
Constant	-1.6853*** (0.0406)	.7309***	1.9079***	-1.3185*** (0.0756)	.7426***	2.3925***	-1.3183*** (0.0270)	.7386***	-.6477***
		(.0063)	(.0718)		(.0560)	(.2400)		(.0058)	(.0395)
Rho 0		-.8800			-.9325			-.8837	

(Continued)

Table 9. (Continued)

Variables	All firms			Formal firms			Informal firms		
	Selection	No Online business operation	Online business operation	Selection	No Online business operation	Online business operation	Selection	No Online business operation	Online business operation
Rho 1			-.8379			-.8318			.9969
Sigma 0		.3879			.8048			.3183	
Sigma 1			1.0078			1.2839			.8611
LR independence test of the equation		$\chi^2 = 3826.36$	Pvalue=.000		$\chi^2 = 992.59$	Pvalue=.000		$\chi^2 = 3677.26$	Pvalue = .000
The overall significance test (Wald chi2)		$\chi^2 = 5047.20$	Pvalue = .000		$\chi^2 = 498.56$	Pvalue=.000		$\chi^2 = 1589.87$	Pvalue = .000
Observations	41732	41732	41732	4646	4646	4646	37086	37086	37086

Notes. The standard deviations are shown in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 10. Estimates of the endogenous switching regression model. Determinants of online business and labor supply

Variables	All firms			Formal firms			Informal firms		
	Selection	No Online business operation	Online business operation	Selection	No Online business operation	Online business operation	Selection	No Online business operation	E- business operation
Turnover in 2016	0.0146*** (0.0024)			0.0011 (0.0038)					
Permanent staff	0.4833*** (0.0186)			0.1989*** (0.0255)			0.3601*** (0.0278)		
Age of the manager	-0.0025*** (0.0006)			0.0002 (0.0010)			-0.0052*** (0.0007)		
The size of firm in 2016	0.2471*** (0.0409)			0.1579*** (0.0410)			0.4301*** (0.1268)	-0.0861 (0.0566)	-0.1637 (.1572)
Age of the firm		.0005 (.0010)	.0044 (.0049)		-.0001 (.0040)	.0024 (.0122)		-.00002 (.0010)	.0025 (.0056)
Instruction of the manager		-.0146** (.0060)	-.0234 (.0221)		.0036 (.0202)	.0208 (.0529)		-.0187*** (.0064)	-.0234 (.0252)
Age of the firm * Instruction of the manager		-.0014** (.0006)	-.0039* (.0020)		-.0014 (.0016)	-.0027 (.0044)		-.0007 (.0006)	-.0002 (.0027)
Region		-.0704*** (.0075)	-.0587** (.0297)		-1.1382*** (.0368)	-1.1091 (.0800)		-.0671*** (.0077)	-.0253 (.0309)
Access to technology issue		-.0322* (.0192)	-.0839 (.0655)		-.0048 (.0882)			-.0381* (.0198)	-.0740 (.0678)

(Continued)

Table 10. (Continued)

Variables	All firms			Formal firms			Informal firms		
	Selection	No Online business operation	Online business operation	Selection	No Online business operation	Online business operation	Selection	No Online business operation	E- business operation
Internet		.0987*** (.0163)	.0135 (.0199)		.0846*** (.0325)	.0006 (.0438)		.1209*** (.0185)	.0287 (.0219)
Concurrence issue		.1051***	.4295***		-.0674*	.2687***		.0956***	.2336***
Bookkeeping		(.0126)	(.0327)		(.0364)	(.0687)		(.0135)	(.0430)
		.0473***	-.1132***					.0741***	-.0142
		(.0102)	(.0263)					(.0130)	(.0324)
Transport infrastructure issues		-.0472***	-.0271		-.0467	-.1832		-.0476***	-.0030
		(.0114)	(.0423)		(.0557)	(.1364)		(.0115)	(.0418)
Access to credit		-.0024	-.0422**		-.0177	-.0585		.0008	-.0287
		(.0068)	(.0195)		(.0221)	(.0405)		(.0070)	(.0213)
Instruction of the manager * Technology		.0004	.0151		-.0294	.0168		.0040	.0092
		(.0111)	(.0315)		(.0367)	(.0768)		(.0116)	(.0334)
Region * Infrastructure		.0613***	.0566		.1224**	.1852		.0563***	.0392
		(.0149)	(.0476)		(.0611)	(.1427)		(.0155)	(.0488)
Staff * Concurrence		-.0472***	-.4159***		.0703***	-.1831***		-.0334**	-.2457***
		(.0126)	(.0254)		(.0202)	(.0337)		(.0141)	(.0417)

(Continued)

Table 10. (Continued)

Variables	All firms			Formal firms			Informal firms		
	Selection	No Online business operation	Online business operation	Selection	No Online business operation	Online business operation	Selection	No Online business operation	E- business operation
Bookkeeping * Technology		-.0708*** (.0227)	.0948** (.0456)					-.0800*** (.0290)	.0371 (.0529)
Constant	-2.0968*** (0.0392)	3.9954*** (.0129)	6.1458*** (.0762)	-1.0257*** (0.0735)	4.2805*** (.0597)	5.2526*** (.1731)	-1.8110*** (0.0356)	3.9945*** (.0129)	6.2883*** (.0885)
Rho 0		-.006			.908			-.012	
Rho 1			-.955			-.942			-.969
Sigma 0		.616			.760			.614	
Sigma 1			1.085			1.087			1.113
LR independence test of the equation		$\chi^2 = 338.10$	Pvalue = .000		$\chi^2 = 427.52$	Pvalue = .000		$\chi^2 = 397.41$	Pvalue = .000
The overall significance test (Wald chi2)		$\chi^2 = 309.79$	Pvalue = .000		$\chi^2 = 50.96$	Pvalue = .000		$\chi^2 = 293.06$	Pvalue = 0.004
Observations	40,179	40,179	40,179	3,866	3,866	3,866	36,374	36,374	36,374

Notes. The standard deviations are shown in parentheses. ***p< 0.01, **p< 0.05, *p< 0.1.

Table 11. Impact of online business on job market										
	Labor demand			Labor supply			Impacts			
	Online business operation	No E- business operation	E- business operation	No E- business operation	ATT	ATU	ATE	ATT	ATU	ATE
Categories										
All firms	2,819	38,913	2,491	37,688	-0.191*** (0.012)	1.322*** (0.001)	1.219*** (0.002)	0.010** (0.004)	1.973*** (0.001)	1.841*** (0.003)
Formal firms	1,640	35,446	1,634	34,679	-0.453*** (0.011)	1.254*** (0.001)	1.138*** (0.002)	0.523*** (0.003)	0.941*** (0.001)	0.913*** (0.001)
Informal firms	3,467	1,179	857	3,009	-0.453*** (0.003)	-1.312*** (0.0003)	-1.254*** (0.001)	0.053*** (0.005)	2.170*** (0.001)	2.025*** (0.003)

Notes. The standard deviations are shown in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Regarding labor supply, for all firms across sectors, the adoption of online business had a minimal effect, with ATT indicating a 1% increase. This trend was also confirmed for firms in the informal sector, whereas firms in the formal sector showed a more pronounced increase. This might appear counterintuitive as the adoption of online business can be seen as a technological evolution that reduces the number of employees required (Frey & Osborne, 2017). However, adopting online business, much like innovation, entails the emergence of new tasks within firms, the development of accompanying skills, or even prompting employees to work overtime (Arntz et al., 2016). Our results reveal that ATUs and ATEs are significantly higher than ATTs, suggesting that non-online businesses have longer working hours than ATTs do. Combined with previous results (see Tables 4 and 6) showing productivity gains from online business adoption, we can infer that online business allows companies, particularly those in the informal sector, to utilize their labor supply more efficiently.

4.5. Discussion of the results

Our empirical estimations strongly support the first hypothesis of our theoretical model (Assumption 1), suggesting that firms that engage in online business activities experience significant productivity changes. By employing two distinct econometric methodologies, the endogenous switching regression method and the smoothed instrumental variable quantile regression method, our findings are robust (Caliendo & Kopeinig, 2008). The use of proxy variables such as Internet access further strengthens the robustness of our results. Online business represents substantial innovation that enables firms to become more efficient. These stages correspond to the phases of innovators and early adopters in Rogers (1962) diffusion model. However, innovation diffusion across the Togolese economy is non-uniform.

Firms in the informal sector primarily benefit from this innovation as they achieve significant performance gains through online business operations (Nagayets, 2005). By facilitating the diversification of products and services, Internet business operations enable companies to reach many potential customers, particularly those in remote areas (UNCTAD, 2021). This allows for improvements in productivity (Khan, 2016). E-commerce is emerging as a vital innovation that propels Togolese businesses, especially those in the informal sector, to enhance their economic performance. This development aligns with the broader trend in developing countries, where e-commerce has become a driver of economic growth and poverty reduction (UNCTAD, 2021; World-Bank, 2016).

The potential of e-commerce to bridge the digital divide and promote inclusive growth in Togo is further supported by studies such as Aker and Mbiti (2010), who emphasize the importance of mobile and digital technologies in enhancing the productivity of African firms. The adoption of online business operations in Togo led to significant changes in firm productivity, particularly in the informal sector. This innovation can boost economic performance and contribute to inclusive growth, especially as the digital divide narrows and more firms adopt e-commerce strategies.

The second panel shows that online business operations and adoption negatively affect employment. Indeed, these findings do not seem to align with the results on the impact on business productivity. The apparent contradiction between these two phenomena can be attributed to the fact that the adoption of information and communication technologies (ICTs), such as Internet operations, can have opposing effects on business productivity and employment. Internet use can enhance business productivity and efficiency, leading to increased productivity. Companies can expand their reach, lower transaction and communication costs, access new markets, and streamline their operational processes through internet use. This viewpoint is supported by research by Jorgenson and Stiroh (1999) and Brynjolfsson and Hitt (2000), who investigate the impact of ICTs on business performance and productivity. However, the adoption of technologies, such as the Internet, can lead to a decline in permanent jobs. This can be attributed to several factors: (i) The adoption of the Internet and digital technologies can result in the increasing automation of work processes, meaning that certain tasks performed by permanent employees can now be executed

by machines or software. Consequently, the demand for labor for these tasks diminishes, which can lead to workforce reductions. Autor et al. (2003) and Brynjolfsson and McAfee (2014) examine this concept and discuss the implications of automation on employment. (ii) Internet use facilitates access to outsourced services and freelance workers, enabling businesses to reduce costs by relying on temporary workers or short-term contracts instead of permanent employees. Grossman and Rossi-Hansberg (2008) and Arntz et al. (2016) studied the impact of outsourcing and offshoring on employment, emphasizing the potential shifts in labor demand. (iii) As previously mentioned, internet use can boost business productivity. This means that companies can achieve the same output or provide the same services with fewer labor resources, potentially leading to workforce reductions (Brynjolfsson & Hitt, 2000; Jorgenson & Stiroh, 1999).

4.6. Implications for public policy

The results of this study have several implications for economic policy, drawing from the experience of certain countries. South Korea, one of the world's most advanced digital infrastructures, has experienced high e-commerce adoption and significant economic growth. The South Korean government's substantial support for the development of broadband infrastructure and communication technology (ICT) has been a critical factor in this success. By investing in digital infrastructure, the South Korean government has fostered an environment favorable to e-commerce, resulting in enhanced business competitiveness and economic growth (Choi et al., 2010; Kim, 2019). Taiwan's experience with e-commerce support programs for small and medium-sized enterprises (SMEs) underscores the importance of providing both technical and financial aid to SMEs in adopting e-commerce. This programme bolstered the growth and global competitiveness of Taiwanese SMEs. By offering support and resources, the Taiwanese government has facilitated the integration of e-commerce into business operations, allowing SMEs to thrive in a digital economy (Ramanathan et al., 2012; Yin & Choi, 2022). In India, the rapid expansion of the e-commerce sector has been fueled by the increasing availability of affordable internet services and the proliferation of smartphones. As more people gain access to the internet, the potential for e-commerce adoption increases. Government initiatives such as "Digital India" have played a significant role in promoting digital literacy and access to online services. By concentrating on the development of digital infrastructure and promoting digital literacy, the Indian government has nurtured an environment that encourages e-commerce growth (Gupta & Sheokand, 2017).

Inspiration can be drawn from these countries' experiences and policies, which concentrate on enhancing digital infrastructure, assisting SMEs in adopting e-commerce, and promoting digital literacy. By doing so, public authorities can create an environment conducive to e-commerce growth, thereby contributing to overall economic advancement. These considerations, when included in development strategies, could also help address the gender gap in investment participation, while bearing in mind the moderating role of information and communication technologies (Yin & Choi, 2023).

Given the negative impact of online business and Internet adoption on labor, we propose several economic policies. In practice, improving employment is necessary to safeguard income and economic momentum in the post-health crisis period (Sodokin et al., 2022; Sodokin, 2023). For instance, the World-Bank (2016) underlines the importance of investing in education and skill development to prepare workers for a labor market undergoing transformation owing to technological advancements. The "New Skills Agenda for Europe" initiative (European Commission, 2016) aims to equip workers with skills pertinent to the evolving technological landscape, with a focus on digital skills and lifelong learning. The Small Business Innovation Research (SBIR) program in the United States provides funding to small businesses engaged in R&D and supports job creation in sectors that are less affected by automation (Audretsch et al., 2015). In response to the challenges posed by automation and outsourcing, Sweden implemented the "Swedish Model" of labor market policies, comprising active labor market policies (ALMPs), generous unemployment benefits, and job transition assistance (Calmfors, 2005). These policies have been instrumental in reducing unemployment rates and improving job transition among displaced workers.

As part of Industry 4.0, Germany has invested in targeted strategies for specific sectors, such as manufacturing and automotive, to aid their transition to a more digital and automated economy (Kagermann et al., 2013). This approach helped maintain competitiveness and employment levels in these sectors. Following the 2008 economic crisis and subsequent surge in unemployment, the United States implemented the American Recovery and Reinvestment Act (ARRA) in 2009, which included measures to fortify social safety nets, such as extending unemployment benefits and expanding healthcare coverage (Zandi, 2009). Singapore's Skills Future Initiative exemplifies a collaborative approach to addressing the challenges of ICT adoption and automation. Launched in 2015, the "Skills Future" unites businesses, educational institutions, and other stakeholders to develop and implement strategies to equip the workforce with skills necessary for the future economy (Tan, 2016).

5. Concluding remarks

This study examines the impact of online business activities on the productivity variations of formal and informal companies as well as on the labor market in Togo. The results show that online business activities significantly increase company productivity, particularly in the informal sector. However, adoption of online business activities has a negative effect on employment. Investigations have revealed that adoption of online business activities has a positive effect on company productivity, especially in the informal sector. This result empirically confirms the theoretical framework based on Rogers' innovation diffusion model (Rogers, 1962), which assumes that technological innovations, such as online commerce, can generate substantial productivity gains for early adopters. Practically, these results highlight the importance of policymakers promoting the integration of online commerce to improve business competitiveness, especially in the informal sector. Regarding customers, our results call on public authorities to expand digital literacy programs among the population and guarantee access to telecommunication networks at an affordable cost. Nevertheless, this study also shows that online commerce reduces labor demand, which is in line with theories on the impact of technological innovation on employment (Frey & Osborne, 2017). This conclusion has major practical implications, and calls for public policies to accompany digital transitions, train workers, and protect employment.

Although this study is innovative, it had several limitations. This study focuses exclusively on analyzing the effects of online commerce on business productivity and employment. However, the adoption of online business activities is likely to have repercussions on other business performance indicators relevant to this examination. First, the impact on profitability was not measured. Improving productivity does not necessarily translate into increased profits, depending on the company's business and pricing strategy. Second, this study does not examine the evolution of market share following e-commerce adoption. However, expansion of the customer base allowed by online sales can change companies' competitive positions. Third, given the influence of online reviews and e-services on customer experience, indicators related to customer satisfaction and loyalty should be analyzed. Fourth, no measure of the environmental effects of online commerce has been conducted, even though it is an important sustainability issue.

Four research paths have been formulated from this perspective. First, it would be interesting to evaluate the long-term effects by following the evolution over time of the impact of online business activities on company growth, employment, productivity, and market competitiveness. Second, comparative studies between countries would allow for a better understanding of economic and institutional contexts. Third, more in-depth research on the heterogeneity of the effects according to sector of activity, company size, and type of employment would provide additional insights. Fourth, qualitative studies of business leaders are useful for understanding the motivations, obstacles, and opportunities related to the adoption of online business activities.

Author details

Koffi Sodokin
 E-mail: ksodokin@univ-lome.tg
 ORCID ID: <http://orcid.org/0000-0002-1763-4363>
 Joseph Kokouvi Djafon
 Mawuli Kodjovi Couchoro
 Yao Mensah Kounetsron
 Akoété Ega Agbodji
 Research Center for Applied Economics and Management
 of Organisations (CREAMO), University of Lome, Lome,
 Togo.

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