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Effect of electronic commerce on output and total factor productivity in Kenya

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Abstract. Kenya seeks to transform into a middle-income country by 2030 with target annual growth rates of 10 percent. However, this has not been realized since growth rates are under 10 percent while 36 percent of the population lives below the poverty line. Various studies interpret this as an underperformance. However, this study held the view that the economic growth witnessed in the years 2007 to 2018pointed to a resilient economy characterized by average steady growth rates of 5.4 percent despite the deterioration of the global economic outlook. This resilience coincided with the adoption of e-commerce, increased output in absolute values and emphasis of Information and Communication Technology as a key industry under the economic pillar of the Kenya Vision 2030. The period also saw the emergence of mobile payment gateways, which is a key enabler for E-commerce among others. E-commerce activities increase efficiency and ease of doing business by reducing costs and barriers of operation, which are important for achieving economic growth in transition countries such as Kenya. The main objective of the study was to investigate the effect of e-commerce on output and total factor productivity. The study developed a framework following the neoclassical and endogenous growth theories. The study used quarterly time-series data from the period 2007 to 2018 and applied Ordinary Least Squares regression models. The results showed that e-commerce had a positive effect on output. The effect of e-commerce on Total Factor Productivity was positive when considering the value of mobile payments while that of card payments was negative. The results suggest that continued investments towards e-commerce in terms of capital and mobile payments technology will be important for Kenya to sustain output growth and productivity increase.
Keywords. E-commerce, ICT, Output, Mobile payments, Total factor productivity.
JEL. 011, 033, 041, 047, P24.

1. Introduction

The digital age has brought about galloping developments in information technology and computer technology. This has contributed to developments in business, government, and population. Business development aspects include the need to engage consumers on social platforms such as Facebook and Twitter, business process outsourcing which entails contracting a third-party service

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provider to handle a specific business process and product sales through online markets (Deloitte, 2015). The Kenyan government has leveraged key technologies in the Information Communication Technology (ICT) to improve tax remittance, access, and payment for government services ultimately improving the ease of doing business in Kenya. Key metrics that measure the ease of doing business are the time it takes to settle taxes, duration and cost of resolving commercial disputes and duration and cost of registering a business (World Bank, 2016). Population aspects include ICTs impact on education through e-learning defined as formal teaching augmented by the use of technology such as computers and the internet, through empowerment which advocates for equal access to opportunities and availability of information enabled by the internet, and social interactions. These aspects, therefore, make information technology paramount for a country seeking to boost its growth potential and Gross Domestic Product (GDP).

Electronic commerce (e-commerce) is the exchange of goods and services for a consideration of a fee over a computer network or a mobile network that has revolutionized the way businesses run, it has positively augmented efficiency by streamlining, business to consumer, and consumer to business processes such as product and service delivery and payment processes. E-commerce platforms enable efficient and purposeful scrutiny for both demand and supply side participants since it provides sellers a wide range of unique platform specific tools that include pricing, terms of trade, payment gateway options, listing and visibility, and information symmetry. Within the platforms, decision-makers interact in subtle ways, which in turn determines diverse outcomes and aspects in the markets. For instance, when a client creates a listing, the client expects a bid for the listed service or good. The client may decide to make one of two choices; first, one may contact the bidders personally for vetting and contract a bidder for the service and secondly, one may decide to drop the contract altogether. This represents an interaction of demand and supply-side dynamics and for markets and for participants it represents personalized service delivery and an efficient system. Forms of E-commerce include Business to Consumer (B2C) where businesses provide services to consumers; Business-to-Business (B2B) where businesses provide services or products to each other; Consumer-to-Consumer (C2C) where consumers provide services between each other and Consumer to Business (C2B) where consumers specify a set or preconditions for a service provider to meet(United Nations Conference on Trade and Development (UNCTAD, 2017).

Kenya ranked 82nd out of 144 according to the Business to Consumer (B2C) index for the year 2017. The index measures a country's readiness for e-commerce, which includes postal reliability score, internet use penetration, secure servers per one million inhabitants and account penetration (UNCTAD, 2017). The case for Kenya is represented by a low ratio of e-commerce users to internet users at 16 percent compared to the

developed world at 80 percent. Further, the ratio of e-commerce users to population is at 5 percent (UNCTAD, 2017).

E-commerce adoption depends on the underlying technological, social economic and political factors in a country (Tasabehji & Moorhouse, 2008). First, technological aspect refers to the uptake and spread of telecommunication infrastructures such as mobile network coverage and internet connectivity. In 2009 Kenya launched an undersea fiber-optic cable at Mombasa that brought up internet speeds twenty times fold and led to an increase in internet subscriptions as indicated by the trends in Figure 1 showing total internet subscriptions from 2008 to 2017.

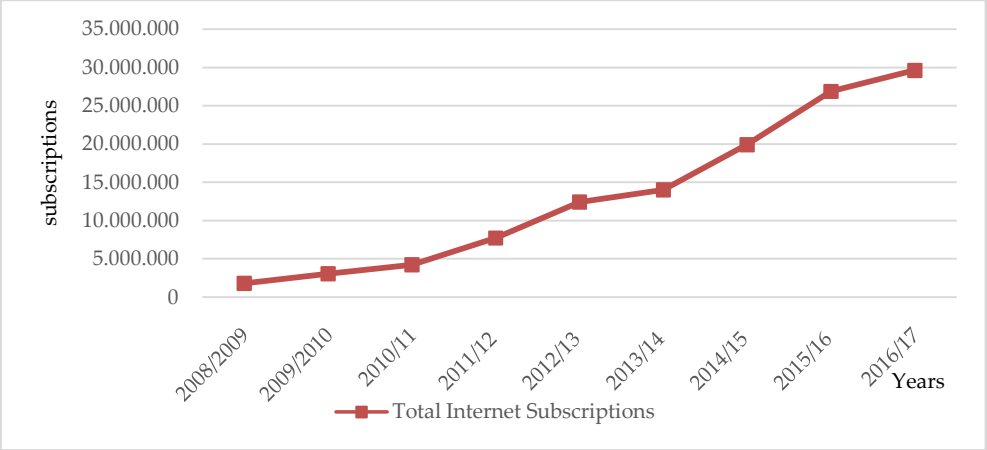

Figure 1. *Total internet subscriptions from (2008–2017)*
Source of Data: Communications Authority of Kenya (2018).

From Figure 1, the number of internet users increased from 11 million in 2011 to 35 million in 2015. Between the years 2014 and 2015, the number of internet subscriptions increased from 16.4 to 23.9 million respectively which was as a result of the increase in the number of licensed internet services providers (ISPs). Further, the ISPs competed based on price and products resulting in a decline in subscription costs and a diverse products array for consumers and businesses. The social and economic aspects that affect the adoption of e-commerce refer to culture and demographic variables such as gender, age, income, and careers. In Kenya the adoption of e-commerce by as the youth is higher compared to other age groups. Political aspects entail regulations imposed by the government and incentives towards the sector such as tax breaks. In order to facilitate competition, reduce cost, increase efficiency and drive financial inclusion, a regulation was passed in 2017 that required interoperability across mobile platforms.

The government of Kenya has set groundwork towards the uptake and spread of internet connectivity and innovations on both political and economic aspects by recognizing ICT as a key foundation to the realization of the vision 2030 (Republic of Kenya (RoK), 2007). This resulted in the mushrooming of e-commerce startups and innovations in Kenya such as Jumia and the e-citizen platform launched in 2013 by the government to tap

into the increasing connectedness. These innovations anchor on the success of mobile money platforms, which facilitate the transfer of money over a mobile network, key players in the industry, include M-Pesa, Airtel money, T-Kash, Equitel, Mobikash, and Tanagaza. The government, through the Central Bank of Kenya also played an indirect role in enhancing e-commerce penetration, by allowing for agency banking which has resulted to an increase in uptake of formal bank accounts and credit cards. An increase in formal bank accounts increases e-commerce services and transactions. This is because credit cards are used to facilitate transactions across consumer-to-consumer or business-to-consumer e-commerce services. These deliberate actions by the government, coupled with social and technological aspects have led exponential growth of the sector with rates as at 2015 at 34 percent (International Trade Centre, 2015). Figure 2 shows the growth in mobile payment transactions, card transactions and GDP absolute values in quarters from 2007 to 2018 respectively.

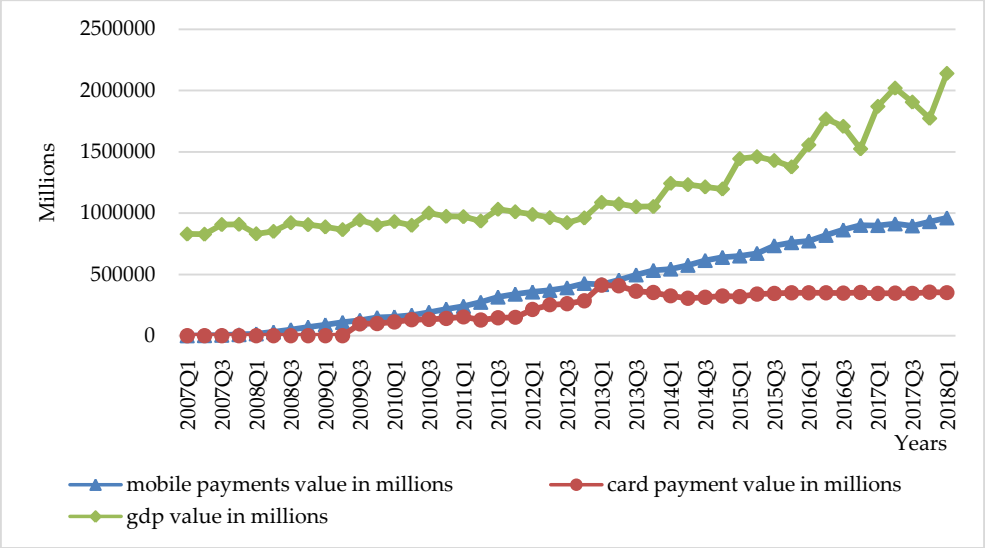

Figure 2. *Mobile payments values, card payment values and GDP absolute value per quarter (2007–2018).*
Source of Data: Central Bank of Kenya (2018).

The trends in Figure 2, shows a gradual rise in mobile payments, card payments, and GDP value between the periods 2007Q1 and 2013Q1. After 2013Q1, the value of card payment transactions fell marginally and plateaued as highlighted by the nearly straight line between 2013Q3 and 2017Q3. In the same period, the value of mobile payment transactions continued to increase with the highest value recorded in 2018Q1. The value of GDP continued to rise while oscillating between periods of contraction and expansions from the period 2013Q1 to 2018Q1 with the highest levels observed in 2018Q1. The trends generally show that since 2013, Kenya witnessed an increase in GDP in absolute values along with increased uptake of e-commerce services, driven by the adoption of mobile and card payment gateways.

The success of mobile payment gateways is due to their ease of access, availability, and use which increases the level of trust in mobile payment gateways in Kenya. Intuitively, an efficient and trusted mobile payment service enables faster transactions on e-commerce platforms. Other payment services that serve e-commerce platforms in Kenya are debit and credit card services, e-wallets such as PayPal and stripe enabled by access to formal banking services. In a survey of internet users in Kenya, UNCTAD (2017) reported that credit card adoption, was at 5-percent far below the rates of adoption of mobile payments, further the survey reported that 79 percent of respondents preferred mobile payments while buying goods and services via a network.

The second key enabler for e-commerce is an efficient delivery system, that is postal and courier services within the country. Figure 3 shows the number of postal and courier outlets in the period 2012 to 2016.

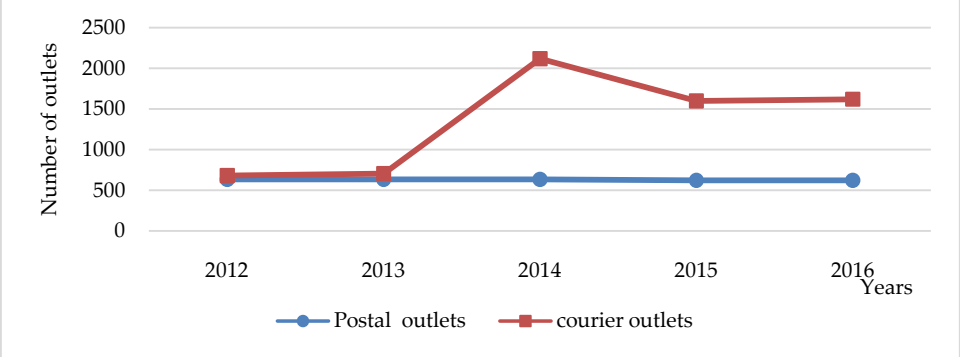

Figure 3. *The number of postal and courier outlets (2012-2016)*
Source of Data: Communications Authority of Kenya (2017).

Figure 3 shows that postal outlets remained unchanged in the period 2012 to 2016. A probable reason for the stagnation of the number of postal outlets was due to an increase in the adoption of courier outlets due to their accessibility and lower costs. In the same period, courier outlets grew rapidly although there was a sharp decline between 2014 and 2015 owing to demand and supply constraints and other market dynamics such as competition and costs (Communications Commission of Kenya (CCK), 2017).

The third key enabler to e-commerce is the availability of merchants and supply-side mechanisms such as an online presence of sellers where buyers can buy goods and services. These seller platforms need to be secure and efficient to safeguard personal information collected from buyers and all payment transactions recorded in the systems (UNCTAD, 2017). Kenya has seen the mushrooming of a number of e-commerce service providers serving diversified sectors such as transport, fast-moving consumer goods, clothing, electronics, utilities, payments, and service delivery by state, it also augments factors of production such as labor.

In order to develop to a middle-income country by the year 2030, Kenya's development agenda set annual growth rates of 10 percent (RoK,

2007). Intuitively, achieving a middle-income state of the economy would translate to lower poverty levels due to an increase in per capita income, reduced un-employment levels and improved living standards. Figure 4 shows the trend of Real GDP Growth in Kenya from the period 2007 to 2017.

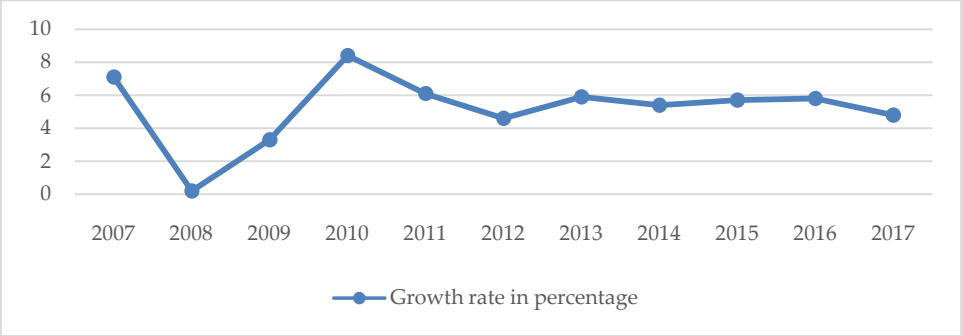

Figure 4. *Trend of Real GDP Growth (1963-2017)*
Source of Data: The Central Bank of Kenya (2018).

Three aspects namely, the role of political environment, the macro-environment and the impact of markets, can arguably explain economic growth in Kenya, (Mwangi, Francis, & Njuguna, 2016). The primary channel through which e-commerce affects output growth is arguably through its impact on markets in Kenya. E-commerce augments markets by breaking down traditional barriers for market participation and access such as ease of entry, geographical barriers, communication, and information asymmetry on both the supply and demand side. In addition to the above benefits, first, e-commerce arguably is a source of revenue for the state where the government charges a tax on goods bought online. Second, merchants receive payments with a markup and service fees. Third, payment service providers such as mobile money companies receive a service fee for every online transaction in Kenya, in comparison to traditional markets where cash on hand is required for transactions and only the state and merchants benefit. Therefore, in order to estimate the impact on markets e-commerce enters the production process as an input. This input in the production process is in the form of investments and R&D, specifically as capital. Capital, in the production process increases the productive capacity of firms. This, therefore, leads to an increase in production and economic growth (Stiroh, 2002).

The second channel though which E-commerce affects output growth is through online labor marketplaces such as TaskRabbit, People per hour and Fivesok which augment the nature of labor. On these marketplaces workers find remote work from developing countries such as Kenya, by listing their services and skill sets. This increases their income levels, therefore, improving their living standards. Kenyan entrepreneurs have taken up this challenge and developed local e-commerce platforms thus creating job opportunities, for instance, a product bought over such platforms and delivered by labor sourced from e-commerce platforms that

provide delivery services such as Sendyit in Kenya. These platforms ultimately lead to an increase in consumption and output growth. Liu (2013) argued that more people have been keen on e-commerce since it provides a wide array of differentiated products which ultimately leads to increased consumption. Further, evidence from China and United States shows that e-commerce has the potential to increase aggregate private investments and consumption. Manyika *et al.,* (2013) showed that for every 100 dollars spent in China, 40-percent represents an increase in consumption.

Many of the advantages of e-commerce benefit small and medium enterprises (SMEs), which form the backbone of a country. SMEs, in both the developed and developing world, employ a majority of the workforce in the manufacturing and service sectors, thereby, contributing significantly to the GDP of a country (World Trade Organization, 2013). The primary reason of increasing usage and adoption of e-commerce among SMEs is due to the need to diversify supply chain strategies. The advent of personal computing to include mobile devices, payments services means that transactions are fast, cost effective and efficient. Therefore, e-commerce has helped remove inefficiencies in supply chains. SMEs leverage ICT in order to stay competitive against large corporations by taking advantage of the numerous opportunities (Noor & Alam, 2009). More importantly SMEs take advantage of e-commerce to spur growth, to lower costs and to increase participation in the economy (Deloitte, 2015). Further, for consumers' e-commerce is often considered as a strategy for reducing costs associated with access to goods and services (Harridge-March, 2004).

E-commerce might have a positive effect on productivity growth by improving the operational efficiency in different sectors and industries of an economy. Total factor productivity growth is a term used to describe an increase in output performance of a production system not attributed to the contributions of factor inputs; it is a residual component of GDP (Solow, 1957). This unexplained change is because of technological progress. According to Kuznets (1966), this can also be termed as "usable knowledge" or changes in a production process efficiency or innovation. Technological progress can result from Research and Development (R&D), learning by doing or by improved management practices. E-commerce which is an innovation in the ICT sector can be described as a general purpose technology (Brenahan & Trajtenberg 1995). This means that firms in an economy can learn from the innovation of other firms which leads to spillover effects and ultimately an increase in TFP (Mirko, Raffaella, & John, 2007). Chen & Ting (2013) showed a significant and positive effect of e-commerce adoption on for large firms in Taiwan. Further, spillover effects due to Research and Development (R&D) in e-commerce lead to a higher level of productivity.

Stiroh (2005) suggests that e-commerce improves productivity, efficiency and leads to higher economic growth rates. This happens due to the fact that e-commerce activities lead the channeling of investments towards ICT

sector. Deloitte (2015) reported that there are numerous ways in which online payments drive economic growth. These include increased productivity, demand for ICT infrastructure and the creation of electronic data. Morrison & Siegel (2001) argued that through positive externalities such as increasing investments in human development R&D e-commerce had a positive effect on overall economic performance and productivity. E-commerce also enhances the development of interrelationships between industries and other sectors that contribute to raise productivity.

2. Literature review

Sarvenaz *et al.,* (2013) studied the impact of E-commerce (EC) on the labor productivity of Iranian manufacturing SMEs following a theoretical model of a Cobb-Douglas production functional form. The study highlighted four sources of labor productivity growth as followed, ICT capital deepening, shared of weighted capital deepening related to other sources of capital, improvements in quality of labor and general advances in TFP. To derive TFP, the study first estimated coefficients of explanatory variables for the econometric model used by the study which were, capital, materials, human capital, a numeric measure of EC (number of employees using the internet over total number of employees and number of employees using computers over total number of employees), all the parameters were a ratio of labor (per labor). Further, the residual term of the growth accounting exercise was used as TFP. The study used secondary panel data sourced from the Statistical Centre of Iran (SCI) and adopted the Random Effects Model (REM) to estimate the effects of EC on TFP. Growth in output per worker was expressed using intensive growth model. The Model estimated e-commerce both as a numerical variable and a dummy variable based on six parameters which were the number of employees using computers, the number of employees using the internet, usage of the internet to gather and offer information, e-buying and e-selling. The study concluded that productivity of labor increased significantly due to the usage of e-commerce. The results showed that e-selling, online communication and marketing, and the number of employees using the internet had a positive effect on labor productivity. Three other measures of e-commerce; number of employees using computers, e buying and using the internet to gather information did not have any significant impact. More importantly, the approaches used in the study to estimate e-commerce led to measurement and estimation errors such as multicollinearity since e-buying for one firm constituted e-selling in another firm.

Sixun (2013) established the impact mechanism of e-commerce development to the national economic growth in China using time series data from 1997-2011. The study used representative variables to indicate consumption, investments, government purchases, and net exports and GDP as a measure of the value of output. According to the study e-commerce enhanced consumption through increasing the number of

internet users and the number of online shopping users. Investment was represented as an increase in advertising, an increase of government purchases was represented by an increase in domain names (CN) and websites, net exports were represented by international outlet bandwidth. In the econometric model, GDP was the dependent variable while domain names, international outlet bandwidth, the number of internet users, online shoppers, online advertising and the number of websites were the independent variables. The findings indicated a long-term equilibrium relationship between all the variables. An increase in domain names, international bandwidth, internet users, online shoppers, the scale of online advertising, as well as the number of websites increased GDP. The conclusion was that e-commerce had a positive effect on GDP. The major drawback in the study was that it took e-commerce as a disaggregated variable of a variety of independent variables, which do not directly measure e-commerce as opposed to this study which estimates e-commerce as an aggregate value of online transactions that represent actual value added to the economy from e-commerce transactions (Simon, 1941).

Huirong (2014) established the dynamic effect relationships between e-commerce, logistics and economic growth in China based on the VAR model using time series data from 2000-2012. Further, the study used the volume of e-commerce transactions as a measure of e-commerce. The study used granger test for causality between the variables and variance decomposition. The study established that e-commerce, in the long run, caused GDP growth and that enhancements in logistics capability in the economy did not cause e-commerce development and GDP growth. The dynamic effects were that e-commerce development led to an increase in GDP and logistics. The study used the volume of e-commerce transactions, however, the value of transactions is a more appropriate measure as it considers the value added to the economy in contrast to volume (Simon, 1941).

Elseyoud (2014) studied e-commerce and economic growth in Saudi Arabia using time series data for the period 2001-2013. The econometric model adopted the export-led growth hypothesis to explain the relationship between output and inputs of Labor and Capital. The study added the size of public sector by adding government consumption spending and private consumption spending. The model estimated followed Barro (1998) growth framework in which real economic growth was modeled to depend on capital labor ratio, terms of trade, scale of government and private sectors respectively, number of business transactions over the internet, expenditure on using ICT, number of; internet users, fixed telephone lines and mobiles, personal computers and credit cards. The findings of the study were that e-commerce increases economic growth, where the main e-commerce indicators such as the number of transactions via the internet, ICT expenditure, and the number of credit cards had a significant and positive impact on economic growth. The weakness of the study falls on use of volume and not the value of

business transactions over the internet as this contradicts the meaning and measure of e-commerce activity (Kuznets, 1941).

Chen & Liu (2015) conducted an empirical study on the impact of e-commerce adoption on total factor productivity based on micro-data at firm level on Taiwanese manufacturing firms. The study categorized the firms reviewed as SMEs, Large firms, high-tech firms and traditional firms. The study derived total factor productivity from a Cobb-Douglas production functional form where the dependent variable was TFP and independent variables included were e-commerce adoption, automation expenditure, inter and intra-industry R&D spillovers and R&D capital stock. E- commerce was measured as a binary variable by using the treatment effects model formally specified as equation 1.

$$ECADT_i^* = \gamma_0 + \gamma_1 logSCALE_i + \gamma_2 logNESTRA_i + \gamma_3 logNESTER_i + \gamma_4 logTFP_{t-1} + \gamma_5 INDDUM_i + \gamma_6 TIME_i + u_i \quad (1)$$

The binary decision becomes $ECADT = \begin{cases} 1, & if\ ECADT_i^* > 0 \\ 0, & otherwise \end{cases}$

Number of employers, (NESTRA), represented firm size (SCALE) and (*NESTER*) represented the intra-industry and inter-industry network externalities while the specific manufacturing industries were *INDDUM1,* Metal and engineering industry, *INDDUM2* was the ICT industry, and *INDDUM3* was the chemical industry. *TIME* was a dummy variable representing time from 2000 to 2002. The findings of the study were that the adoption of e-commerce had a positive impact on productivity. The study cited a limitation of lack of data on e-commerce sales and transactions which would have formed a more accurate measure of e-commerce activity. This study addressed this challenge by using quarterly data on e-commerce transactions through mobile payment services and card payment services.

3. Methodology

3.1. Theoretical framework and empirical models

3.1.1. The framework for analyzing contribution of e-commerce to output

This study used the neoclassical model developed by Solow (1957) and Swan (1956) that focuses on four variables: output(Y), capital(K), Labor(L) and knowledge or the effectiveness of labor (A). The model implies that at time(t), the economy's endowment of factor inputs combines to produce output. The production function takes the form as shown in equation 2.

$$Y_t = A_t K_t^{\alpha} L_t^{\beta} \quad (2)$$

Where t denotes time and $0 \leq \alpha + \beta \leq 1$. Lu (2011), Stiroh (2002) and Mirko (2006) supported the extension of the model to include e-commerce

as a capital component. The reformulated production function in this study was as in equation 3.

$$Y_t = A_t K_t^{\alpha} KI_t^{\beta} L_t^{1-\alpha-\beta} \quad (3)$$

Where, $0 \leq \alpha \leq 1, 0 \leq \beta \leq 1$; A is TFP that measures the efficiency of input transformation, K is installed physical capital, KI is installed capital to e-commerce, L is the amount and quality of the labor force. t Represents time. α Measures the elasticity of output with respect to physical capital and β measures the elasticity of output with respect to e-commerce capital when the supply of labor and physical capital is at a constant. Mathematically transforming Equation 3 yields;

$$\frac{\partial logY_t}{\partial t} = \frac{\partial logA_t}{\partial t} + \alpha \frac{\partial logK_t}{\partial t} + \beta \frac{\partial logKI_t}{\partial t} + (1-\alpha-\beta) \frac{\partial logL_t}{\partial t} \quad (4)$$

Equation 4is further specified further as 5 to show the components of output growth

$$\frac{\dot{Y}_t}{Y_t} = \frac{\dot{A}_t}{A_t} + \alpha \frac{K_t}{K_t} + \beta \frac{\dot{K}I_t}{K_t} + (1-\alpha-\beta) \frac{L_t}{L_t} \quad (5)$$

From equation 5, output Growthg_Y is given by $g_A + \alpha g_K + \beta g_{KI} + (1-\alpha-\beta) g_L$

The first term g_A represents TFP growth, a term that captures the effects of technological change in the growth process. The second and third terms, that is $g_K + g_{KI}$ represents capital deepening attributed to physical and e-commerce capital, this is an essential term as it increases the potential for the economy to produce. The last term g_L captures the labor effect as the quality, and productivity of labor increases. Further linearizing equation 3 to obtain TFP and the contribution of factors to output as the reformulated equation 6 below:

$$\ln Y_t = \vartheta + \alpha \ln K_t + \beta \ln KI_t + \delta \ln L_t + \varepsilon_t \quad (6)$$

From the equation 6, estimates of the contributions of capital (KI, K), labor (L) and TFP (A) to output can be obtained by substituting into equation 6 the estimated values of elasticity of output with respect to each factor input and further multiplying by the corresponding log value. Equation 6 can therefore be specified as 7 below:

$$y = \vartheta + Ck_t + Cki_t + Cl_t - \varepsilon_t \quad (7)$$

Where t denotes time, y represents the log of output, Ck denotes the contribution of physical capital, Cki denotes the contribution of e-commerce capital and Cl denotes the contribution of labor.

This study adopts the models as specified in equation 7 to model output as a function of physical capital, e-commerce capital and labor. The general form of the model is as given in equation 8 below:

$$Y = f(K, KI, L) \tag{8}$$

3.1.2. The framework for analyzing the effect of e-commerce on TFP

The study adopted the endogenous growth theories as modelled by Romer (1990) and Aghion & Howitt (1998).

$$\dot{A}_t = B[\alpha_K K_t]^{\beta}[\alpha_L L_t]^{\gamma} A_t^{\theta};\ B \geq 0, \gamma \geq 0, \beta \geq 0 \tag{9}$$

Equation 9 is a generalized Cobb-Douglas function modelling the R&D sector. θ Reflects the relationship between the R&D process and stock of knowledge at time t, there are no restrictions placed on θ. The R&D production function, therefore, can exhibit constant, decreasing or increasing returns to scale. Equation 9, therefore, implies that when the stock of capital, labor and knowledge doubles, there could occur a duplication of discoveries or increased discoveries. Equation 10 shows the dynamics of knowledge.

$$\frac{\dot{A}_t}{A_t} = B[\alpha_K K_t]^{\beta}[\alpha_L L_t]^{\gamma} A_t^{\theta-1} \tag{10}$$

Since $\frac{\dot{A}_t}{A_t} = g_A$ and specifying equation 10 to obtain equation 11 below:

$$g_A = B[\alpha_K K_t]^{\beta}[\alpha_L L_t]^{\gamma} A_t^{\theta-1} \tag{11}$$

Equation 11 shows the evolution of knowledge or Total factor productivity growth.

The study reformulated equation 11as suggested by Romer (1990) and Hakim, *et al.,* (2009) to include e-commerce variables and other externalities associated with e-commerce.

In order to derive TFP growth or technical change equation 11was reformulated to the equation 12 below.

$$A = M_t^{\alpha_1} C_t^{\alpha_2} O_t^{\alpha_3} D_t^{\alpha_4} F_{t-4}^{\alpha_5} \tag{12}$$

Where M_t is the value of the share of mobile transaction in GDP while C_t represents the value of the share of card transaction in GDP. O Represents the degree of openness of a country. D Represents diversification. F_{t-4} Represents the lagged financial deepening, this is because the expectation about financial deepening is that benefits start accruing in the future. The study assumed that after 4 quarters (1 financial year) benefits would begin accruing. Labor and capital were dropped from the TFP model since their effect is captured in the growth accounting exercise in equation 7. Further,

including output and factor inputs in the model would lead to independent variable being perfectly related to the dependent variable, more importantly including both output and factor inputs would lead to multicollinearity problem which would undermine the significance of the independent variables. Equation 12 therefore shows the extended Cobb-Douglas equation. Linearizing the equation 12, 13 is obtained s below:

$$\ln A = \alpha_0 + \alpha_1 \ln M_t + \alpha_2 \ln C_t + \alpha_3 \ln O_t + \alpha_4 \ln D_t + \alpha_5 \ln F_{t-4} + \varepsilon_t \quad (13)$$

Where;$\alpha_0$is a constant, α_1 represents the elasticity of TFP with respect to the share of mobile transactions in GDP, α_2 represents the elasticity of TFP with respect to the share of card transactions in GDP, α_3 represents the elasticity of TFP with respect the degree of openness, α_4 represents the elasticity of TFP with respect to diversification index and α_5 represents the elasticity of TFP with respect to lagged financial inclusion. From estimation of 13, $\alpha_1$and α_2 jointly give the net effect of e-commerce in TFP.

The study will adopt the model as specified in equation 13. The general form of the of TFP model is given as the regression model below:

$$A = f(M_t, C_t, O_t, D_t, F_{t-4}) \quad (14)$$

3.2. Definition and measurement of variables

Table 1. *Definition and measurement of variables*

Variable	Definition	Measurement
Output	The total value of final goods and services in a given period.	Reported GDP for each quarter.
Degree of Openness	The level to which a country engages in transactions with the rest of the world in a given time period.	Summation of exports and imports as a ratio of gross domestic product for each quarter.
E-Commerce Capital Stock	Stock of capital for e-commerce services in a given period.	Estimated value of capital stock for e-commerce for each quarter using Constructed using perpetual inventory method (PIM)
Physical Capital Stock	Stock of physical capital in a given period.	Estimated value of physical capital stock for each quarter using Constructed using perpetual inventory method (PIM)
Labor Force	The total number of people who are able to work in a country during a given time period.	The number of people between the ages of 15-64 years.
Mobile Transactions	E-commerce transactions conducted via mobile phones to buy a good or a service	Value of total transactions by mobile money in each quarter as a share of GDP.
Card Transactions	E-commerce transactions conducted via a credit card to buy a good or a service.	Value of total transactions by credit cards in each quarter as a share of GDP.
Total Factor Productivity	This is the portion of GDP growth not attributed to production inputs	The quantity of the Solow residual for each quarter.
Financial Inclusion	This is access to formal financial services	The quantity of credit from commercial banks as a share of GDP
Diversification Index	The extent to which output is differentiated in a given economic period	Summed value of share of exports per industry.

3.3. Data type and sources

This study used published secondary time series data for the period 2007Q1 – 2018Q4 sourced from official government document including statistical abstracts and the publications from Central Bank of Kenya. Other sources included the international financial statistics (IFS), the World Bank development indicators (WDI), the Communications Authority of Kenya, the Africa Development Indicators and the Penn World Tables. The study used quarterly data to capture the seasonality of e-commerce and for accuracy purposes. In order to estimate e-commerce capital, the study used the perpetual inventory method as described below:

The study estimated the initial level of capital KI and K from the steady state position where;

$$K_0 = {}^{I_0}/_{\partial + g} \tag{15}$$

Where I_0 shows the initial level of investment at time 2007Q1, ∂ is the depreciation rate, and was assumed to be 4 percent (Bosworth, 2003), g is the average geometric growth of real investment over the period 2007Q1 to 2018Q3. The equation 3.16 presents capital stock at time *t-1.*

$$K_t = (1 - \partial)K_{t-1} + I_t \tag{16}$$

Where the specific variables are as defined in equation 6 for time t and *t-1*.

3.4. Data analysis and time series property tests

Since time-series data often exhibits non-stationarity, the study conducted unit root tests to check for non-stationary series. Failure to do so would have led to spurious regression results. The Augmented Dickey-Fuller (ADF) test determines whether the variables used in the study had unit roots. Before conducting the stationarity test, the study plotted a line graph for each of the series to determine whether it exhibited a constant, trend or both. This was then followed by the ADF test where the observed trend characteristic was specified for each of the series to determine the order of integration. If as series was found to be integrated, it was differenced according to the order of integration to make it stationary.

Following the results of the stationarity tests, the study conducted a co-integration test on the non- stationary series. The study conducted the co-integration tests based on the Johansen Co-Integration Test. High correlation leads to very large standard errors of coefficient, which in turn may yield insignificant t-ratios despite a large R-Squared. The consequence is that a null hypothesis that should be rejected fails to be rejected (Greene, 2008). The coefficients would lead to multicollinearity and inaccurate estimates. The study constructed a correlation matrix based on independent variables where the acceptable threshold for a coefficient is

less than 0.8 for any two variables. A coefficient higher than 0.8 warranted the test for multi-collinearity.

3.5. Estimation of models to address objectives

The study sought to address two objectives. The first objective was to investigate the contribution of e-commerce and factor inputs to output. This was achieved by first running regression on the model in Equation 6. Following that to estimate the percentage contribution, the contribution for each factor input and TFP was divided by the log of output (y). The equations for each factor input and total factor productivity are as specified below.

$$\%\ contribution\ of\ physical\ capital = \frac{Ck_t}{y} \bullet 100 \quad (17)$$

$$\%\ contribution\ of\ e-commerce\ capital = \frac{Cki_t}{y} \bullet 100 \quad (18)$$

$$\%\ contribution\ of\ labor = \frac{Cl_t}{y} \bullet 100 \quad (19)$$

$$\%\ contribution\ of\ TFP = \frac{\vartheta}{y} \bullet 100 \quad (20)$$

equations 17 to 20 were used to answer the first objective. The second objective sought to investigate the effect of e-commerce on total factor productivity. Equation 5 was reformulated to derive the value of TFP for each period as specified in equation 21.

$$\ln TFP = \vartheta = \ln Y_t - \alpha \ln K_t - \beta \ln KI_t - \delta \ln L_t - Cons \quad (21)$$

Where α Measures the elasticity of output with respect to physical capital and β measures the elasticity of e-commerce capital when the supply of labor and physical capital is at a constant. $Cons$ represents a constant term. Equation 21 can further be simplified as equation 22 below:

$$tfp = \vartheta = y - Ck_t - Cki_t - Cl_t - Cons \quad (22)$$

Where t denotes time, y represents the log of output, $Ck, Cki\ and\ Cl$ denotes the contribution of physical capital, e-commerce capital and labor respectively as obtained in equation 6. Equation 22 shows that TFP is obtained by subtracting the contributions of factor inputs from log of output. More importantly, equation 22 gives the estimated value TFP by observing that TFP is equal to output change not accounted for by changes in inputs. The study used TFP derived from equation 22and OLS estimation method following the models in equation 13 to address the second objective.

4. Results

4.1. Descriptive statistics

Descriptive statistics on the study variables are as in Table 2.

Table 2. *Descriptive statistics of the study variables*

Study variable	Minimum	Maximum	Mean	Std. Dev.	Observations
Output	559481	1197623	885197	180692	47
E-commerce capital stock	26774.99	102917.2	66384.99	16891.62	47
Labor force	9.4258	17.909	13.302	2.6481	47
Share of Mobile transactions in GDP	0.001151	0.842441	0.451506	0.28353	47
Share of Card transactions in GDP	0.018347	0.353868	0.230254	0.114241	47
Diversification	0.159638	0.279183	0.242790	0.047332	47
Financial inclusion	1.032685	2.915414	2.015633	0.622974	47
Degree of Openness	0.110679	0.165856	0.135694	0.012851	47

The gap between the maximum and minimum of output in the period 2007Q1 and 2018Q3 showed the spread was as expected since the minimum corresponded to 2007Q1 and the maximum corresponded to 2018Q3 which showed economic growth. The spread of Labor met the expectations with the minimum and maximum values recorded in 2007Q1 and 2018Q3 respectively, this showed as the economy grew the demand for labor increased due to the labor-intensive nature of the economy. E-commerce capital stock exhibited maximum and minimum values in the years 2007Q1 and 2009Q3 respectively. The mean and standard deviation for all the variables suggests that the data for each series was normally distributed and had sufficient variability to allow inclusion in regression models for evaluating contribution of each factor to output growth.

The periods 2007Q1 and 2018Q3 recorded the minimum and maximum values of the share of mobile transactions in GDP respectively, which was consistent with expectations as the adoption of mobile money, increased along with the expansion of the economy and increasing volume of mobile transactions. The share of card transactions value was lowest in 2007Q1 and highest in 2014Q3, which was in line with expectations as more Kenyans adopted mobile payment gateways as opposed to card payment gateways. 2016Q4 and 2007Q3 recorded the highest and lowest level of diversification, respectively, which was in line with expectations as Kenya recorded innovations in the financial sector such as mobile money services and micro-lending services, and e-commerce in the retail sector. The spread of financial inclusion suggested increasing access to financial services as shown by the minimum and maximum values recorded in the periods 2007Q2 and 2015Q3 respectively. The degree of openness recorded the lowest value in 2007Q4 and the highest value in 2011Q3.For all the variables that were included in the model foe analysis of effects on TPF, the means and standard deviations indicate sufficient variability for inclusion as independent variables.

4.2. Unit root test results

The study conducted stationarity test to check whether any of the series had a unit root to rule out spurious and meaningless regression results. The ADF test was used. Under the ADF test, the null hypothesis of presence of unit root is rejected at the 5 percent level, if the computed ADF statistic (t-value) in absolute terms is greater than the critical value. The results are presented in Table 3.

Table 3. *ADF unit root test results*

Variable	Estimation Level	Critical Value (5%)	T-Statistic	P-Value	Conclusion
Log of Output	Level with intercept	- 2.931	-2.967	0.0461	Stationary
Log of E-Commerce Capital Stock	Level with trend and intercept	-3.510	- 3.898	0.02	Stationary
Log of Physical Capital	Level with intercept	-2.933	-3.037	0.0395	Stationary
Log of Labor Force	Level with intercept and trend	- 3.510	- 3.511	0.0231	Stationary
Log of Share of Mobile Transactions In GDP	Level with trend and intercept	-3.510	-14.628	0.000	Stationary
Log of Share of Card Transactions In GDP	Level with intercept	-2.926	-9.0206	0.00	Stationary
Log of Diversification Index	Level with trend and intercept	-3.510	-6.033	0.000	Stationary
Log of Financial Inclusion	Level with trend and intercept	-3.510	-4.337	0.0064	Stationary
Log of Degree Of Openness	Level with trend and intercept	-3.510	-7.784	0.000	Stationary

The results in Table 3showed that all the series were stationary at 5 percent level of significance. The same is also supported by the p-values associated with each computed value which are all less than 0.05. the results indicated that that each of the time series did not have a unit root and hence were all integrated of order zero [I(0)]. The study therefore applied standard time series regression to estimate the models.

4.3. Correlation analysis results

Tables 4 shows the correlation matrices for the independent variables in the output model.

Table 4. *Correlation analysis results for output model*

Variable	Log of E-Commerce Capital	Log of Physical Capital	Labor
Log Of E-Commerce Capital	1.0000		
Log Of Physical Capital	0.9078	1.0000	
Labor	0.7776	0.9417	1.0000

The decision rule was that pair wise correlation coefficients of less than 0.8 were acceptable for variables to be included in a regression model. The output model showed large positive correlation coefficients between the independent variables. Apart from the coefficient between labor and e-commerce capital, other coefficients were greater than 0.8. However, this was in line with expectations because, one of the assumptions in a production function is about the complementarity of inputs.

Table 5. *Correlation analysis results for TFP model*

Variable	Log of Mobile Transactions /GDP	Log of Card Transactions /GDP	Log of Degree of Openness	Log of Financial Inclusion	Log of Diversification Index
Log of Mobile Transactions/GDP	1.0000				
Log of Card Transactions/GDP	0.9668	1.0000			
Log of Degree Of Openness	0.2485	0.2721	1.0000		
Log of Financial Inclusion	0.7903	0.8374	0.1145	1.0000	
Log of Diversification Index	-0.2373	-0.2283	-0.0225	-0.1910	1.0000

The pair wise correlation coefficient in the TFP model were below 0.8, however, the correlation coefficient between ratio of mobile transactions and card transactions to GDP was high. The study therefore proceeded to estimate the variance inflation factor (VIF) for the TFP model to test for multicollinearity.

4.4. Contribution of e-commerce capital to output

The study estimated the contributions of e-commerce to output by first regressing log of GDP on logs of physical, e-commerce capital, and labor as specified in equation 6. The regression exercise yielded the coefficient as reported in Table 6.

Table 6. *Regression estimate of the output equation*

Dependent Variable: Log of Output		No. of Observations: 47		
Independent Variables	Coefficient	Std. Error	t-stat	P > |t|
Log of Physical Capital	.0786***	.01686	4.66	0.000
Log of E-Commerce Capital	.0171	.01160	1.48	0.147
Log of Labor	.7306***	.04120	17.74	0.000
Const.	10.35***	.07107	145.57	0.000
R-squared:	*0.9947*	*Adjusted R-squared: 0.9943,*		
F (3, 43):	*2712.309*	*P(f-statistic): 0.0000*		

Notes: The asterisks *** indicate significance at 1% level.

From Table 6, the adjusted R-squared indicates that the independent variables jointly explain 99.43-percent of variation in the log of output showing that the model had a good fit. The p-value of the f-statistic is less than 0.05 signifying that not all estimated coefficients are statistically insignificant at 5-percent level. Diagnostic tests to ascertain statistical soundness of the model included the residual normality, homoscedasticity and no autocorrelation test as well as model specification and stability tests. The results are presented in Table 7.

Table 7. *Diagnostic test results for the output model*

Diagnostic test	Type of test	p-value	Conclusion
Residual Normality Test	Jacque-Berra	0.8003	Residual series is normally distributed
Heteroscedasticity	Breusch-Pagan/ Cook-Weisberg test	0.2809	Homoscedastic
Serial Correlation test	Breusch-Godfrey LM	0.1224	No serial Correlation
Specification test	(RESET)	0.080	No omitted values

From Table 7, the p-value of Jarque-Bera statistics was greater than 0.05 and indicated normally distributed residuals. The test for serial correlation using the Breusch-Godfrey LM test produced a p-value of the f-statistic greater than 0.05. The study, therefore, concluded that there is no serial correlation in the model. The p-value of the f-statistic from the Breusch-Pagan/ Cook-Weisberg test for Heteroscedasticity was greater than 0.05, therefore, the study failed to reject the null hypothesis of homoscedasticity. The model specification tests (RESET) failed to reject the null hypothesis of no omitted variables since the p-value of the f-statistic was greater than 0.05. The stability tests (CUSUM) revealed that the model was stable since the residuals lied within the dual standard error bands as shown in the following Figure 5.

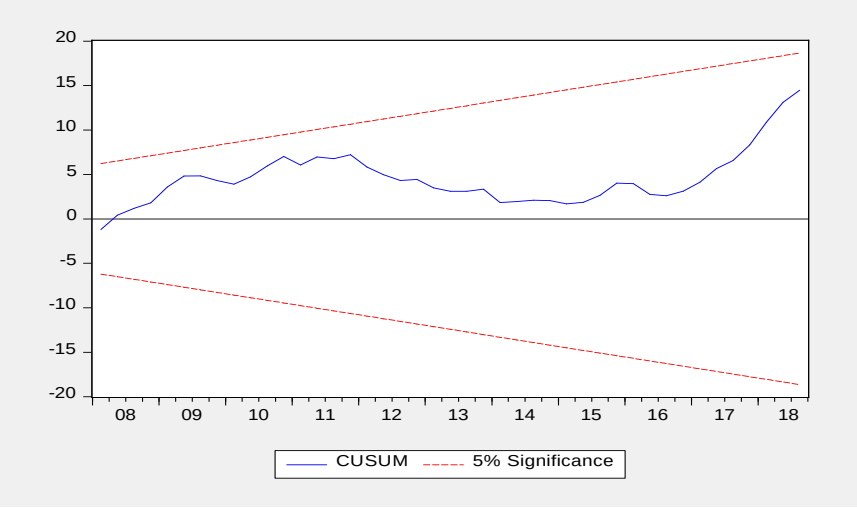

Figure 5. *Stability test results for output model*
Source of Data: Authors computation

Following the diagnostic test results on the output model, the study therefore concluded that the model was statistically sound and that appropriate conclusions could be made from the empirical results. The output model yielded the estimates of elasticity of output with respect to each input. Each estimate of elasticity was then multiplied by the log of corresponding factor input to yield the factor contributions to output as specified in equations 17 to 20.

4.4.1. The contribution of e-commerce capital

The coefficient for log of e-commerce capital was positive but not statistically significant at 5-percent level since the p-value was greater than 0.05. The positive coefficient all the same indicates that e-commerce has a potential positive contribution to output. The results suggest that in the given study period, e-commerce capital did not have any significant effect to output growth in Kenya. More importantly from Figure 6 below, the trend is positive and increasing at a decreasing rate. Further, the highest value corresponds to the third quarter of 2018 and on average the contributions to output were at 1.62-percent. The trend can be explained by the shifts in adoption of ICT including investments and innovation witnessed in the study periods among other factors. For instance, in the period 2007Q1 to 2009Q3 saw the introduction and increasing adoption of mobile payments gateway in Kenya. Between the periods 2009Q3 and 2015Q1, the contributions oscillated between periods of expansion and contraction, as the Kenyan government refocused its efforts towards providing capital to the manufacturing and agricultural sectors.

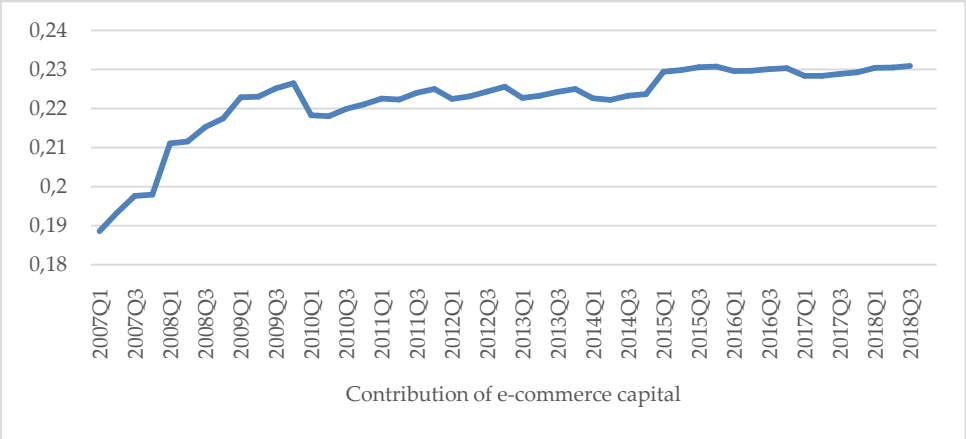

Figure 6. *Trend of the contribution of e-commerce capital to output*
Source of Data: Authors Computation

4.4.2. The contribution of other factor inputs

The coefficient for log of physical capital was significant since it had a p-value less than 0.05. The results show that a percentage change in physical capital led to 0.0786-percent change in output holding other factor inputs constant which represented the elasticity of output with respect to physical capital. The sign of the coefficient was consistent with expectations that physical capital increases the production potential in an economy (Solow, 1957; Swan, 1956). The Figure 7 below shows the trend of the contribution of physical capital to output.

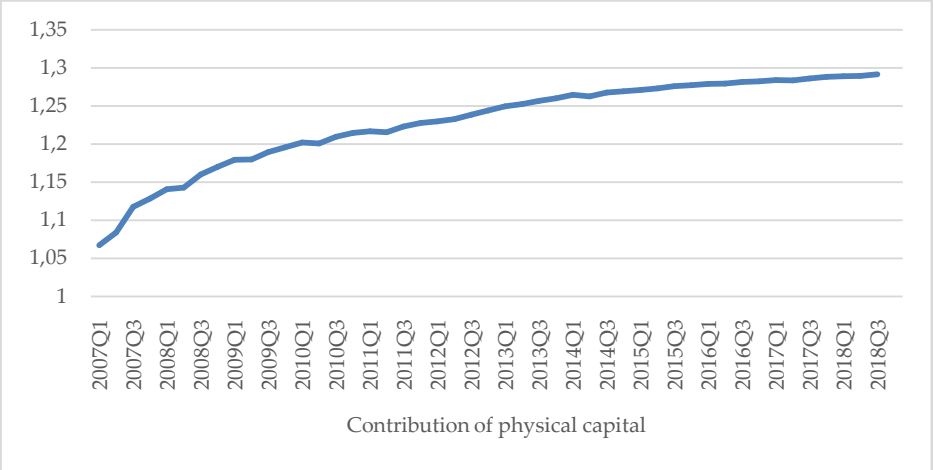

Figure 7. *Trend of the contribution of physical capital to output*
Source of Data: Authors computation.

The study used the coefficient with respect to log of physical capital to generate estimates of the contribution of physical capital to output following equation 17. The Figure 7 highlights the time profile of physical capital, which contributed 9.22-percentto output. The trend suggested that the contribution of physical capital was increasing at a decreasing rate. One possible reason of the declining contribution could have been attributed to declining investments, as financial intermediaries preferred channeling credit to the government perceived as less risky as opposed to lending to the private sector. This new phenomenon witnessed in Kenya from the period 2016Q3, coincided with the capping of interest rates to at most4-percent above the Central Bank Rate (CBR).Studies by Hammouda (2010), Fikkert (2002) and Levy (1989) showed that physical capital had a positive effect on output which was consistent with this study and supported the general consensus. The findings of this study, however, contradicted a study by Kalio (2012) that showed the contributions of physical capital to be more than 70-percent.

Log of labor had a positive and significant coefficient since the p-value was less than 0.05 with an elasticity value of 0.7307. The results indicate that a percentage change in labor use lead to a 0.7307-percentchange in output when other factor inputs are held constant. The results also confirmed the expected positive sign of the effect of labor and capital on output, which was consistent with economic theory. The positive sign of the coefficient was also consistent with studies by Hakim *et al.,* (2010) and Timmer (2013). Further, the size of the coefficient by Aquilars (2012) was at 0.73 which was almost similar to the coefficient of labor in this study. The following Figure 8 shows the trend of the contributions of labor to output.

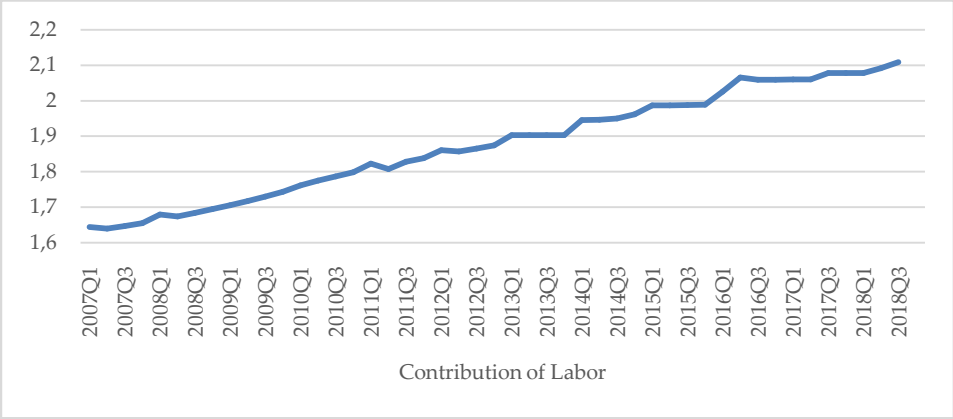

Figure 8. *Trend of the contribution of labor to output*
Source of Data: Authors Computation.

The mapping of the contributions of the log of labor showed that of all production inputs in Kenya, labor emerged as the largest contributor to output at 15-percent. This was consistent with expectations as Kenya is a labor-intensive market where 2 million people out of 19 million are in formal employment while the rest are self-employed either in the formal or informal sectors. The contribution of labor also grew over the period of study with the highest contribution recorded in the period 2018Q3. From the Figure 9, the contributions are increasing at an increasing rate. The above phenomenon met expectations that, as the shares of the contributions of both e-commerce capital and physical capital decrease the share of the contribution of labor increases. This contradicts studies by Timmer (2013) who showed the share of labor to be declining. The findings of the study also contradict Aquilars (2012), who showed that the contribution of labor was at 25-percent. The Figure 9 below shows the trend of total factor productivity.

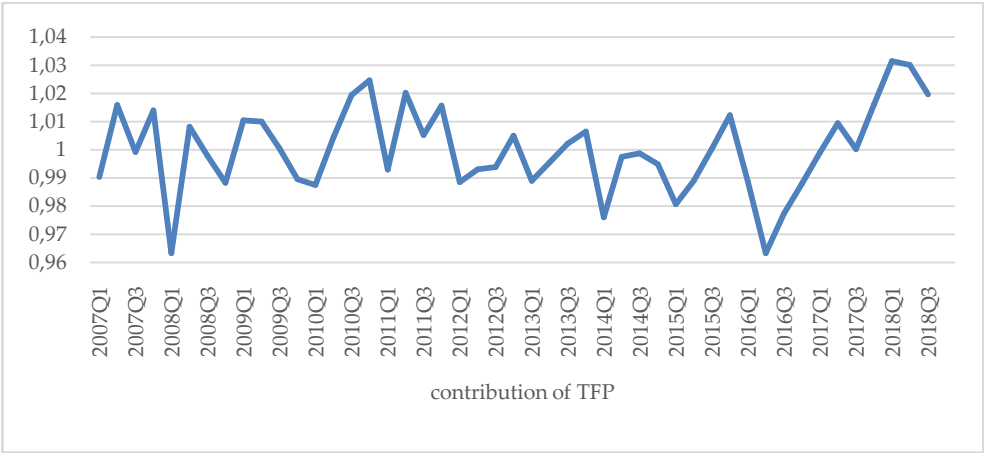

Figure 9. *Trend of total factor productivity*
Source of Data: Authors Computation

Total factor productivity also played a significant role in increasing output. Total factor productivity oscillates between periods of decline and expansion. TFP contributions accounted for more than 7-percent of the

contributions to output. Figure 10 shows that productivity was always positive and between the values 0.96 and 1.03 during the study period, this is consistent with TFP values for developing countries as shown in Seker (2011). The lowest value corresponds to the period 2016Q2 while 2018Q1 recorded the highest value of TFP. Further, a closer look at the Figures 6 and 10 showed periods of similar patterns in the direction of the contribution of TFP and e-commerce capital, which was telling of the relationship between e-commerce and TFP. The figures support the inference that with increasing adoption of e-commerce and increased investments towards e-commerce infrastructure and services, the contribution of e-commerce to output would increase. This is because despite the low adoption and investments towards e-commerce by enterprises, the sign of the contribution was positive.

4.5. Effect of e-commerce on total factor productivity

To obtain TFP values for each period, the study substituted the estimated coefficients from the output equation, solved for total factor productivity by subtracting from log of output, the constant and the contributions of labor, e-commerce and physical capital. The obtained values for log TFP were regressed upon the de-trended log values of e-commerce indicators, diversification index, degree of openness, and financial inclusion following equation 13. The regression results are as in Table 8.

Table 8. *Regressions estimate of the TFP model*

DEPENDENT VARIABLE: Log of Total Factor Productivity			No. of Observations: 47	
Independent Variables	coef	std. err.	t-stat	p > |t|
Log of Ratio of Mobile Transactions to GDP	.049***	.0132302	3.71	0.001
Log of The Ratio of Card Transactions to GDP	-.055 ***	.0151599	-3.62	0.001
Log of Degree of Diversification	.067**	.0251641	2.66	0.012
Log of Degree of Openness	.0255	.0250599	1.02	0.316
Log of Financial Inclusion	.0204	.0153008	1.33	0.192
Log of Financial Inclusion (-1)	-.0223	.0158606	-1.41	0.169
Log of Financial Inclusion (-2)	.0095	.0161518	0.59	0.560
Log of Financial Inclusion (-3)	.0076	.0158801	0.48	0.635
Log of Financial Inclusions (-4)	-.0196**	.0139275	-2.18	0.036
Cons	-.0159001	.1168167	-0.14	0.893
R-squared: 0.4347	*Adjusted R-Squared: 0.2805*			
F (3, 43): 2.82P (f-statistic): 0.0142				

Notes: The asterisks *** and ** indicate significant at 1% and 5% level respectively.

From Table 8 the independent variables jointly explain 28.05-percent of variation in TFP. The p-value of the f-statistic is less than 0.05 signifying that some of the estimated coefficients are statistically significant at 5-percent level. Diagnostic tests to ascertain statistical soundness of the model included the residual normality, homoscedasticity and no autocorrelation test as well as model specification and stability tests. The results are presented in Table 9.

Table 9. *Diagnostic test results for the TFP model*

Diagnostic test	Type of test	p-value	Conclusion
Residual Normality Test	Jacque-Berra	0.3695	Residual series is normally distributed
Heteroscedasticity	Breusch-Pagan/ Cook-Weisberg test	0.1648	Homoscedastic
Serial Correlation test	Breusch-Godfrey LM	0.2284	No serial Correlation
Specification test	(RESET)	0.1032	No omitted values

From Table 9 and following diagnostic tests to ascertain the models soundness, the following were the conclusions. The p-value of Jarque-Bera statistics greater than 0.05 indicated normally distributed residuals. The serial correlation tests, produced a p-value greater than 0.05, the conclusion was there was no serial correlation. Following the Breusch-Pagan/Cook-Weisberg test, the study concluded that the residuals are homoscedastic since the p-value of the f-statistic is greater than 0.05, the decision rule is you fail to reject the null hypothesis of Homoscedasticity. From the RESET tests results, the null hypothesis is that the model has no omitted variables. The decision rule is to fail to reject the null if the p-value is greater than 0.05. The stability tests (CUSUM) revealed that the model was stable since the residuals lied within the dual standard error bands as shown in Figure 10.The study, therefore, failed to reject the null since the p-value of the f-statistic was greater than 0.05. Following the residual test results on the TFP model, the study therefore concluded that the model was statistically sound relevant conclusions could be made from the empirical results.

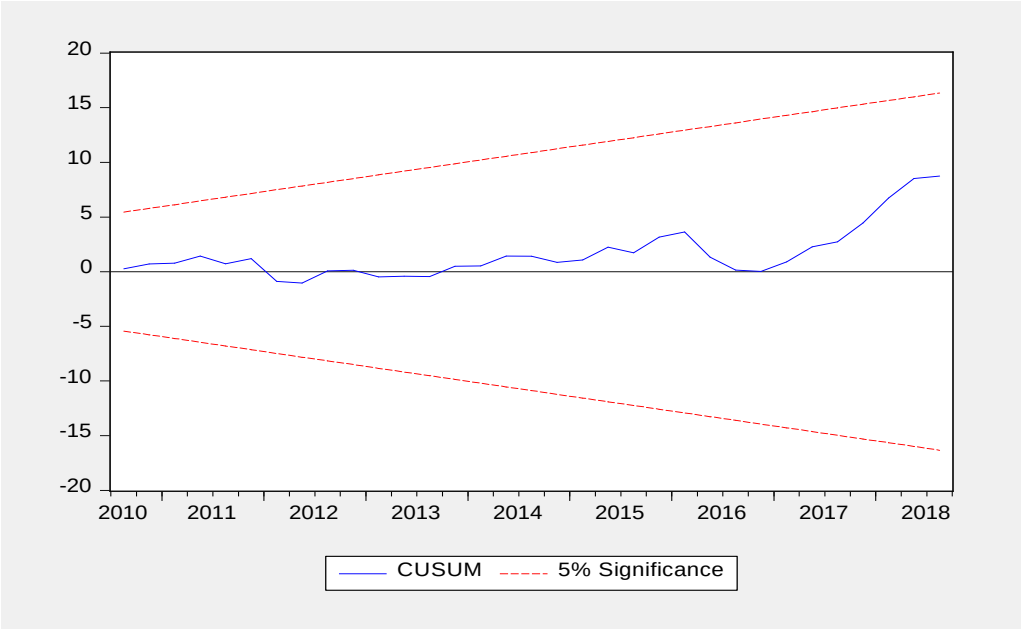

Figure 10. *Stability test results for TFP model*
Source of Data: Authors Computation

4.5.1. Effect of e-commerce on TFP

In this study, two indicators of e-commerce were used, mobile transactions and card transactions, since these utilized electronic technologies in effecting exchange. The coefficient for the log of the ratio of mobile transaction to GDP was positive and significant since the p-value was less than 0.05.The results suggest that a percentage change in the ratio of mobile transactions to GDP leads to 0.049-percentchange in TFP.

The sign of the coefficient of the value of mobile payments was positive and consistent with the expectations. From Endogenous growth theory, the level of TFP increases as more investments are channeled towards R&D and as the innovations are continually used. This means that as more e-commerce transactions occurred via mobile payments coupled with an increase in investments towards mobile payments, the net effect is an increase total factor productivity. The Kenya National Bureau of Statistics (2016) report shows that enterprises use of mobile payments for receiving payments was at 79.3 while its use for making payments at 73.7-percent. A study by Savarenz & Elsadiq (2013) showed that e-commerce had a positive and significant effect on labor productivity. Further, studies by Chen & Liu (2015) showed that increasing e-commerce adoption leads to higher total factor productivity which is consistent with this study.

Coefficient of the ratio of card transactions to GDP was significant at 5-percentlevel since the p-value of the coefficient was less than 0.05. The results indicate that a percentage change in the ratio of card transaction to GDP leads to0.0549-percentdecrease in TFP. The negative sign on the coefficient was also in line with the expectations. The negative sign and direction means that as more e-commerce transactions occur via cards, the level of total factor productivity falls. This is because the level of productivity of capital increases as cards are used for the purchase of capital equipment and luxury goods by high net worth individuals. The results suggest that as more people adopt e-commerce, the preferred method of payment is via mobile payments, a view supported by UNCTAD (2017). Consequently, for Kenya, increasing investments towards mobile payment technologies will lead to a significantly larger TFP.

4.5.2. Other factors that affect growth of total factor productivity in Kenya

The log of diversification index was positive and statistically significant since it had a p-value of less than 0.05. The value of the coefficient indicate that a percentage change in the level of diversification leads to a 0.067-percent change in TFP, holding all other factors constant. The findings met expectations of increasing TFP as Kenya moves from a highly specialized economy where Exports are primarily raw materials such as coffee, tea, and horticultural products to a diversified economy where exports are final goods such as plastic, chemicals and metal products. The findings, therefore, suggests that as the economy diversifies beyond the export of raw materials and towards the export of finished goods so does the level of total factor productivity. As highlighted in Chapter 1 of the study, the

period under investigation marked the onset of the ICT revolution. This suggests firms adopted technological equipment in order to remain competitive against new firms hence leading to a higher level of diversification. These findings however contradict a study undertaken by Hakim *et al.,* (2010) on growth, productivity and diversification in Africa that showed that the sign was negative with a coefficient of diversification of -2.048, for the period 1980 to 2000, with the highest level of diversification index reported in the year 2000 at 0.4.In comparison to the study, the average diversification index was reported at 0.24. More importantly, Hakim *et al.,* (2010) argued that, the negative sign of the coefficient implied that as an economy moves from high level of specialization to becoming more diversified, the total productivity of both labor and capital rises.

Coefficients of financial inclusion at level and those of first through to third lags were not statistically significant. However, financial inclusion at lag level 4was significant at 5-percent level since the p-value of the coefficient was greater than 0.05. The findings of the study suggested that after four periods a percentage change in financial inclusion leads to a decrease in TFP by 0.0196-percent. Some probable reasons for the inverse relationship are, firstly that investment opportunities are thin, and the private sector credit growth witnessed could have mainly been used to supplement personal consumption rather than investments by private firms towards renewing their technologies or investing in research and development. The lag effect is due to the fact that investments often accrue returns after a long period. The findings are consistent with findings by Hakim *et al.,* (2010).

Coefficient of the degree of openness was not significant at 5-percent significance level since the p-value was greater than 0.05. However, the direction of the coefficient was positive. Hakim *et al.,* (2010) found openness to be a significant determinant of TFP but with a weak coefficient. A study by Aquilars (2012) found the coefficient of the degree of openness to be significant and strong which contradicted the findings of this study. The results suggest that openness led to import of technology embodied in capital goods and intermediate goods that would have led to a positive sign and direction of TFP. Such capital and intermediate goods may include e-commerce technology such as computers, mobile phones, telecommunication equipment and banking cards.

5. Conclusion

The study's main objective was to measure the effect of e-commerce on output and total factor productivity. The results indicated that e-commerce had a positive contribution to output. Labor contributed significantly to output and registered the largest contribution while total factor productivity had a positive contribution, and showed high variability. Physical capital also emerged as a large contributor to output. The above findings suggested that for Kenya to experience episodes of growth,

emphasis should be placed towards increasing the proportion of labor utilized in production. Further, the findings suggested that since physical capital expanded Kenya's potential for production, appropriate investments geared towards capital deepening should be increased. More importantly, the findings suggested that despite the declining share of the ICT in GDP, coupled with low adoption of e-commerce there was a positive but insignificant effect on output.

The de-trended value of mobile payments had a positive coefficient in the TFP model this suggested that Kenya experienced an increased level of productivity when more economic transactions occurred via mobile payments. The de-trended value of card transactions had a negative co-efficient which suggested that Kenya experienced a decrease in the level of productivity when transactions occurred via cards. Diversification suggested a positive and significant effect on TFP implying increasing diversification would increase the level of TFP. Lagged financial inclusion had a negative effect on TFP. The degree of openness had no significant effect on TFP.

Following the study results, some important policy implications are identified. First, there is need to tighten competition laws especially in the mobile payments market. This would in turn lead to decreased barriers of entry for new firms, which would lead to more innovation and increased adoption by e-commerce companies. Citing market and profit incentives, such a move would enable the channeling of more investments towards e-commerce and eventually a more significant impact on output.

Secondly, since increased usage of mobile payments leads to higher level of productivity, firms and business need to be enlightened on the need to adopt these services. Government agencies should be required to adopt mobile payment services to increase efficiency. Thirdly, there is need to create industry specific standards aimed at security and technology for mobile money platforms as this is a relatively new market. Further, the study also revealed that the adoption of cards for e-commerce services is declining in Kenya. Card service providers can arrest this decline by reducing the transaction costs, costs of acquiring and replacing cards and investing more towards interoperability between card payment services and mobile payment services. More importantly cards induce inefficiencies where when making transactions therefore business should shift focus to mobile payment services to stay competitive. Fourthly, since labor produced the largest coefficient, the government should divert more expenditure towards higher learning, vocational training, and other training institutions.

Finally, diversification has a positive effect on TFP, therefore, to achieve a higher level of diversification and TFP, there is need to differentiate products further beyond Kenya's primary exports. One probable way is through investments in new and emerging technologies such as e-commerce which would introduce new market dynamics and enable both

local and international sales. Increasing diversification and e-commerce intuitively leads to a higher degree of openness.

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