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Measuring the economic contribution of the ICT sector in Ethiopia

A SAM-based analysis

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Abstract

The paper shows that the ICT sector has contributed above 4 per cent to the GDP. Moreover, it has contributed to the diversification of the export sector, bringing much needed hard currency and supporting the value addition in the economy. Over time, the urban-rural divide in ICT commodities consumption has come down, and both rural and urban rich households spent a similar share of their expenditure on ICT goods and services in 2016. Moreover, we have shown that the ICT sector gives a big boost to non-ICT domestic production. Our findings confirm that the ICT sector is important as a producer of final goods and services and intermediate inputs.

Background and motivation

The development of information and communication technology (ICT) has significantly contributed to the growth of gross domestic product (GDP) and labour productivity in both developed and developing countries since the 1990s. In fact, the economic contribution of ICT in the economies of developing and less-developed countries differs compared to the case in developed countries as the latter invested much in ICT. For example, wholesale and retail trade have experienced more rapid productivity growth (OECD, ICT and Economic Growth evidence from Countries,Industries and Firms, 2003; Elena, Bogdan, Angela, & Sorin, 2018). Thomas (2014) argued the absence of absorptive capacities due to lack of skilled human capital and other complementarity factors such as R&D expenditures in developing countries as an explanation for this difference (Thomas, 2014).

Meanwhile, the rapid expansion of ICT has played crucial importance in economic growth as ICT enables users to have quick and easy access to information and knowledge. By using ICT, business companies could be able to communicate faster and better so that they reduce production costs and improve productivity. Moreover, ICT could also allow access to new markets and lower capital costs thereby increasing the efficiency of financial markets. Generally, it is supposed that ICT could enable developing countries to have a 'leapfrogging' advantage for increasing productivity.

At the aggregate level, the contribution of ICT to economic growth can be distinguished into three channels (OECD, ICT and Economic Growth evidence from Countries,Industries and Firms, 2003). As a capital good, investment in ICT contributes to overall capital deepening and hence raises labour productivity. Investment in ICT establishes the infrastructure for the use of ICT (the ICT networks) and provides productive equipment and software to businesses. As long as firms producing these technologies are left to sufficient competitive pressure, the prices of these technologies will continue to decline, encouraging ICT investment and stimulating further productivity growth.

The second important economic contribution of ICT is associated with ICT producing sectors. Production in the sector has been characterized by rapid technological progress and strong demand. Hence, the sector can grow fast and thus has made a significant contribution to economic growth, employment and exports.

The third impact of ICT on economic growth and employment at the aggregate level is linked to sectors that are intensive users of ICT. Most economic activities under such categories are services sectors such as finance, business services and distribution. The intensive use of ICT may help companies increase their overall efficiency and thus raise

MFP. Furthermore, greater use of ICT could contribute to network effects such as lower transaction costs and more rapid innovation, which will improve the overall efficiency of the economy, i.e., MFP (OECD, ICT and Economic Growth evidence from Countries,Industries and Firms, 2003).

After the reform of 2018, Ethiopia has put Information Communication Technology (ICT) as a sector that will help the country advance its economic transformation agenda. Accordingly, the Government of Ethiopia has put ICT at the core of its development plan. The Homegrown Economic Reform, a three-year reform program, has prioritized ICT as the potential growth strategy. Accordingly, policy to remove bottlenecks hampering the effectiveness of the sector is being addressed. In addition, it also features prominently as one of the focus areas in the ten-year development plan. However, the sector's contribution to the Gross Domestic Product (GDP) is not known and monitored. With a lack of such information, it is difficult to make policy decisions with significant economic implications.

Given that ICT is a key factor in the economic and social development in both the Homegrown Economic Reform and the ten-year development plan, it is essential to examine the state and contribution of the ICT sector to economic growth and employment in the growing economy of Ethiopia. Therefore, the objective of this study is to identify gaps in empirically quantifying the economic contribution of the ICT sector and come up with possible estimates by using the Social Accounting Matrix and the associated SAM Multiplier analyses.

Several issues make measuring the contribution of the ICT sector a challenging task. First, the ICT sector is a dynamic sector, with new products and services appearing frequently. Second, it is not readily available in the national account statistics. Furthermore, the sector produces final products but is also a critical enabler for other sectors. Hence, other sectors use it as an input. The financial service, hotel and accommodations, and transport sectors rely on ICT services. The estimation of GDP focuses on final products to avoid double counting. Hence, the existing GDP estimation in Ethiopia does not address the contribution of ICT.

The outcome of this study is expected to be an important input in the policy formulation and budget allocation to the ICT sector by the Ministry of Finance and Economic Cooperation (MOFEC). Since the Ministry of Innovation and Technology (MInT) is responsible for designing policies that help the ICT sector to play the role expected in the Homegrown Economic Reform and the ten-year development plan, reliable information is important in the ICT policy development and implementation.

Literature review

Concepts and Definition of ICT Sector

The term Information and Communication Technology (ICT) has been commonly used in our day-to-day activities with many but similar definitions. Among the many definitions of ICT, the simplest and commonly used definition is as an electronic medium for creating, storing, and manipulating, receiving and sending information from one place to another. ICT has made information delivery faster, more convenient and easy to access especially after the 1990s. The functioning of ICT as a good or service is possible with the convergence of telephone and computer networking through a single cabling system with ease of data storage, manipulation, management, and retrieval. ICT is concerned with activities associated with database management, computer programming, software development, web designing, mobile application development, project management, security and networking analysis, media equipment, internet and intranet and application software and so on. According to Grace et.al (2004), ICTs are tools that facilitate the production, transmission, and processing of information with a broad definition of ICTs ranging from traditional technologies such as the printed word to the most modern communications and data delivery systems (Grace, Kenny, & Zhen-Wei Qiang, 2004).

There have been many updates on the concepts, definitions and classifications of the ICT sectors as well since the first definition by the OECD member countries in 1998 which was later revised in 2002. The OECD member countries in 1998 agreed to define the ICT sector as a combination of manufacturing and services industries that capture, transmit and display data and information electronically (OECD, 2002). This definition was based on the international standard classification of activities (based on ISIC Rev. 3) and considered to be the first step to obtain some initial measurements of ICT sector indicators. However, the activity-based definition of ICT was reviewed in April 2002 aimed at fostering international comparability of statistics with the help of more detailed ISIC classifications (based on ISIC Rev. 3.1).

Both definitions of the 1998 and 2002 ICT sector by OECD were expressed in terms of the characteristics of the products. Accordingly, for the ICT manufacturing industries, the products or goods must fulfil the function of information processing and communication including transmission and display or use electronic processing to detect, measure and/or record physical phenomena or control a physical process. Likewise, for the ICT service, the products (services) must be intended to enable the function of information processing and communication by electronic means. This OECD definition of the ICT sector breaks the traditional ISIC dichotomy between manufacturing and services activities as the ICT sector was supposed to combine manufacturing and services

industries whose products capture, transmit or display data and information electronically.

Table 2.1 The 2002 OECD ICT sector definition (ISIC Rev. 3.1)

1	**ICT manufacturing industries**
3000	Manufacture of office, accounting and computing machinery
3130	Manufacture of insulated wire and cable
3210	Manufacture of electronic valves and tubes and other electronic components
3220	Manufacture of Televisions and radio transmitters and apparatus for line telephony and line telegraphy
3230	Manufacture of Televisions and radio receivers, sound or video recording or reproducing apparatus and associated goods
3312	Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment
3313	Manufacture of industrial process control equipment
2680	Manufacture of magnetic and optical media
2	**ICT services industries**
5151	Wholesale of computers, computer peripheral equipment and software
5152	Wholesale of electronic and telecommunication parts and equipment
6420	Telecommunications
7123	Renting of office machinery and equipment (including computers)
72	**Computers and related activities**

Source: OECD (2002, 2009)

Furthermore, the new ICT sector definition was provided through making major revisions in 2007 based on ISIC Rev4 (OECD, 2009). The ICT sector definition (2007) differs from the previous definition of 2002 in those products which “use electronic processing to detect, measure and/or record physical phenomena or control a physical process” are now excluded, thus narrowing the scope of the ICT sector. Thus, the new OECD ICT sector definition (2007) used the following guiding principle in identifying ICT economic activities or industries (OECD, 2007);

> “The production (goods and services) of a candidate industry must primarily be intended to fulfil or enable the function of information processing and communication by electronic means, including transmission and display.”

Moreover, the 2007 definition of ICT sector definition of OECD in a broader sense (sometimes referred to as the information economy) includes both the ICT sector and Content and media sector.

The content and media sector definition considers the publications & audio and video recordings of print and electronic versions as part of the ICT which has been treated as one element of the information economy. To be more specific, the content and media

industries are those that are engaged in the production, publishing and/or electronic distribution of content products. The content and media sector originated since the rapid transformation and diffusion of information and communication technologies significantly affected industries that create and distribute content (such as text, audio, and video). According to the 2007 definition of ICT sector definition (OECD, 2009), the following general principle (definition) was used for the identification of content and media products:

> "Content corresponds to an organized message intended for human beings published in mass communication media and related media activities. The value of such a product to the consumer does not lie in its tangible qualities but its information, educational, cultural or entertainment content."

Hence the list of ICT industries (ISIC Rev 4) that meet the condition above can be grouped into four major sectors namely ICT manufacturing industries, ICT trade industries, ICT services industries and ICT content and media industries as shown in table 2.2.

Meanwhile, the sector definition was complemented by the ICT goods definition in 2003 which was based on the 2002 version of the Harmonized System (HS) used for trade statistics and the ICT services definition in 2007 based on a draft version of the CPC Ver. 2 (OECD, 2009). This definition of ICT products was, however, revised in 2007. The following guiding principle was used to identify ICT products: "ICT products must primarily be intended to fulfil or enable the function of information processing and communication by electronic means including transmission and display" (OECD, 2009). The 2007 ICT products definition consists of 10 broad categories, namely Computers and peripheral equipment, Communication equipment, Consumer electronic equipment, Miscellaneous ICT components and goods, Manufacturing services for ICT equipment, Business and productivity software and licensing services, Information technology consultancy and services, Telecommunications services, Leasing or rental services for ICT equipment and Other ICT services.

However, both social accounting matrices (SAMs) of the Ethiopian economy, namely the Ethiopian SAM 2010/11 published by IFPRI and SAM 2015/16 of Policy Studies Institute, are constructed using the International Standard Industrial Classification of version 3.1(ISIC Rev3.1). That is, the sectoral and product (commodity) concordances are based on the ISIC Rev3.1. Therefore, it requires mapping of the sector and products codes of ISIC Rev 4 to ISIC Rev 3.1. For the current study, however, the ISIC Rev 4 to ISIC Rev 3.1 mapping is not essential as the ICT sector and ICT product concordances are made by aggregating the sectors and products already in the SAM (please see the methodology part for the aggregation procedure).

Table 2.2 The 2007 OECD ICT sector definition (Based on ISIC Rev 4)

1	**ICT manufacturing industries**
2610	Manufacture of electronic components and boards
2620	Manufacture of computers and peripheral equipment
2630	Manufacture of communication equipment
2640	Manufacture of consumer electronics
2680	Manufacture of magnetic and optical media
2	**ICT trade industries**
4651	Wholesale of computers, computer peripheral equipment and software
4652	Wholesale of electronic and telecommunications equipment and parts
3	**ICT services industries**
5820	Software publishing
6110	Wired telecommunications activities
6120	Wireless telecommunications activities
6130	Satellite telecommunications activities
6190	Other telecommunications activities
6201	Computer programming activities
6202	Computer consultancy and computer facilities management activities
6203	Computer Facilities management activities
6209	Other information technology and computer service activities
6311	Data processing, hosting and related activities
6312	Web portals
9511	Repair of computers and peripheral equipment
9512	Repair of communication equipment
4	**Contents and Media industries**
5811	Book publishing
5812	Publishing of directories and mailing lists
5813	Publishing of newspapers, journals and periodicals
5819	Other publishing activities
5911	Motion picture, video and television programme production activities
5912	Motion picture, video and television programme post-production activities
5913	Motion picture, video and television programme distribution activities
5914	Motion picture projection activities
6010	Radio broadcasting
6020	Television programming and broadcasting activities
6391	News agency activities
6399	Other information service activities N.E.C.

Source: OECD (2007, 2009, 2011)

Contributions of ICT to the economy from a macroeconomic perspective

The debate over choosing between ICT and other development imperatives that occurred in the 1990s, with the assumption that investment in ICT draws scarce resources away from more urgent development needs (World Bank, 2003), has recently been treated as a debate that no one gives attention. In the globally interconnected economy, the relationship between ICT and Non-ICT investment has now shifted from trade-offs to that of complementarity even among ordinary people. These days, ICTs are recognized as essential tools of development—tools that can empower poor people, enhance skills, increase productivity, and improve governance at all levels (Robert, 2005) implying that development projects that are supported with ICT are likely to be successful. This has caused the ICT sector to emerge as a rapidly growing sector. Moreover, ICT is a general-purpose technology and widely used by other non-ICT sectors, the development of the ICT sector affected all segments of the economy and the society in general due to the increased efficiency following the ICT usage.

The contribution of ICT to economic growth and employment from a macroeconomic point of view can be seen from the role of ICT in enhancing productivity. The fact that business activities are highly associated with ICT with continuously falling costs for the users as well as the contribution of ICT to innovation and the development of new products and processes have paved the way to increase productivity. According to Christine and Alexander (2004), there are three channels through which ICT can influence economic growth: TFP growth in sectors producing ICT, Capital deepening and TFP growth through reorganization and ICT usage (Christine & Alexander, 2004). This has also been confirmed and presented in the study by OECD (2003) and stated as follows:

> "In most analysis of economic growth, three effects are distinguished. First, as a capital good, investment in ICT contributes to overall capital deepening and therefore helps raise labour productivity. Second, rapid technological progress in the production of ICT goods and services may contribute to more rapid multifactor productivity (MFP) growth in the ICT-producing sector. And third, greater use of ICT may help firms increase their overall efficiency, and thus raise MFP. Moreover, greater use of ICT may contribute to network effects, such as lower transaction costs and more rapid innovation, which will improve the overall efficiency of the economy, i.e., MFP (OECD, 2003).

Many researchers employed a variety of methodologies to assess the contribution of ICT to economic growth. The most used methodologies applied include the growth

accounting approach, the sectoral contribution analysis to productivity growth within an economy, and cross-country regression analysis approach.

The macroeconomic level empirical work on the relationship between ICT and economic growth is most often assessed using the growth accounting. Growth accounting is the most widely used approach to measure the contribution of ICT investment to economic growth. It involves decomposing the growth of value added into the growth of inputs used in the production process, namely labour, ICT investments and non-ICT investments. This decomposition requires knowing the measure of the elasticity of value added to each input. However, having elasticities of inputs is not a simple task for researchers thus they rely on some method to estimate them.

There are two methods of estimating these elasticities. The first one is using the assumption elasticity of each input is equal to its share in the value added. This assumption will be valid, however, with a set of strong hypotheses such as the technology of production or production function exhibits constant returns to scale, firms' objective is profit maximization and the Hicksian neutrality of technological progress. Moreover, this approach assumes that the difference between the growth in value-added and growth of factors of production (growth of value-added that is not explained by growth in inputs) is due to an increase in total factor productivity (TPF). As a result, all deviations from the above hypotheses and all measurement errors in the statistical data are misinterpreted as differences in TFP across countries and over time. The second method of estimating inputs elasticity is through econometric techniques. This approach, although it doesn't impose any a priori hypotheses, avoids postulating a relationship between production elasticities and income shares by directly estimating productivity has its own limitations that it is less flexible as coefficients are fixed across at least one dimension of the data and requires a larger set of observations.

Several growth accounting studies reveal economically significant contributions of ICT capital to economic growth after the mid-1990s in developed economies.

A review of the impacts of ICT at the aggregate level of the economy related to economic growth and employment will be conducted. The weaknesses and strengths of the empirical studies will be reviewed.

ICT and economic transformation in Ethiopia: Overview of ICT-related policies

These days, information and communication technology (ICT) has been an integral part of everyone's day to day activity to the extent that a modern society without ICT is impossible. ICT has been increasingly used as a key enabler and transformational tool to foster economic growth, accelerate knowledge transfer, develop local capacities and

raise productivity in many sectors of both developed and developing countries (Marc & Mariana, 2014). In recent times ICT has changed not only the types of goods and services consumed by consumers but also it has changed production methods and systems, production locations, infrastructure and business organization. Development projects assisted by ICT have greater potential to achieve better outcomes on the ground than the one that is not supported by ICT (Marc & Mariana, 2014).

Cognizant of this very fact, the Government of Ethiopia gave due emphasis for ICT in its socioeconomic development plan and believes that ICT could enable to use innovative and reliable technologies that are useful to accelerate the rate of economic growth and reduce poverty. The first National ICT Development Plan was launched in the Five-Year Action Plan under the Ministry of Capacity Building with support from UNDP in in 2006. The plan aimed to build an ICT-driven economy that could fully participate in an Internet-based and interconnected global economy that competes in the global world (Marc & Mariana, 2014). Likewise, the ICT sector was given special attention in the first Growth and Transformation Plan (GTP I) 2010/11–2014/15). It was clearly stated that the telecom and ICT sectors were believed to play key strategic pillars in GTP I and thus the Government planned to focus on "upgrading the already built ICT network to accommodate emerging latest information technologies; improve the network quality and expansion of services; ensure all-inclusive telecommunication service delivery and ICT assisted development as it is key for other development programs" (Federal Democratic Republic of Ethiopia, 2010).

Likewise, the ICT sector was given due attention in the second Growth and Transformation Plan (GTP II) 2015/16-2019/20. It was clearly stated that development in the ICT sector could play a significant role to increase productivity, enhancing competitiveness, accessing timely information to the public, creating job opportunities and generating foreign exchange earnings to the economy. To help the sector grow during the plan period, "the major strategic directions were to enhance the information communication technology infrastructure and human development, utilize ICT in government administration, industry development and private sector development. ICT equipment producing industries have started to emerge in the economy, while several ICT services providing enterprises have already become operational in the ICT Park constructed in Addis Ababa" (National Planning Commision, 2016). Nevertheless, the performance of the ICT sector was not as expected during the plan period.

In the 2019 Home Grown Economic Reform (HGER), ICT has been considered as an integral and essential part of Ethiopia's growth strategy and supposed to play a catalytic role for both as an industry and as an enabler of socioeconomic transformation. The reform recognized rational that "unlocking the potential of ICT services in the economy requires an enabling policy, regulatory environment, infrastructure, and human capital.

During this reform period, a digital momentum can be built by taking advantage of low-hanging fruits such as the country's growing Science Technology Engineering & Mathematics (STEM) graduates, the telecom sector liberalization, revitalization of the existing ICT park, and necessary regulatory reviews" (FDRE, 2019). Accordingly, promoting the use of ICT for modernizing the civil and public services to enhance efficiency and effectiveness of service delivery, promoting e-commerce and digitization of the financial and logistic sectors, Expanding ICT infrastructure throughout the country and ensuring its accessibility and promoting the export of IT-enabled services are some of the key reform measures in the new economic reform.

Methodology and data

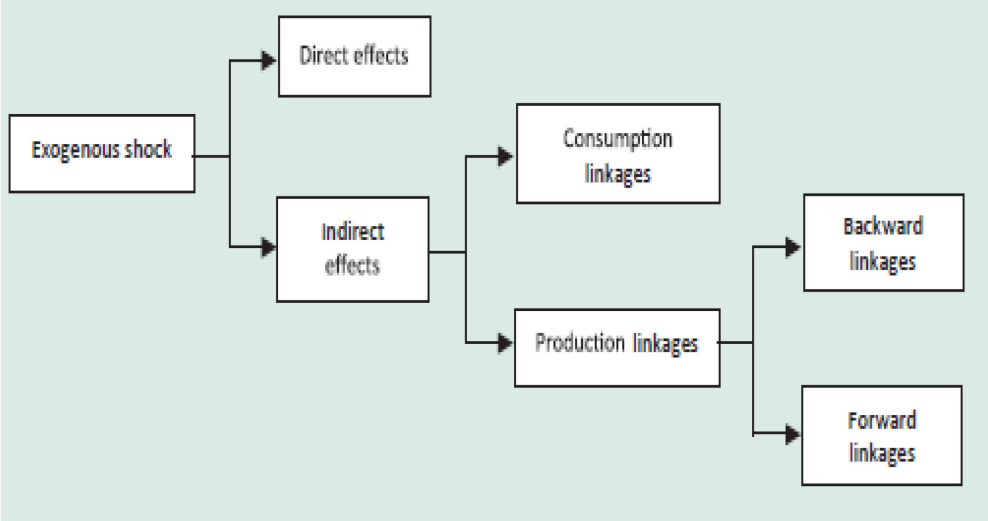
Introduction

The proposed work aims to measure ICT sectors as a producer of goods and services and as enablers for other sectors. For this purpose, Social Accounting Matrices (SAM), which is a more elaborate representation of the economy, has been used. Since the National Accounts Statistics has limited disaggregation (with no ICT sectors), it requires creating a new account for the ICT sector in the SAM to assess the contribution of the ICT sector as a producer of final goods and services. Moreover, we suggest the use of SAM multiplier analysis to estimate the impact of a shock on the provision of ICT goods and services on the economy.

SAM multiplier analysis

SAM multiplier models are well suited to measuring the short-term direct and indirect impacts of interventions. Detailed and step-by-step discussion about SAM Multiplier is available by Breisinger, Thomas, and Thurlow (2009) and Round (2003). The SAM multipliers models estimate the total effects (direct and indirect effects) of a shock by taking into account the forward and backward linkages in an economy. For example, to produce an output, a given sector demands inputs from other sectors in the economy. The procurement of supplies as inputs from the domestic economy represents the backward linkages in production. An intervention, which increases the demand for ICT products, will create demand for inputs used in the ICT products via the backward production linkages. There are also forward linkages in production for sectors that use ICT products as input. In addition to the production linkages, the SAM multiplier accounts for consumption linkages as household income increases. Figure 1 below shows a detailed representation of the total effects.

Figure 1 Direct and Indirect Impact of a shock



Source: Breisinger, Thomas, and Thurlow (2009)

The first step in SAM multiplier analysis is determining the endogenous and exogenous accounts (see Round (2003)). Usually, the government, the rest of the world, and investment demands are considered exogenous. According to Round (2003), the government action is policy-driven, the rest of the world is outside of the domestic economy, and investment is not modelled endogenously. Hence, the assumption of making the three accounts exogenous is reasonable. We follow the same procedure and make the three accounts the exogenous account. Mathematically, let's assume x is a vector of exogenous demand of goods and services; y is the vector of final demand of goods and services, and A is a square matrix representing a pattern of outlay (see Round (2003)).

$$y = Ay + x$$

Hence, the endogenous accounts can be written as a function of the exogenous accounts as shown below.

$$y = (I - A)^{-1}x = M_A x$$

I is an identity matrix and M_A is the SAM multiplier matrix. Accordingly, we will use the model to analyse the impact of a change in the exogenous demand as shown below, mathematically.

$$\Delta y = M_A \Delta x$$

The ICT programs will increase the investment, export and consumption of ICT goods and services because of the incentive provided to participant enterprises directly. The direct expenditure by the will lead to indirect effects shown in Figure 1.

The SAM multiplier is a tool to quantify the direct and indirect effects of shocks on the system. However, it is important to note the assumptions behind the model. The first critical assumption is that the input-output relationships will remain the same before and after the intervention. Second, the consumption pattern of households is also assumed to remain the same. Finally, the model also assumes prices are fixed. We also believe such changes are likely to take time. Therefore, to estimate the total effect, the SAM multiplier is suitable.

Similarly, the pioneering work of Leontief (1986) input-output analysis is essential to understand the production linkages and is based on systematic exploitation information contained in an input-output table that shows the distribution of sales of each industry or sector of the economy in terms of purchases of its products by all the other sectors, households, government and foreign countries (Leontief, 1986). Input-output tables record transactions between economic sectors, each producing a product and at the same time, consuming products from other industries. The horizontal rows of the input-output table show how the output of each sector is distributed among other sectors as intermediate demand and final demand while the vertical columns show how each sector obtains intermediate inputs from other sectors or how each sector distributes the output as intermediate inputs and added value. Thus, the input output matrices show the interdependence among sectors of the economy from the production side. We will use the input-output multiplier to estimate the production linkage.

Data used: ICT concordance and data work on SAM (ICT as a sector)

The database used in the analysis of this study is basically the Ethiopia Social Accounting Matrix 2015/15 (SAM 2015/16 of Policy Studies Institute). However, as SAM has no ICT accounts, it requires creating a new account for the ICT activity in the SAM to assess the contribution of the ICT as a producer of final products.

As far as the definition of ICT is concerned, now the definition of OECD (2007, 2009) for ICT is considered in this study. However, it is open to the comments and recommendations of the stakeholders.

As stated above, the ICT sector is grouped and classified according to the OECD's ICT definition of OECD (2007, 2009), the International Standard of Industrial Classification (ISIC Rev 4). The OECD (2009) defined the information economy sector as comprising two industries, ICT sectors (ICT manufacturing trade and services) and ICT content and media. These sub-sectors are based on and conforms to International Standard Industrial Classification of All Economic Activities Revision 4 (ISIC Rer.4) of the United Nation, Department of Economic and Social Affairs Statistics Division (UN, 2008).

In Ethiopia, the Information and Communication is available neither in the Official National Account statistical system nor in the social Account Matrix 2015/16 of Ethiopian Policy Studies Institute as a sector. However, for this study a new account of the ICT sector is created by using the OECD's definition (2007, 2009) of ICT sector in a broad sense. Therefore, the ICT sector is divided into three subsectors: (1) ICT manufacturing sector that produces electronics, computer, and peripheral components, telecommunications devices, consumer electronics, instruments and appliances of magnetic and optical media which has been created by considering the existing SAM account of "aelecq". (2) ICT service sector that basically includes wholesaling of computers, electronics, components, software applications, software services, telecommunications services, postal services, information processing services, computers and telecommunications equipment repair services of communication equipment; and this account is created by combining the SAM accounts of "acomm' and "aoserv" (3) ICT media and content sector which includes publishing of books and other publishing activities, Sound recording and music publishing activities, broadcasting, recording and other information activities. This account is created by combining the SAM accounts of "apaper"

Likewise, the non-ICT activities are grouped to form new accounts in the modified or aggregated Input-Output table. Product aggregation using the same procedure is applied based on OECD (2009) Product definition. The following table shows the concordances of activities in the aggregated Input-Out puts table.

At the aggregated level, the ICT account can be created by merging all the three accounts of the ICT subsector stated above and as well as aggregating all non-ICT sectors /products. In this way, we will have two accounts (ICT sector and non-ICT sectors) and the effect of the ICT sector on the overall economy and other sectors will be assessed.

Similarly, mapping for ICT products can be carried out based on the ICT products definition stated in section 2.1. However, in the present study, as the concordance of the SAM accounts is based on ISIC Rev3.1 the new ICT products accounts are created by merging the accounts of products or commodities that belong to the ICT products consistent with the definition of OECD (2009).

Table 3.1 Aggregation of SAM Accounts

No.	Aggregated Sector/Product	Activities included	Products /commodities included
1	Agriculture and Mining	atef, abar, awhea, amaize, asorg, apul, aveg, afruit, aoils, acash, acoff, aenset, acrop, aflower, alive, afor, awood, afish, amining, adairy	ctef, cbar, cwhea, cmaize, csorg, cpul, cveg, cfruit, coils, ccash, ccoff, censet, ccrop, cafeed, cflower, clive, cmeat, cmanure, cmilk, cfor, cwood, cfish, cmining, cdairy
2	Food Processing	agmill, agmillserv, asugar, avprod, afood	cgmill and cgmillserv, csugar, cvprod, cfood
3	Beverage and Tobacco	abev, atob, amtob,	cbev, atob, amtob,
4	ICT manufacturing	aeleq	celeq
5	Petrol and Chemical	aoil, achem, afert, apharm	coilptr, cchem, cfert, cpharm
6	Textiles and Apparel	atext, aspin, aapar, aleath	clcott, ctext, cspin, capar, cleath
7	Cement and Minerals	aminprod, acement	cminprod, ccement
8	Metals	ametals, amprod	cmetals, cmprod
9	Other manufacturing	aveh, amach, aomanu, aelec	cveh, cmach, comanu
10	Construction	awater, aconst	cwater, cconst
11	Trade	atrad	ctrad
12	Hotels	ahotel	chotel
13	Transport	atrans	ctrans
14	Financial service	afserv	cfserv
15	Education and Health	aeduc, ahealt	ceduc, chealt
16	Government Services	apadmin	cpadmin
17	Real estate	arest	crest
18	ICT services	acomm, aoserv	ccomm, coserv
19	ICT Contents and Media	apaper	cpaper

Source: Authors' aggregation from Ethiopian SAM 2015/16 based on OECD ICT sector /Product definition (2007, 2009)

Therefore, there are three major ICT products are created from the existing SAM accounts. These are 1) ICT Equipment that includes Computers and peripheral equipment, Communication equipment, Consumer electronic equipment and other ICT components and goods, which is created by using the "celecq "account of the SAM. 2) ICT services, which includes Manufacturing services for ICT equipment, Business and productivity software and licensing services, Information technology consultancy and services, Telecommunications services, Leasing or rental services for ICT equipment and Other ICT services. This account is created by merging "ccomm" and "coserv" accounts of the SAM. 3) Content and media product are created by using the "cpaper" account of the SAM.

After appropriate concordances based on the above classifications, we can have the following structure of the input-output table (IOT) or Supply and Use table (SUT) adopted from UN Handbook on Supply and Use Tables and Input Output-Tables (United Nations, 2018). The interest of this paper is on the use table (3rd row and 2nd Column, i.e., intermediate consumption and final use).

Table 3.2 Simplified Supply and use tables framework

	Activities	Products	Final Demand	Total
Activities		Outputs by products and Industry		Total Outputs
Products	Intermediate Consumption by Product and Industry		Final uses by product and Category	Total Use by Products
Factors	Value added by Component and Industry			Value Added
ROW		Total Import		Import
Total	Total Output by Industry	Total Supply by Industry	Total Final Use	

Source: Adapted from UN Hand Book on Supply and Use Tables and Input Output-Tables (2018)

Results and discussions

We have discussed in the methodology section that ICT is a producer of final goods and services destined for the international or local market. Consumers and governments use ICT goods and services as final consumptions. Moreover, businesses also use ICT goods for investment (as final goods) and ICT goods and services as an intermediate input.

In the first sub-section, we will discuss the contribution of ICT to value-added/GDP, its export share over time, and which households spend the most on ICT. In the second

sub-section, we will discuss the role of ICT as an enabler delving into its interlinkage with the non-ICT sector.

ICT as a sector

The value-added is the gross value of production minus intermediate inputs, which provides the contribution of the sector to Gross Domestic production. Table 4.1 shows the ratio of value-added to the gross value of outputs in the ICT sector was 77.36 per cent in 2010/11, while the ratio marginally declined to 73.47 per cent in 2015/16. This can be interpreted as the ICT production technology in 2015/16 was more input-intensive than the production technology in 2010/11. In fact, the massive ICT investment particularly the expensive ICT spending in the telecommunication subsector is expected to increase the overhead costs and lower the value-added to output ratio in the ICT sector. Likewise, the ICT sector contributed 5.82 per cent of GDP in 2011, but the share of ICT value added to GDP declined to 4.07 per cent in 2015/16.

The ICT trade shares (both import shares and export share) improved in 2015/16 compared to the shares in 2010/11 indicating that the economy is getting connected to the global world. The ICT goods and services import increased from 4.60 per cent of the total import in 2010/11 to 11.39 per cent in 2015/16. Likewise, the ICT export of goods and services increased from 0.01 per cent in 2010/11 to 2.50 per cent of the total export of goods and services in 2015/16.

Table 4.1 Output and Trade share of ICT in Ethiopian Economy

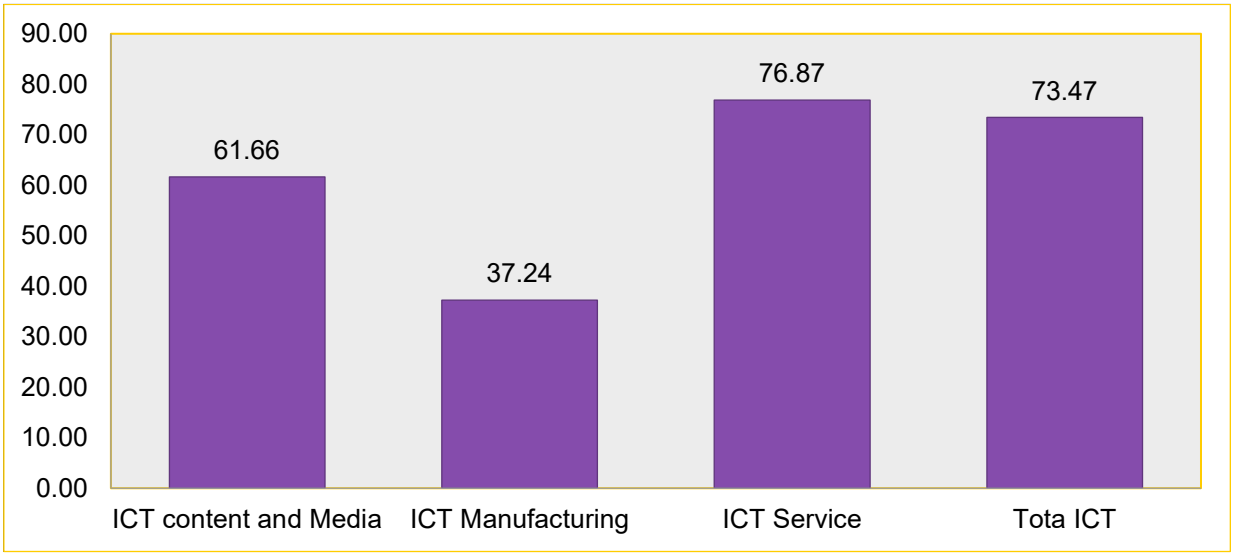
Production and Trade shares of ICT	2010/11		2015/16	
	ICT Sector	Non-ICT Sector	ICT Sector	Non-ICT Sector
Value added/Output at Factor price	77.36	58.69	73.47	66.12
Sector value added /Total value-added	5.82	94.18	4.07	95.93
Sector Import share (% total Import)	4.6	95.4	11.39	88.61
Sector Export share (% total Export)	0.01	99.99	2.5	97.5

Source: Authors' calculation from Ethiopian SAM 2010/11(IFPRI) and SAM 2015/16 (PSI)

The ICT sector has sub-components discussed in section 3. Figure 4.1 depicts the value-added to the gross value of production ratio for the ICT sector and its subgroups. Accordingly, about 73.5 per cent of the gross value of production is value-added. The remaining 26.5 per cent of the gross value of production is the expenditure for intermediate inputs in aggregate. The highest ratio of value-added to gross production is

recorded in the ICT services subsector, mainly in the telecommunications sector, accounting for 77 per cent of the gross value of production. The lowest ratio is observed in the ICT manufacturing sector with a score of only 37 per cent. These indicate that ICT manufacturing is an input-intensive activity, and the ICT service sector has the highest value-added to the value of production ratio.

Figure 4.1 Value added to the Gross value of production if ICT sector



Source: Authors' calculation from Ethiopian SAM 2015/16 (PSI)

Table 4.2 presents the intermediate input and final demand structure for ICT, non-ICT, and all goods and services. The data show that the proportion of ICT goods and services used as intermediate inputs (in total demand) is higher than that of the case for non-ICT goods and services. In 2010/11, the proportions of goods and services demanded as intermediate input was 43.5 per cent of total demand for ICT goods and services, while it was only 31.07 per cent and 31.65 per cent for non-ICT and all goods and services, respectively. Meanwhile, the intermediate demand for the year 2015/16 for the ICT goods and services as a share of total demand was 28.19 per cent, which was only slightly higher than the case for non-ICT goods and services. The share of intermediate demand for the ICT goods and services in 2015/16 was lower than that of the cases in 2010/11.

Private consumption demand for ICT products stayed relatively stable with a consumption to total demand ratio of 44.35 per cent and 43.50 per cent in 2010/11 and 2015/16, respectively.

Table 4.2 Demand Values in Billion Birr and Shares (Intermediate and Final Demands)

Demand Types	2010/11					
	Overall	Share (%)	ICT Sector	Share (%)	Non-ICT Sector	Share (%)
Intermediate input	312.83	31.65	19.93	43.49	292.91	31.07
Private Consumption	424.33	42.92	20.32	44.35	404.01	42.86
Final demand	675.72	68.35	25.89	56.51	649.82	68.93
Total demand	988.55	100.00	45.82	100.00	942.73	100.00
Demand Types	2015/16					
	Overall	Share (%)	ICT Sector	Share (%)	Non-ICT Sector	Share (%)
Intermediate input	714.37	26.72	38.45	28.19	675.91	26.64
Private Consumption	882.79	41.11	59.35	43.50	823.44	40.98
Final demand	1959.01	79.73	97.97	71.81	1861.04	80.20
Total demand	2457.06	100	136.43	100.00	2320.63	100.00

Source: Authors' calculation from Ethiopian SAM 2010/11(IFPRI) and SAM 2015/16 (PSI)

The value-added of ICT and non-ICT sectors are shown in Table 4.3. The value-added of each sector is distributed to the factors that are used in the value addition process. As the fourth column in table 4.3 shows, non-agricultural capital contributed the largest share in value addition accounting for 62.60 per cent in 2010/11 and 49.80 per cent in 2015/16. Non-agricultural capital contribution in the value-added to the non-ICT sector accounting was 43.51 per cent and 36.27 per cent in 2010/11 and 2015/16, respectively. This confirms that the ICT sector is capital intensive compared to the non-ICT sector.

However, a comparison of the contribution of labour to the value addition seems against the concept of capital–skill complementarity, which assumes that the ICT sector demands skilled workers more than an unskilled one. One would expect, the increased use of ICT could raise the relative demand for skilled workers compared to unskilled workers, which leads to an increased wage of skilled workers relative to unskilled workers in the industry. However, the valued added share in the ICT sector for unskilled labour (labour with no formal education) is higher than the valued added share of skilled labour in both 2010/11 and 2015/16, accounting for 22.12 per cent and 4.17 per cent in 2010/11 and 36.10 per cent and 9.14 per cent in 2015/16. This could be due to many unskilled workers engaged in the ICT investment activity, especially in the investment of ICT infrastructure development contributing to the lower number of skilled and semi-skilled workers engaged in the sector.

Table 4.3 Factor Contribution to VA (Values in Billion Birr)

	2010/11					
Factor Contribution to VA (billion ETB)	Total VA	Share (%)	ICT_VA	Share (%)	Non-ICT_VA	Share (%)
Labour with no Education	130.96	28.54	5.42	22.12	125.53	28.90
Labour with Primary Ed.	19.94	4.35	1.70	6.95	18.24	4.20
Labour with Secondary Ed.	14.58	3.18	1.02	4.16	13.56	3.12
Labour with College Ed.	11.34	2.47	1.02	4.17	10.32	2.38
Capital Land Rural	52.47	11.43	-	-	52.47	12.08
Capital Livestock Rural	25.23	5.50	-	-	25.23	5.81
Non Agricultural capital	204.31	44.53	15.35	62.60	188.96	43.51
Total	458.84	100.00	24.52	100.00	434.31	100.00
	2015/16					
Factor Contribution to VA (billion ETB)	Total VA	Share (%)	ICT_VA	Share (%)	Non-ICT_VA	Share (%)
Labour with no Education	479.90	34.05	18.70	36.10	461.20	33.97
Labour with Primary Ed.	103.90	7.37	2.10	4.05	101.80	7.50
Labour with Secondary Ed.	46.41	3.29	0.47	0.90	45.94	3.38
Labour with College Ed.	119.21	8.46	4.74	9.14	114.47	8.43
Capital Land Rural	103.12	7.32	-	-	103.12	7.60
Capital Livestock Rural	38.73	2.75	-	-	38.73	2.85
Non Ag capital	518.18	36.76	25.80	49.80	492.38	36.27
Total	1409.45	100.00	51.80	100.00	1357.65	100.00

Source: Authors' calculation from Ethiopian SAM 2010/11(IFPRI) and SAM 2015/16 (PSI)

There has been the greatest ICT infrastructure investment and of course, there is a significant increase in the introduction and consumption of ICT goods and services in recent times. Under normal circumstances, the prevalence of new technology could increase the relative demand for different types of labour leading to corresponding changes in their relative wages. However, in the Ethiopian context, given that the ICT service sector is at its infant stage of development and is driven by ICT investment-infrastructure development, the type of labour that is highly demand is unskilled labour and thus the contribution of unskilled labour is higher compared to other labour types.

Table 4.4 presents the consumption structure of ICT by household type in 2010/11 and 2015/16 in urban and rural areas. Accordingly, at the household level, the share of ICT expenditure in total expenditure of the households was about 4.79 per cent in 2010/11

and 4.32 per cent in 2015/16. The data also show that the proportion of expenditure on ICT goods and services by urban households exceeded that of the rural household expenditure. Rural household expenditure is 3.35 per cent of their total expenditure in 2010/11. The urban household expenditure for the same period was 8.35 per cent.

In 2015/16, the share expenditure on ICT goods and services among rural households closed the gap and approached those of the urban households. The share of expenditure on ICT goods and services for urban households declined to 4.59 per cent of their total expenditure, while the corresponding share for rural households increased to 4.15 per cent. This could be explained by the expansion of ICT services to rural areas and a decline in the access and usage cost in urban areas.

As the third column of Table 4.4 shows, rich households of both rural and urban areas spent relatively the highest ratio of expenditure on ICT goods and services to total expenditure in both 2010/11 and 2015/16. In 2010/11, rural rich households spent 4.57 per cent of their total expenditure on ICT goods and services and urban rich households spent about 8.88 per cent of their expenditure on ICT goods and services. Likewise, in 2015/16, rural rich households spent 4.77 per cent of their total expenditure on ICT goods and services, while urban rich households spent 4.80 per cent of their expenditure on ICT goods and services.

Column 4 on Table 4.4 presents the share of each household group expenditure in total ICT goods expenditure. Accordingly, the urban rich spent the most followed by the rural middle-class households. Specifically, 42.76 per cent of the total ICT expenditure was made by the urban rich households and 27.61 per cent of the total ICT expenditure was covered by rural middle-class households in 2010/11. Rural rich households paid about 18.39 per cent of the total ICT expenditure while the urban middle-class expenditure on ICT goods and services is only 7.05 per cent in 2010/11.

In 2015/16, the share of expenditure on ICT goods and services by rural middle-class households stood at 37.11 per cent followed by 24.78 per cent of the total ICT expenditure by the urban rich households. The share of ICT expenditure by the rural rich households is 13.31 per cent and the ICT expenditure by the urban middle class is 13.33 per cent of the total ICT expenditure.

Table 4.4 Consumption patter of ICT by Household type

Household types	2010/11			
	ICT Expenditure (Billion Birr)	Total Expenditure (Billion Birr)	ICT share in Total Expenditure (%)	Share in total ICT Expenditures (%)
Rural Poor	0.79	33.58	2.36	3.90
Rural Middle class	5.61	187.04	3.00	27.61
Rural Rich	3.74	81.76	4.57	18.39
Rural Total	**10.14**	**302.38**	**3.35**	**49.90**
Urban Poor	0.06	1.10	5.29	0.29
Urban Middle class	1.43	23.02	6.23	7.05
Urban Rich	8.69	97.83	8.88	42.76
Total Urban	**10.18**	**121.95**	**8.35**	**50.10**
Total Households	20.32	424.33	4.79	100.00
Household types		2015/16		
Rural Poor	6.14	166.74	3.68	10.35
Rural Middle class	22.02	535.80	4.11	37.11
Rural Rich	7.90	165.65	4.77	13.31
Rural Total	**36.06**	**868.19**	**4.15**	**60.77**
Urban Poor	0.66	20.00	3.32	1.12
Urban Middle class	7.91	180.25	4.39	13.33
Urban Rich	14.71	306.44	4.80	24.78
Total Urban	**23.28**	**506.69**	**4.59**	**39.23**
Total Households	59.35	1374.88	4.32	100.00

Source: Authors' calculation from Ethiopian SAM 2010/11(IFPRI) and SAM 2015/16 (PSI)

ICT as enabler

The discussion in this sub-section will delve into the role of ICT as an enabler. The previous discussion of ICT's contribution to GDP (as a producer of final goods and services) is a narrow way to look at the economic contribution of the sector. Apart from producing final goods and services for consumption and investment, ICT is an intermediate input and supports the production process in non-ICT sectors. This means a shock to the ICT sector will have far-reaching consequences.

In this sub-section, we will present the total impact of a shock to ICT in two parts. The first part discusses the production linkages, i.e., focusing on the direct and indirect effect of creating an exogenous demand shock for ICT goods and services emanating for production, which will help us easily demonstrate how the multiplier analysis works.

However, as production increases, the income of households will increase, leading to more demand for consumption, which is referred to as the consumption linkages. Hence, the second part discusses the total effect or the SAM multiplier, which companies the production as well as consumption linkages.

Production Linkages/ Input-Output Multiplier

Activities buy intermediate inputs (goods and services) in the commodities market and hire land, labour, and capital in the factor markets. The payment for factors in the factor market is the value added by the sector. The total value of output or outlay is the sum of the intermediate inputs and value-added of the sector. Table 4.5 shows the volume of intermediate inputs and the total value of output for ICT and non-ICT activities/sectors for Ethiopia in 2015/16.

In 2015/16, ICT output was valued at 70.5 billion ETB. ICT activity used ICT goods and services amounting to 4.6 billion ETB as intermediate inputs. The non-ICT sectors also used ICT goods and services amounting to 33.9 billion ETB as intermediate inputs.

Table 4.5 shows that the intermediate input for the ICT sector was mainly provided by the non-ICT sector (14.1 billion ETB) and only 4.6 billion ETB came from the ICT sector itself.

Table 4.5 Input Output Table for two sectors 2015/16 (billion ETB)

Items	ICT Activity/Sector	Non-ICT Activities/Sector
ICT goods and services use (Intermediate inputs)	4.6	33.9
Non-ICT goods and services use (Intermediate inputs)	14.1	661.8
Factor payment (Value-added)	51.8	1357.7
Total Output	70.5	2053.3

Source: Authors' calculation from Ethiopian SAM 2015/16 (PSI)

From the matrix of input-output shown (see Table 4.5), we can estimate the corresponding technical coefficient matrices and the Leontief inverse matrices for the two aggregated sectors.

Table 4.6: Technical coefficients matrix for the two sectors, Ethiopia 2015/16

	ICT Sector	Non-ICT Sector
ICT products	0.0653	0.0165
Non-ICT Products	0.2000	0.3223

Source: Authors' calculation from Ethiopian SAM 2015/16 (PSI)

Using the technical coefficient, an exogenous increase of 10,000 ETB worth in demand for ICT commodities will lead to intermediate input demand (i.e. ICT sector to itself) increase by 625 ETB (row1, column 1) and non-ICT sector input by 2000 ETB (row 2, column 1). The total increase in the value of intermediate demand due to an exogenous increase of 10,000 ETB shock in the ICT sector leads to a 2653 ETB demand increase (i.e. 653 +2000 ETB) in the first round.

To produce the 625 ETB ICT goods and 2000 ETB non-ICT goods will lead to another round of intermediate demand. The process will continue, and the total impact will be the sum of the exogenous shocks and the endogenous demand increase as the result of the sectoral interlinkages.

Similarly, an exogenous demand increase worth 10,000 ETB in non-ICT goods and services leads to a first-round endogenous demand of 165 ETB in ICT sector goods.

Similar iteration will lead to a total impact on the economy. Table 4.7 presents the total impact of an exogenous shock to ICT and non-ICT to measure the extent of production interlinkage between the ICT and non-ICT sectors.

Table 4.7: Leontief inverse matrix for 2015/16

Items	ICT Commodity	Non-ICT commodity
ICT sector	1.0754	0.0262
Non-ICT sector	0.3174	1.4833
Output Multiplier	1.3928	1.5095

Source: Authors' calculation from Ethiopian SAM 2015/16 (PSI)

Table 4.7 shows that a 1 unit increase in ICT commodity demand leads to a 0.32 unit increase in demand for non-ICT goods. In comparison, a one-unit increase in non-ICT exogenous demand will only lead to a 0.026 unit increase in production of the ICT sector.

Continuing with the previous example, Table 4.7 shows that the total impact of an exogenous demand shock to ICT goods will lead to a total increase in output equal to 13,928 ETB (i.e., 10,754 for ICT and 3,174 for non-ICT). In other words, the output multiplier for the ICT sector is 1.39. The analogous figure for the non-ICT sector is 1.5

that is for an exogenous demand increase worth 10,000 ETB in the non-ICT, the output will increase by 15,095 ETB.

SAM Multiplier Analysis

As discussed in the methodology section, the total effect on the economy is the sum of the production and consumption linkage. Table 4.8 discusses the total impact of an exogenous increase in the demand for ICT goods and services. As shown below, a 1 unit exogenous shock in ICT goods and services demand will lead to a 0.43 unit increase in GDP, more than the production linkage indicates.

Table 4.8: Total Impact for one unit increase in ICT demand

	Output Multiplier	Value-added Multiplier
ICT Exogenous shock (1)	2.03	1.43

Source: Authors' calculation from Ethiopian SAM 2015/16 (PSI)

Conclusion and recommendations

The simple exercise has shown that the ICT sector has contributed above 4 per cent to the GDP and has become increasingly integrated into the international market, contributing to expanding and diversified export. Domestically, rich households in urban areas consume ICT goods and services. However, the urban-rural divide has come down over time, and both rural and urban rich spent a similar share of their expenditure on ICT goods and services in 2016. A potential explanation could be the fall in the relative price of ICT commodities, particularly in services, in urban areas and service expansion in rural areas. In terms of the employment impact, unskilled labour contributes the most to the ICT sector, followed by highly skilled labour (that have tertiary education). This could be explained by the fact that Ethiopia's development in Ethiopia has been characterized by expansion of communication infrastructure and urban centred value-added ICT services are in the early stage of development.

Moreover, we have shown that the ICT sector gives a big boost to non-ICT domestic production. This indicates that investments in the ICT sector trigger a chain of actions and reactions that significantly increase the production of the national output. This virtuous multiplier effect is mainly due to the pervasiveness of ICT and its ability to spread quickly in the economic fabric. The increasing use of ICT in many companies is changing the production techniques, improving the production times and efficiency. In addition, the widespread use of ICT can open new production lines, which in turn develop and distribute ICT applications. This work is a starting point for further research on the effects of technology on the country's economic growth. The next goal is to update the I-O analysis when the latest data is available.

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