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Estimation of detailed macroeconomic data using general equilibrium modeling for Ethiopia.

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Abstract

A detailed and updated macroeconomic database is crucial for providing a thorough description of economic structure, developing economic models, and conducting several policy analyses. As a result, several statistical methodologies are dedicated to constructing, updating and balancing the social accounting matrix(SAM). However, this thesis employs an economic model, i.e., the computable general equilibrium model (CGE), to estimate an updated social accounting matrix (SAM). Based on economic theory, this methodology introduces an exogenous shock to some macroeconomic variables. Then new SAM is extrapolated based on the set of equations and behavioral parameters. This methodology is applied to estimate SAM for Ethiopia, updated to 2019. After estimation, the results are used to highlight the significant changes in the economic structure of Ethiopia. Thus, the results indicate that there is an improvement in the real GDP of Ethiopia. This growth is driven by increased productivity, high output multiplier effect, and strong backward linkage in the industrial and service sectors. This improvement is an outcome of high public-led investment that focuses on the industrial and service sector. However, these two sectors have a lower share in export earnings and total employment compared to the agriculture sector. Moreover, there is a shift in household consumption preference to domestically produced commodities due to income and price effects. Therefore, this shift along with the outward-looking trade policy, improved merchandise commodities' trade balance.

Keywords

SAM , CGE model, Ethiopia, GTAP database, GTAP model

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Abbreviations

SAM	**S**ocial **A**ccounting **M**atrix
CGE	**C**omputable **G**eneral **E**quilibrium
GTAP	**G**lobal **T**rade **A**nalysis **P**roject
WEO	**W**orld **E**conomic **O**utlook
IFPRI	**I**nternational **F**ood **P**olicy **R**esearch **I**nstitute
WBG	**W**orld **B**ank **G**roup
AfDB	**Af**rica **D**evelopment **B**ank
EFY	**E**thiopian **F**iscal **Y**ear

I. Introduction

1.1 Background of the study

There is an increasing demand for a detailed database for policy analysis and the development of new economic models. Thus, detailed macroeconomic data, i.e., social accounting matrix(SAM), helps provide detailed data on the current economic activities within the economy. For instance, SAM is crucial when implementing comprehensive models such as the computable general equilibrium (CGE) model. Therefore, there are several works on constructing social accounting matrix (SAM) based on various methods. However, frequent construction of a new SAM is challenging and costly, which is the other major issue discussed in the literature (Robinson et al., 2001). This is because the construction of SAM is supplemented by data collected from several sources such as national accounts, Input-Output tables, labor force surveys, household surveys, and government accounts. Hence the availability of consistent data within the same time frame is one of the main challenges. So, updating the existing SAM based on the available information is mainly used to estimate new SAM. Hence there is vast literature dedicated to estimating a new SAM by employing several methods such as RAS, minimizing linear difference, minimizing cross-entropy, High Posterior Density(HPD) as well as updating the GTAP database (Thurlow and Wobst, 2003; Saluja and Yadav, 2006; Breisinger et al., 2007; Douillet et al., 2012; Britz, 2021).

Estimating an up-to-date SAM also provides several advantages for least developed countries like Ethiopia. Detailed data on current economic activity is helpful for various development-oriented policy analyses. Moreover, a database that provides ample information on the interaction between economic sectors is useful in drawing reliable policy conclusions. Initially, the Ethiopian Development Research Institute (EDRI) constructed the first SAM for Ethiopia in collaboration with the European Commission-Joint Research Center (JRC). The institute developed three SAMs, and the first SAM was estimated in 2007 based on data from the 2001/02 (EFY). This was followed by new SAMs based on the EFY of 2005/06, 2010/2011, and 2015/2016, respectively (Mengistu et al., 2019). The most recent national SAM was developed by the Nexus project in collaboration with International Food Policy Research Institute (IFPRI) in 2018. This SAM was based on the standard Nexus SAM Structure, which disaggregates domestic production sectors into 42 activities and factors of production into the land, capital, and three labor categories (Aragie and Thurlow, 2021).

The approaches used in updating the SAM are based on an iterative algorithm, information theory, or minimizing the entropy motivated by the Bayesian view and maximum likelihood estimation. For instance, the cross-entropy method attaches probability distribution to the prior information based on the row and column sum. Then this is solved numerically to find a coefficient matrix that minimizes the distance between the initial and new coefficient matrix. However, an economic model can also be used to update the existing SAM databases. An economic model such as the general equilibrium model can update the existing database with recent data or projections (Roson and Britz, 2021; Diffenbaugh et al., 2012; Boulanger et al., 2016).This approach introduces exogenous shock to selected macroeconomic aggregates to estimate new SAM relying on the interlinkage between different economic sectors. More specifically, the structural equations in the model are iteratively solved to extrapolate new estimates after implementing an exogenous shock.

Moreover, it is crucial to acknowledge that the CGE model entails some limitations in terms of assumptions, choice of parameters, and functional forms, as in other economic models (Iqbal et al., 2001). However, this model provides flexibility in capturing the available information, i.e., several economic shocks. In addition, this model has a stronger foundation in economic theory, which helps provide interpretable estimates. In particular, it is useful in capturing and explaining the consequent outcomes using economic intuition. Therefore, this thesis employs general equilibrium modeling to estimate Ethiopia's recent detailed macroeconomic database updated to 2019. Mainly by considering the compounded average changes to selected economic aggregates such as value-added by sector, private and government consumption expenditure, import and export value, and demographic changes within 2014-2019. Then the updated database is used to describe the significant changes in the Ethiopian Economic structure. Mainly the changes in the composition and magnitude of value-added, cost structure, household income, household demand, and employment, based on the sectoral disaggregation.

1.2 Objectives of the study

The general objective of this study is to estimate global SAM for Ethiopia updated to 2019. More specifically, this thesis aims to:-

- Provide a detailed macroeconomic database disaggregated into ten production activities, six factors of production, and two regions.

- Provide a descriptive assessment of the consequent changes in sector output and cost structure composition since 2014.

- To describe the changes in the total employment and labor composition by skill level in each sector.

- Provide a descriptive assessment of the changes in household consumption behavior and income within the five years.

- Describe the changes in the trade sector performance in Ethiopia within five years.

1.3 Significance of this study

As part of the growth and transformation plan, there are ongoing development-oriented studies conducted by different national and international organizations. These studies aim to provide solutions to the existing socio-economic challenges, such as stabilizing inflation, poverty reduction, sustainable economic growth, trade liberalization, and other economic issues. Thus, several studies use SAM since it provides a detailed structure of an economy. This database provides detailed information on production, income, investment, trade flow, consumption, and other economic activities. However, one of the main challenges in conducting these studies is the lack of a detailed and updated database. Therefore, this study has significance in providing a detailed macroeconomic database, updated to 2019, and supplementing upcoming economic policy analysis.

1.4 Methodology and data source

1.4.1 Data source

This experiment used the GTAP global SAM to estimate a new detailed macroeconomic database for Ethiopia. This database depicts the magnitude of economic variables, presented on aggregate terms and suitable for computable general equilibrium modeling. Coordinated by the center for global trade analysis, the global trade analysis project (GTAP) was founded in 1992 by Professor Thomas W. Hertel in the Department of Agricultural Economics at Purdue University. The GTAP database provides a consistent representation of the world economy for a pre-determined reference year. This database is based on national Input-Output tables, which are supplemented by various international datasets and cover 121 countries, 10 aggregate regions of the world, and 65 sectors in each region.

Constructing a new SAM requires lengthy and costly data collection, so the GTAP database is updated every three to four years. Thus, the most recent database, i.e., the GTAP version 10 database with the reference year of 2014, is used as a baseline in this experiment. This global SAM, with 141 regions, 65 sectors, and 6 factors, is updated to estimate a new database. The database is updated based on the average percentage change in major macroeconomic variables within the five years. Thus, to compute the percentage change, recent data on demography, value-added by sector, private household, and government final consumption expenditure in Ethiopia are collected from the National Bank of Ethiopia (NBE). Moreover, data on the value of exports and imports of goods and services are collected from Trade Map. This data bases the input tax credit calculation on Ethiopian Revenue and Customs Authority and UN COMTRADE statistics. Lastly, data on gross value added and demography of the rest of the world is collected from the World Development Indicators(WDI) database provided by the World Bank(WB).

1.4.2 Simulation method

This updating experiment is based on the standard computable general equilibrium (CGE) model that GTAP provides along with simulation software, i.e., RunGTAP. This model describes the interaction between economic sectors and the sectors reaction to a given change in policy, technology, and other exogenous factors. The standard GTAP CGE model is widely used in implementing several studies on trade policy, global climate change, economic growth, and other policy issues. So, it is advantageous to use a model that is widely applied and tested to estimate a reliable database. A detailed description of the standard GTAP CGE model is provided in the structure of the GTAP paper by (Hertel and Tsigas, 1997).

Primarily, disaggregation of sectors, factors, and regions is implemented in GTAPAgg software. This software is used to prepare a database for the GTAP economic model. It is mainly used to prepare an aggregation scheme that is a mapping system between sectors, factors, and regions of the original GTAP database. At first, the GTAP-10 database considers five factors of production: skilled and unskilled labor, capital, land, and natural resources. Then labor is further disaggregated based on the latest broad labor classification focused on skill level. This classification considers the education level or on-job training required to perform the tasks and duties for each occupation. Thus, labor is classified as high, medium, and low skilled based on the latest international standard classification of occupations (ISCO-08 and ISCO-88), as shown in Table C.1. Moreover, the GTAP database considers 65 sectors, classified according to the UN general classification of international standard industrial classification (ISIC) and current population survey (CPS). This sectoral aggregation is then mapped with the list of sectors provided in the national account of Ethiopia to form ten sectoral aggregations, as depicted in Table A.1. Lastly, the regional aggregation comprises Ethiopia and the rest of the world, forming two regions. So, an aggregation scheme of ten production sectors, six factors of production, and two regions is prepared prior to simulation.

After preparing the database, i.e., the global SAM of 2014 is used as a baseline to estimate the new SAM. The estimation method introduces exogenous shock to main macroeconomic variables, such as the percentage change in value-added, private households and government expenditure, and population size between 2014 and 2019. Moreover, percentage changes in trade sectors, mainly imported and exported value changes, are incorporated as an exogenous shock. The compounded annual growth rate(CAGR) of value-added, export and import value, and household expenditure is calculated to consider average growth rate. Furthermore, this macroeconomic variables are measured at the current price so that the values may be overstated or understated due to price change, i.e., inflation. Hence, the GDP deflator is used to calculate the real percentage change of the abovementioned variables. Then, after introducing the real percentage changes to the model, the sets of differential equations and parameters are iteratively solved to extrapolate an updated database.

This study used RunGTAP software, a visual interface, to run the simulation. This software provides single-step and multi-step solution methods. The single step solution method, known as the Johansen method, is a linear solution method that considers the model as a linear system. However, this method does not provide an accurate result for the non-linear GTAP model and when there is a larger exogenous shock in the model. Thus, non-linear solution methods are used to reduce linearization errors, such as a multi-step Eulers', midpoint, modified midpoint(Graggs), and other non-linear solution methods.

The Euler solution method employs one sided derivative estimate to move from n to n+1, given an initial value. It a well known method for solving an initial value problem (Pearson, 1991). Given the initial condition as $y = y_0$ when $x = x_0$ and the first order derivative $\frac{dy}{dx} = f(y, x)$ for all y, x, the Euler method calculates the solution of the initial value problem first by dividing the interval from x_0 to x_1 in N equal steps as:

$$h = \frac{x_1 - x_0}{N}$$

Then $x^{(s)} = x_0 + s * h$ for $0 \leq s \leq N$ number of solutions. Thus, given that $x^{(0)} = x_0$ then $x^{(N)} = x_0 + N * h$ for N number of solution.

Then given the initial condition, $y^{(0)} = y_0$ and the estimate of y as $y^{(s)}$ when $x = x^{(s)}$, the derivative of y at a point x is used to calculate $y^{(s+1)}$ as shown below:

$y^{(s+1)} = y^{(s)} + h * f'(y^{(s)}, x^{(s)})$ for $0 \leq s \leq N - 1$ number of steps and h step size. And this is an estimate of y when $x = x^{(s+1)}$.

And as $N \rightarrow \infty$, y$^{(N)}$ is calculated as the estimate of the y_1. That is

$$\lim_{N \to \infty} y^{(N)} = y_1$$

this means that for any given assigned tolerance $\epsilon > 0$ there is a finite value of N such that $\|y^{(N)} - y_1\| < \epsilon$. Moreover, based on theorem 5.1 in Pearson (1991), if $f(x, y)$ is infinity differentiable and satisfies the Lipschitz condition then convergence of $y_1^{(N)}$ to y is guaranteed for a given non-zero vector.

However, the Euler solution method provides an accurate result when there is a smaller number of steps since it has lower order accuracy (Pearson, 1991). Therefore, another solution method i.e., the modified midpoint(Graggs) method, is used to provide accurate results when there is a higher number of steps by using a centered estimate. So given the above initial condition, step size and $f'(x, y)$, the estimate of y when $x = x^{(s+1)}$ is calculated as:

$$y^{(s+1)} = y^{(s-1)} + 2h * f'(y^{(s)}, x^{(s)})$$

for $0 \leq s \leq N - 1$. This method diverges from the Euler's method since it uses $N + 1$ calculation to approximate the value of y at a point x. This means that the estimate of $y^{(2)}$ is based on $y^{(0)}$ and the derivative of y with respect to x at $x = x^{(1)}$. So this solution method is a good approximation of y and provides an accurate result (Pearson, 1991).

In addition, a multi-step solution approach reduces errors by dividing exogenous shocks into specific components. For instance, a 5 % increase in value-added in the grains and crops sector is computed as two consequent increases of 2.44%. Thus, the first 2.44% shock is implemented as a first step which generates an updated database. Then, the new database is used to implement the second half shock of 2.44%, leading to the total increase of $1.0244 \times 1.0244 = 1.05$. Consequently, the size of the errors is reduced since the errors are proportional to the size of the shock. So, halving the exogenous shock leads to less than half-size error than the error produced when considering a 5% shock. Thus, dividing the shock into specified components minimizes error and provides accurate results. Therefore, this study employs a multi-step Gragg's solution method. Specifically, two Gragg's solutions are used with 2-steps and 6-steps per solution to estimate the new macroeconomic database.

1.5 Organization of this study

This thesis is organized based on five sections. The first section includes an introduction followed by a literature review in the second section. The third section consists of a description of the social accounting matrix and the general equilibrium model. The fourth part includes discussion of the results followed by a conclusion in the last section.

II. Literature Review

Input-output tables, developed by Wassily Leontief in late 1930, analyze the interdependence of industries or sectors in an economy. These tables describe a system of linear equations that are organized to capture the flow of products from a producing sector to the final consumption of the product. An extension of the input-output table is the Social Accounting Matrix (SAM) which further includes the circular flow from factor payment to final demand for products and income. It is a square matrix, with each cell representing the payment from the column account to the row account. This matrix is essential for macroeconomic, and microeconomic policy analysis. This is because the matrix contains a detailed record of economic activities and interactions between different economic agents. The first concept of the Social Accounting Matrix (SAM) was introduced by Stone (1961) at the "Cambridge growth project" in Cambridge, UK. The matrix was built to represent the national account which was later further developed in the world bank by Pyatt et al. (1976).

There have been several papers devoted to constructing SAM based on aggregate data from input-output tables, national accounts, household surveys, and other sources. For instance,Cicowiez and Lofgren (2017) provided three methods to build a macro-SAM using cross-country data. Primarily, a single SAM with one activity, commodity, and aggregate treatment of savings and investment. It initially included data such as GDP at market prices, disaggregated tax payments, the balance of payment indicators related to factor income, and current transfers from the World Bank and IMF. Then the rest of the SAM cells are calculated based on the aggregate data provided. The other two method includes disaggregated treatment of the saving and investment. Next, a computer program is applied to construct cross-country SAM for 133 countries. Moreover, SAM can be constructed on a country basis by first constructing aggregated macro-SAM followed by disaggregation into micro-SAM (Reinert and Roland-Holst, 1992; Yusuf, 2006;

Althumairi, 2021). Furthermore, there have been several works that extended the standard SAM with further disaggregations. For instance, financial SAM was constructed with more disaggregation to incorporate financial assets and loans by adding capital and financial asset account of agents (Aslan, 2005; Hernandez, 2008).

Ethiopia faces several developmental challenges that require a comprehensive economy wide analysis to support policy-related decisions. For instance, policy issues include choices on development strategy for better economic performance, the role of expanded international trade, agriculture-led industrialization, and other policy-pressing issues. Therefore, a detailed database such as SAM is widely used in these studies. The first SAM for Ethiopia, based on economic flows in EFY 2001/02, was constructed in 2007. This SAM classifies 42 production activities, 61 commodity groups, five primary factors, two household groups, 17 tax instruments, trade margins, transport margins, government, investment, and the rest of the world. Then SAM, for the year 2005/06, was developed using the data system and economy-wide modeling to support policy analysis in the Ethiopian project of the Ethiopian development research institute (EDRI) and the Institute of Development Studies (IDS) Sussex project. The SAM contains 256 separate accounts, making it Ethiopia's first comprehensive SAM. The construction of this SAM involved three steps. First, an initial macro SAM was constructed based on the available aggregated data source. Then, this highly aggregated macro-SAM was disaggregated and balanced based on detailed information to create the "proto-SAM". The proto-SAM contains 99 activities with 65 differentiated agricultural activities, one aggregated forestry and fishery activity, 21 industrial activities, and 12 service activities. In addition, the matrix entails 14 households classified as rural and urban by income level. Thus, this matrix comprises regionally disaggregated agricultural production and income generation for Ethiopia's five main agro-ecological zones. (Tebekew et al., 2015).

Even though several cross or single-country social accounting matrices exist, the other main issue is updating the matrix based on recent data. Thus, various approaches were introduced to update and balance the SAM based on the available information. Stone and his colleagues developed the first bi-proportional technique to update and balance input-output tables, which is the RAS approach (Bates and Bacharach, 1963). Initially, the concept of the RAS method was introduced by

Kruithoff and Sheleikhovski (1930) and later adopted by Stone to update input-output tables. This method is an iterative method of bi-proportional adjustment of non-negative rows and columns, which is based on equality constraints. However, this method faces a challenge in balancing SAM when there are negative entries. As a result, this method was later extended to the generalized RAS method to account for negative matrix entries.

Initially, Günlük-Şenesen and Bates (1988) proposed a new RAS balancing technique that allows for balancing matrix with negative entries. Hence papers such as Thissen and Löfgren (1998) worked on updating the SAM with an application to a specific country by using the generalized RAS. This approach enables the input-output tables with negative entries to be balanced and updated. However, the preceding balancing techniques are based on the separate treatment of negative and non-negative entries. Thus, this approach is not feasible in providing an optimal solution. Junius and Oosterhaven (2003) reformulated this balancing technique to balance input-output tables that include both negative and positive entries. This was later further modified by Lenzen et al. (2007) with efficient control of zero entries and maximum information principle for an accurate result. Later balancing matrix with no positive entries i.e., a matrix with only zero and negative entries was proposed by Temurshoev et al. (2013).

There are several applications and extensions of the Generalized RAS (GRAS) approach for updating and balancing SAM based on the single, cross, and multi-regional country. For instance, Abela and Theuma (2021) applied GRAS method to estimate SAM for Malta. The GRAS method was employed mainly to update and balance SAM with negative values. The results indicated that the updated SAM represents more accurately the accounts of Maltese economy. In addition, Temursho et al. (2021) extended the generalized GRAS method to multi-regional generalized (MR-GRAS) method. This method is applicable to construct, update and balance supply and use table (SUTs), Input-output tables and SAMs on a national and international level. Moreover, papers such as Lahr and De Mesnard (2004); Jackson and Murray (2004) compared the bipropotional methods and concluded that the GRAS method provides a more accurate result.

Nevertheless, the experiment becomes a constrained optimization problem when there is bound to the available information. For instance, a lack of information on the total sum of a column leads to an inequality-constrained problem. Hence the G-RAS approach is not feasible for updating and balancing SAM when there is minimum information. As a result, Golan et al. (1996) suggested the maximum entropy econometrics method for updating and balancing SAM. It is a Bayesian estimation technique used to update Input-Output tables based on prior information on the total sum of the row and column of the matrix. This approach aims to estimate a coefficient matrix that minimizes the entropy distance between the prior matrix and the new matrix. However, this approach relies on the information on the column and row sum. In addition, this approach doesn't entirely solve the problem of incomplete information and the bi-proportional solution of the RAS method is a first-order condition for this approach. This was later extended to the cross-entropy approach to consider different kinds of prior information with inequality constraints and errors in measurement (Robinson et al., 2001). The cross entropy method is based on information theory and implements the Bayesian view, i.e., "Use all the information you have but do not assume any information". Thus, this method is used to recover and process an incomplete database when the sum of the column is not known. This approach considers the entropy of probability distribution as a measure that is attached to each support. The support provided is an initial value with prior probability with a particular distribution. Hence, given a new set of information, the cross-entropy method minimizes the distance between the attached probabilities.

The cross-entropy method is vastly used in the literature. For instance, Robinson et al. (2001) applied a cross-entropy method to update and balance the social accounting matrix for Mozambique with 55 activities and commodities. This was implemented by first constructing detailed prior SAM with aggregate entries for factors and households. Then cross-entropy method was used to update the prior matrix by dealing with errors and further disaggregating across households and factors. Moreover, Davies and Thurlow (2013) updated SAM for South Africa, first by collecting data from different sources to build the prior SAM, then balancing the matrix based on the cross-entropy method. Similarly, more studies implemented the cross-entropy method to update and balance SAM based on the available set of information (Thurlow, 2008; Lemelin et al., 2013; Causapé et al., 2018).

In addition, the cross-entropy method is used to disaggregate and balance the existing SAM to include further classification of activities. For instance, the GTAP database, global SAM, was further disaggregated to account for the different electricity generation technologies to form the GTAP-power database. First, the GTAP version 9 database is disaggregated based on two electricity generation technologies, base and peak load. Then the cross-entropy method is used to balance the disaggregated database (Peters, 2016; Chepeliev, 2020). Similarly, the GTAP database is disaggregated to include different types of croppig activity. The cropping activity was primarily disaggregated to rainfed and irrigated to form the GTAP-water database. Then, cross-entropy was used to balance the disaggregated database (Haqiqi et al., 2016).

Ethiopia's 2010/2011 social accounting matrix was developed and balanced using the cross-entropy method. This was organized by the Nexus project led by International Food Policy Research Institute(IFPRI). Initially, the first macro-SAM was constructed based on an initial input-output table and three data sources: national accounts, government financial surveys, and balance of payments. Then, this macro-SAM is further disaggregated into 75 sectors based on crop production and price data from FAOSTAT. The factors of production, mainly labor, were further disaggregated based on sector-level worker and household income shares. In addition, households' income and expenditure were disaggregated across representative households. After disaggregation, balancing the SAM was carried out using the cross-entropy method (Ahmed et al., 2017).

Later in 2015/16 new SAM was constructed jointly by the Ethiopian development research institute, the policy studies institute, and European Commission-Joint Research Centre (JRC). The estimation of this SAM differs from the previous SAM as the construction of the prior SAM was solely based on microdata. Afterwards, the microdata was aggregated to form a macro-SAM. Then the RAS and cross-entropy methods were employed to balance the updated matrix (Mengistu et al., 2019). Recently 2018 SAM was developed by the Nexus project in collaboration with IFPRI and its partners. This SAM was based on the standard Nexus SAM Structure, which disaggregates domestic production into 42 activities, and factors are classified into the agricultural land, capital, and three labor categories. Labor is disaggregated based on three education categories. Representative households are classified based on rural areas, urban areas, and per capita expenditure quintile. The remaining accounts include enterprises, government, taxes, savings and investment, and the rest of the world.

Moreover, in collaboration with other various institutions, the nexus project estimated an updated SAM for some other African countries based on the standard Nexus SAM structure. For instance, the nexus project by IFPRI and CAPMAS estimated a 2019 SAM for Eygpt by updating the 2014/15 SAM. The Updated

SAM included 69 sectors, 73 products, ten households, and 13 factors of production. Then labor is further classified across the rural and urban areas and education levels. Similarly, capital is classified based on activities such as crops, livestock, mining, and others. Then the cross entropy method and RAS method were employed to balance the disaggregated SAM (Serag et al., 2021). Similarly, a 2013 SAM for Ghana was constructed based on the standard Nexus SAM structure. The SAM contains 55 activities, 56 commodities, and three factors of production and household classified based on region and income level. Then Cross-entropy and RAS method was applied to balance the disaggregated database (Ghana Statistical Services et al., 2017). Moreover, similar methodology and the standard nexus SAM structure were employed to update and balance national SAM for other countries (Siddig et al., 2018; Salhine et al., 2020; Randriamamonjy and Thurlow, 2017).

In addition, other methods of updating and balancing SAM are discussed in the literature, such as the linear loss method and High Posterior Density (HPD) method. The former aims to minimize the absolute distance between the original matrix and the unbalanced new matrix. The latter aims to minimize the squared distance between the two matrices. The HPD method is also based on the Bayesian criterion that maximizes the posterior likelihood of the error term with a particular prior distribution. The prior distribution is the raw data, along with the accounting identities. The high posterior density method provides accurate result when the error terms are normally distributed. However, the cross-entropy method provides accurate results when the error terms have other different probability distributions (Britz, 2021). In addition, Rodrigues (2014) proposed that bayesian approach to balancing and updating SAM is efficient when combining several data with different level of quality and source. Furthermore, Müller and Ferrari (2011), fit the CGE model into the observed macroeconomic variables to estimate future baseline scenarios. Then used the high posterior density(HPD) method to minimizes the distance between the matrices by adhering to the CGE model constraints.

Moreover, Fousseini et al. (2018) compared the Huber, OLS, and Hellinger methods of balancing the social accounting matrix. The OLS approach is based on finding a coefficient matrix that minimizes the squared distance between the old and new SAM. In contrast, the Huber minimization of the cost function minimizes the error term. The cost function takes quadratic form when the error terms are below a certain threshold and linear form when the error terms are above. The

Hellinger method is based on the minimization of Hellinger's distance, which is symmetric, between the new and old coefficient matrix of attached probabilities. Thus, after comparing these methods, the Huber and Cross-entropy methods effectively minimize the error and preserve factor intensity within sectors.

Updating a detailed database based on general equilibrium modeling is used to estimate new baseline database. This approach is based on introducing exogenous shocks to major economic drivers to account for policy-related or other significant changes within the economy. For instance, Boulanger et al. (2016) updated the GTAP version 9 database to separate the impact arising from the import ban between 2011-2014. They analyzed the short-run impact of the agri-food import ban. The updating method included exogenous shock to macro variables such as GDP, population, factor endowments, land productivity, and Croatian accession into the EU. Moreover, Diffenbaugh et al. (2012) Updated the GTAP version 9 database to generate baseline data for 2008-2020 and analyzed the impact of climate change on corn yield volatility. Similarly, an exogenous shock was introduced on macroeconomic aggregates such as total factor productivity, population, labor force, investment, ethanol production, and oil prices.

Moreover, a similar experiment can be used to construct a future baseline scenario. For instance, Roson and Britz (2021) presented the G-RDEM model to construct a long-run macroeconomic scenario with projected changes of key economic drivers at the global and regional levels. This model extends the CGE model to consider a non-homothetic demand system and sets saving as an endogenous variable. Moreover, in this model, productivity is differentiated across sectors; debt dynamic is included through foreign debt accumulation, and input-output estimates are updated to vary over time. Then, using this model, a long-run baseline scenario was estimated by introducing the projection of population size and GDP projection, which is collected from SSP3, as an exogenous shock to the model. In addition, Walmsley et al. (2006) constructed a baseline scenario for 11 regions based on the GTAP database and GDyn model. This experiment introduced the real growth rate in GDP, gross domestic investment, population, skilled and unskilled labor force, and tariff and quota as an exogenous shock to estimate a baseline scenario. In addition, another model, the USAG model, was employed to forecast the future baseline for USA commodities. This model was mainly used with the CGE model to forecast the future baseline for 500 USA industries (Dixon and Rimmer, 2009).

III. Structure and estimation of social accounting matrix for Ethiopia

3.1 Structure of Social Accounting Matrix (SAM)

A social accounting matrix (SAM) is a square matrix whose subsequent rows and columns present the incurred payment and corresponding receipt of economic agents. Each cell on the matrix represents a payment from the column to row account such as payment to labor as a factor of production. Let M_{ij} be the matrix of SAM transactions, where t_{ij} is a payment from column account i to row account j. Based on the convention of double-entry bookkeeping, the sum of the column must be equal to the sum of the row i.e., the total receipt must be equal to total expenditure as shown below:

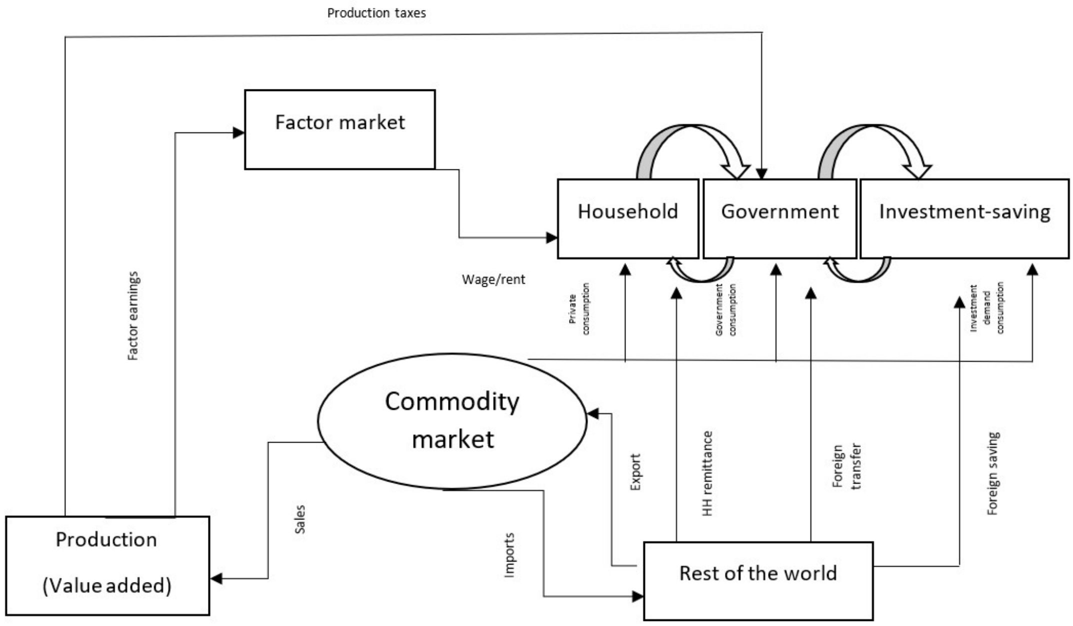
$y_i = t_{ij} = t_{ji}$

where y_i is the total receipt and expenditure of account i. Following this, the coefficient matrix is calculated as:

$$A_{ij} = \frac{t_{ij}}{y_j}$$

Which is by diving each entry in the cell by the total column sum. The column sum of the coefficient matrix must equal one, a singular matrix, since the column sum should be equal to row sums that is expressed in matrix notation as y = A. Thus, this convention implies that the SAM displays the total circular flow of goods and services and payments among production sectors and other economic agents. A simple graphical representation of this circular flow is shown in figure 1.

Figure 1. A graphical representation of the circular economic flow



Source: Causapé et al. (2018), Burfisher (2017), and own elaboration

Firms produce goods and services by employing land, labor, capital, and other primary and intermediate inputs as a factors of production. Then firms receive revenue from sales of the produced goods and services in the domestic market and exports to the rest of the world. In addition, producers incur production cost, which includes factor cost in the form of wages or rent and production tax paid to the government. On the other hand, households receive income as a return from labor, capital, land, and foreign transfers in the form of remittances. Then they allocate their income for consumption of domestic and imported commodities, savings, and income tax, as shown in figure 1. Lastly, after receiving revenue from income and production tax, the government allocates the revenue for public consumption of goods and services, public saving, and foreign transfer. Moreover, the investment demand for both domestic and imported goods and services compensated by using the total savings of the economy. Similarly, producers demand intermediate input both from domestic and foreign market.

A single country Social Accounting Matrix(SAM) generally includes seven basic accounts that are: commodities, activities, factors of production, private household, Government/public institution, and the rest of the world (ROW). The general representation of the social accounting matrix is shown in figure 2.

The activities account shows the costs and revenue from production activity. On the column activity account all the costs incurred for the production process, such as factor cost, production tax, intermediate inputs, and imported goods are indicated. Thus, the sum of this account is considered as the total cost of production. Moreover, the row account of activities records the revenue of producers from sales of commodities in the domestic and foreign markets to satisfy household, government, and investment demands. Thus, this account sums up the total output of the economy. The activity account can be further disaggregated based on economic sectors. In this study, the activity account will be disaggregated into ten sectors of the grain and crops, meat and livestock, mining and extraction, processed food, textile apparel, light manufacturing, heavy manufacturing, Utility construction, transport and communication, and other service sectors.

Figure 2. Simple representation of social accounting matrix

	Commodities	Activities	Factors	Household	Government	Saving-investment	ROW	Total
Commodities				HH consumptio n	Government expenditure	Investment expenditure	Export to ROW	Demand
Activities	Domestic production							Gross output production
Factors		Renumeration of factor					Factor income from ROW	Factor income
Household			Distribution of income to HH	Within household transfer	Government transfer		Transfer to HH	HH income
Government	Net tax on products	Net tax on production	Factor income tax	Direct household tax			Transfer to government from ROW	Government income
Savings-investment			Depreciation	Household savings	Government savings	Capital account transfer	Capital transfer to ROW	Savings
ROW	Import		Factor income distribution to ROW	HH transfer to ROW	Government transfer to ROW			Payment to ROW
Total	Supply	Cost of production	Expenditure on factors	HH expenditure	Government expenditure	Investment	Income from ROW	

Source: Causapé et al. (2018), Burfisher (2017), and own elaboration

The commodities account shows the flow of the produced goods and services. The row account includes the expenditure on domestic and imported commodities, net product tax, and other transaction costs. Thus, the private, government, investment, intermediate and foreign demand for goods and services sums up to be the total demand of the economy. In contrast, the column account shows the total supply of goods and services. Moreover, the following two accounts include household expenditure and income. On the column account, the expenditure on goods and services is included. Thus, this account adds up to the total expenditure of each household. On the other hand, the factor income, domestic and foreign transfer, is recorded in the row account. Then this is summed up to be the total income of each household. Next is the investment-savings account, that record the capital stock and saving in the economy. In the row account, household savings, capital inflow, and deprecation sum up to form the economy's total savings. On the other hand, the column account records all the investment expenditure and capital outflow that adds up to be the total investment in the country. The last account records the inflow and outflow of income, including exports and imports, on the row and column accounts, respectively.

3.2 General equilibrium modeling to estimate updated SAM for Ethiopia

The general equilibrium model captures the interaction between an economy's supply and demand side that is based on economic conditions. The model is based on the concept of the neo-classical theory that is cost-minimizing producer, average-cost pricing, optimizing household behavior, and market clearing assumptions. Therefore, the model is solved simultaneously to obtain sets of price and quantity to reach equilibrium between demand and supply. This model includes both exogenous and endogenous variables in which the model indicates the changes in endogenous variables following an external shock. In the standard GTAP CGE model, the top nest allocates value-added and intermediate inputs based on the Leontief function to produce the total output. Next, the value-added production nest allocates primary factors aggregated based on the constant elasticity of substitution (CES) function. This aggregation implies that there is a substitution between capital, labor, land, and natural resource. In contrast, the composite intermediate nest is based on Leontief's specification. Thus, there is no substitution between intermediate inputs. Lastly, firms distribute domestically produced goods and services to the domestic and foreign markets.

On the other hand, households allocate the regional income based on the Cobb-Douglas (CD) per capita utility function specified over three final demands: private household expenditure, government expenditure, and savings. Then private household demand, with non-homothetic nature, is specified based on the constant difference of elasticities(CDE) utility function. This function is based on calibrated income and own-price elasticity of demand. The government demand for goods and services is specified based on the Cobb-Douglas utility function. Moreover, households and firms combine domestic and imported commodities based on Armington (1969) specification. This specification assumes imperfect substitution between imported and domestic commodities depending on the composite prices. Thus, the consequent change in the endogenous variable is based on calibrated elasticity of substitution between inputs and commodities in each sub-nest.

This study uses this model to estimate a detailed macroeconomic database updated to 2019. Mainly, this is carried out by introducing the changes in the significant macroeconomic aggregates to the model. The macroeconomic aggregates include the sector's value-added, export, and import value. In addition, the changes in private household consumption expenditure, government consumption expenditure, and population are incorporated. This is because these variables are Ethiopia's major determinants of economic growth (Wolde, 2007; Gebru, 2015; Gebreegziabher, 2018; Degu et al., 2019). Moreover, this study conducted a simple correlation analysis to determine the association between economic growth and the abovementioned variables. Thus, the result shows a high association between the variables with the overall economic growth in Ethiopia, as shown in table 1. The figure shows the Pearson statistical correlation between the GDP per capita and the macroeconomic aggregates over time. Therefore, a positive and significant correlation exists between GDP per capita and consumption expenditure, import, export, and sectoral value added . On the contrary, there is a negative and significant correlation between GDP per capita and population growth rates. This roughly implies there exists a significant linear association between the economic growth rate and the macroeconomic aggregates over time.

TABLE 1

Pearson correlation coefficient between GDP per capita and major economic aggregates

	GDP_percapita	popn_growth	HH_exp	Gov_exp	Export	Import	agr_VA	Manuf_VA	Service_VA
GDP_percapita	1								
popn_growth	-0.900***	1							
HH_exp	0.996***	-0.913***	1						
Gov_exp	0.970***	-0.908***	0.953***	1					
Export	0.816**	-0.839**	0.848**	0.718*	1				
Import	0.910***	-0.682*	0.882***	0.880***	0.610	1			
agr_VA	0.951***	-0.920***	0.969***	0.894***	0.862**	0.762*	1		
Manuf_VA	0.956***	-0.965***	0.949***	0.981***	0.771**	0.807**	0.919***	1	
Service_VA	0.977***	-0.958***	0.988***	0.946***	0.867**	0.815**	0.980***	0.962***	1
* $p < 0.05$	** $p < 0.01$	*** $p < 0.001$							

Source: World development indicators(WDI) data, World bank 2019 and own estimation

Thus, a compounded annual growth rate (CAGR) between 2014 and 2019 is calculated for each aggregate variables based on the recent data. Then this percentage change is introduced to the model as an exogenous shock.

3.2.1 Total output by sector

In the production structure of the model, there is a total output nest, at the top, that aggregates the value-added and intermediate inputs based on the Leontief production function. This aggregation combines the composite demand for value-added and intermediate input for each production sector. Since the Leontief aggregation implies no substitutability between value-added and intermediates, the price variable is omitted (Hertel and Tsigas, 1997). The total output nest is represented in the equations below:

$$qva(j,r) + ava(j,r) = qo(j,r) + ao(j,r)$$

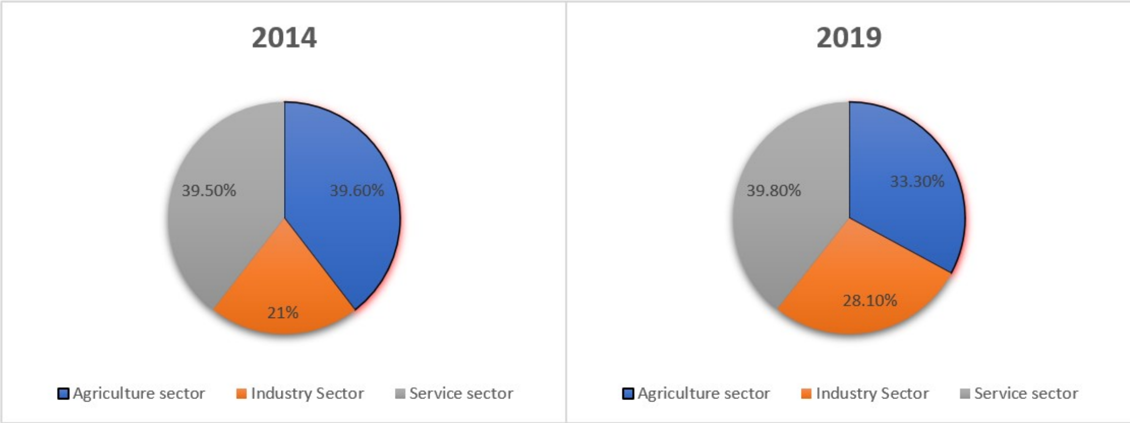
$$qf(i,j,r) + af(i,j,r) = qo(j,r) + ao(j,r)$$

In the above equation $ava(j,r)$ and $af(i,j,r)$ express the input augmenting technical change for value-added and intermediate inputs. Furthermore, the term ao(j,r) is the Hicks neutral technical shifter indicating a shift in the production process with lower input to get a specific output level. In the standard GTAP CGE model, the behavioral variables are in percentage change instead of levels(Hertel and Tsigas, 1997). Thus, the input augmenting technical change variables are expressed in percentage terms.

The value-added variable indicates the total output by each sector after netting out the primary factor cost incurred during the production process. For instance, the value added by the grains and crops sector is the value of yield after deducting the factor costs such as labor and land used. Thus, with CES aggregation, this production nest indicates the price and quantity demand for primary factors such as land, labor, and capital. The constant elasticity of substitution (CES) aggregation implies that there is substitution between factors of production. Then on the other side there is the intermediate composite nest. This nest, with Leontief aggregation, expresses the demand for intermediate inputs such as the demand for fertilizer to produce grains and crops. Thus, each production sector has a total production nest with corresponding quantity demand and price for each primary factor and intermediate inputs.

The changes in firm value added is crucial factor to consider since firm productivity has a major role in an economy. As depicted in Kimuyu and Eshete (2014), the productivity of economic sectors is one of the major economic drivers of the Ethiopian economy. For instance, the agriculture sector was the primary sector that contributed to the economic growth in Ethiopia. This sector employs a large portion of the labor force and has a strong correlation with other economic sectors like food processing industries. However, currently, there is an ongoing transformation of the Ethiopian economy from agriculturally based to an industry and service sector-based economy. According to the Ethiopian economic outlook on the African development bank report (2021), the economic growth of 8.4 percent was led by the service and industry sectors in 2019. In contrast, the share of the agriculture sector is lower than in previous years (AfDB, 2021). Hence, it is evident that the share of total output has changed in each sector over the five years, as shown in figure 3.

Figure 3. Sectors' share in GDP



Source: World development indicators(WDI), world bank 2019

According to the National Bank of Ethiopia (NBE) annual report (2019), grains crops production, animal farming hunting, and forestry production contributed the most to the agriculture sector output. In addition, the construction sector takes considerable credit for the growth in the industrial sector due to the expansion of roads, railways, and residential house constructions. The advancement in the share of the service sector is due to the increase in real estate and other service returns. The increased productivity in those sectors is related to many aspects of the economy. For instance, producers combine household factors and intermediate inputs from other production sectors. Thus, on the supply side, firms' productivity is influenced by labor supply, capital stock, and the supply chain in the economy. On the demand side, firms and households are influenced by total output, prices, and income. Moreover, institutional policies such as tax policy affect firms' production process. Thus, firm productivity is correlated with employment, income distribution, tax policy, exchange rate policy, and other factors. For these reasons, the total productivity of firms is one of the primary indicators of economic growth.

Moreover, firm productivity is highly interlinked with other economic agents, mainly through consumption and income linkage. For instance, the agriculture sector played a significant role in stimulating economic growth in Ethiopia through its direct and indirect impact on consumption and income (Tadele, 2004). Mainly for labor-intensive economies like Ethiopia, changes in firms' productivity are crucial in determining the labor demand and household income. So, the five-year compounded average change of sectors' value-added in Ethiopia is introduced into the model as an exogenous shock. This change in sectors value added is mainly driven by technical enhancement in production process. For instance, increased crop productivity means producing certain hectares of crops with less labor cost due to improved technology such as tractors. Thus, the change in sectors' value added is incorporated by shocking the value-added augmenting technical shifter (ava(j,r)).

Moreover, the average change in the gross value-added of the rest of the world is comprised in the analysis. This is due to the nature of the Ethiopian economy, i.e., small economy, import intensive, and externally dependent. Thus, the change in the global economy is crucial as it has a significant role in the Ethiopian economic performance. After the external shock, other economic variables adjust to the changes in quantity and prices, based on the model structure shown in Hertel and Tsigas (1997). For example, a decrease in the value-added of the grains and crops sector leads to a lower demand for labor and land as factor of production. As a result, households receive lower income which leads to a decrease in the final demand of goods and services due to the income effect.

3.2.2 Population

Ethiopia has a population size of around 112.9 million as of mid-2019. It is the second-most populous country in Africa due to a high population growth rate of 2.6 percent. The population size has a positive role in economic advancement since it increases labor endowment and household demand. More specifically, the population size affects future market demand through price and supply elasticity. On the contrary, population size has a negative impact when considering the scarcity of natural resources such as land. Mainly developing countries with high population growth rate that surpasses the GDP growth rate face negative economic consequence. For instance, there is a negative correlation between population growth rate and GDP per capita in Ethiopia as shown in table 1. In addition, according to Alemu (2014) there is a negative impact of high population growth rate in short run while high population size is an asset in the longer term.

Moreover, in the Standard GTAP CGE model, private household behavior considers the population growth rate, and the utility function is based on per capita income. Thus, echoing the Malthusian theory, the population growth rate surpassing the GDP growth rate in Ethiopia negatively affects the per capita income and private households' utility. According to Degu et al. (2019), an increase in population size leads to an increase in the quantity demand for goods and services. In contrast, high population size and high population growth rate led to reduced advancement in the Ethiopian economy. Hence, it is evident that the population growth rate changes impact economic activity, mainly in countries with high population growth rate.

The global population size increased by 5 percent over the five years. Similarly, the Ethiopian population size increased by around 14 percent. Hence, this percentage change in the total population in Ethiopia, from 2014- to 2019, is considered as one of the exogenous shocks. Similarly the change in the global population size is incorporated. This is because the CGE model is based on an open economy and the international flow of goods and services in the foreign market is incorporated in the model. Thus, domestic products' foreign demand and supply are captured under the total exports and imports account. In addition, labor endowment is impacted by the inflow and outflow of the labor force. Hence, it is crucial to consider the change in the population size of the rest of the world to estimate a credible macroeconomic database. Thus, this experiment comprises the growth rate in population size for both regions over the five years.

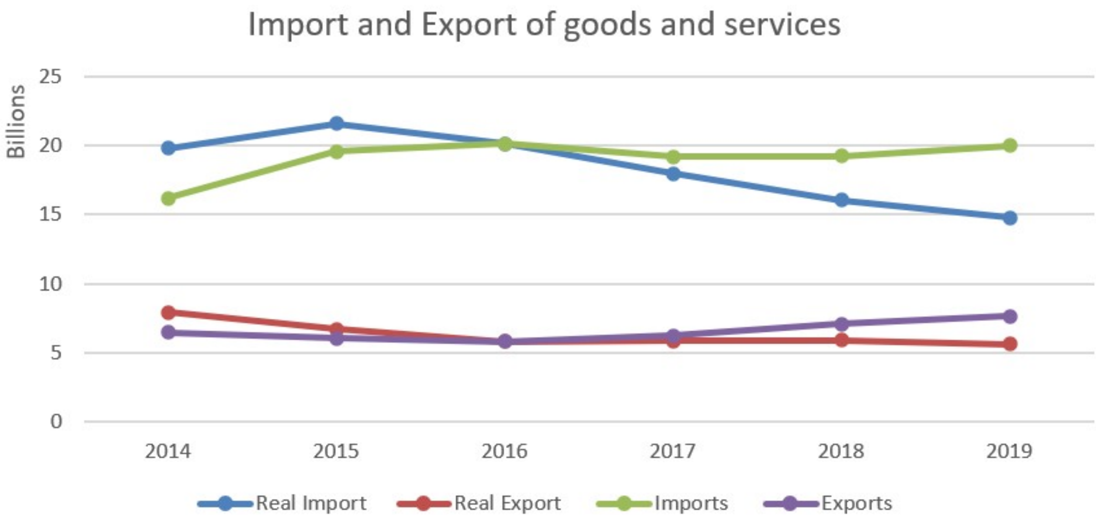
3.2.3 Trade Balance

The trade sector mainly imported capital good, is one of the major economic drivers in Ethiopia (Eshete and Kimuyu, 2014). This is because of the continuous increase in total imports in Ethiopia, which led to a persistent trade deficit in the balance of payment(BOP) over the past years. However, recently the total exports in Ethiopia have been expanding due to increased trade and outward looking tarde policy. For instance, according to the Ethiopian economic outlook on the African development bank report (2021), export revenue increased while the imported quantity declined. Furthermore, according to the National Bank of Ethiopia (NBE) annual report (2019), the overall balance of payment indicated a higher deficit, even though the merchandise trade deficit improved. This is due to the increase in the total annual export by 12 percent due to higher export earnings from coffee, flower, gold, live animals, khat, textile and apparel, and electricity.

This implies that higher merchandise export was recorded as compared to previous years.

Whereas the total merchandise import showed a decline, mainly due to decreased import of fuel, capital goods, and consumer goods. As shown in figure 4 there is an increase in the value of exports over the five years. But there is a decline in the value of imported goods and services. The change is lower when considering inflation but, there is still an improvement in merchandise trade.

Figure 4. Total value of imports and export of goods and services in Ethiopia



Source: World development indicators(WDI), World bank 2019

The trade sector plays a crucial role in facilitating the productivity of economic sectors and generating higher income. For instance, increased trade has a labor augmenting effect and leads to an increase in total employment in the manufacturing sector (Haile et al., 2013). Moreover, least developed countries like Ethiopia face a shortage of foreign currency due to the persistent current account deficit. As a result, increasing the foreign currency reserve through increased export earnings is one of the pillars of Ethiopia's second growth and transformation plan (Lelissa, 2015). For those reasons, the changes in imports and exports are crucial in determining the magnitude of growth in Ethiopia. Thus, the average change in the value of exports and imports is incorporated in the simulation. However, in the standard CGE model, the value of exports and imports are one of the endogenous variables.

Thus, these variables require to be exogenous to implement the shock in the model. Hence the shock is implemented based on two stages. Initially, Ethiopia's export and import value are set to be exogenous in the model closure. Then the import technical shifter for Ethiopia is set as endogenous to adhere to the economic conditions. After the transformation of the variables, the real five-year average change in the value of imports and export for all ten sectors is introduced as an exogenous shock. Then, other economic variables will adjust to the exogenous changes based on the established price, tariff and elasticity linkages between sectors in the model.

3.2.4 Government and private consumption expenditure

Having considered the changes in the economy's supply side, it is also essential to consider the changes in the household demand. Generally, household demand includes private households, government, and investment demand. Households distribute the total regional income according to the aggregate per capita utility function with Cobb-Douglas(CD) functional form as shown below:

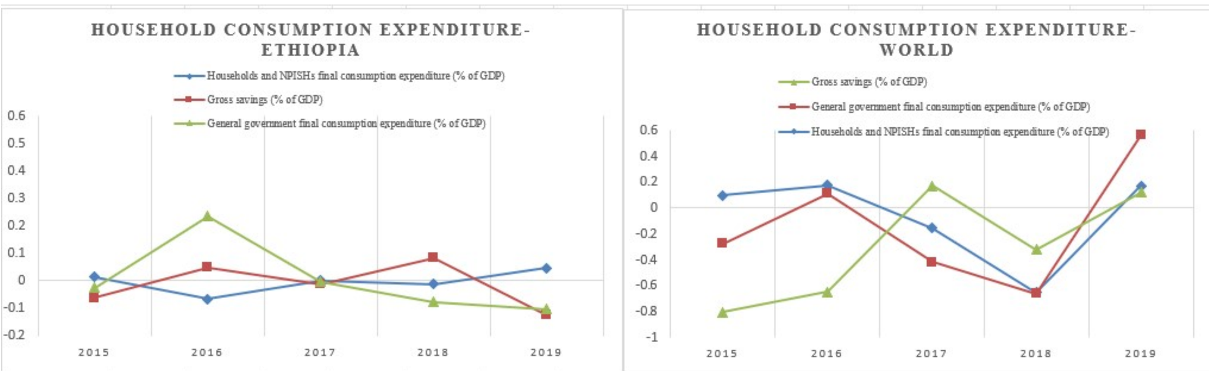
$$Y(r) * u(r) = p_{exp}(r) * up(r) + G_{exp}(r) * [ug(r) - pop(r)] + S_{exp}(r) * [q_{save} - pop(r)] \; ; \forall r \in REG$$

Hence, the overall income is distributed according to a certain percentage share of total income in the standard macroeconomic closure. This distribution implies that the real expenditure depends on income and prices (Hertel and Tsigas, 1997). Thus, consumption expenditure reflects the household preference and is interlinked with regional income and prices.

Over the years, there has been an increase in private household consumption expenditure. The global private consumption expenditure increased by 9.5 percent in nominal terms from 2014- to 2019. At the same time, the global public consumption expenditure increased by 71.4 percent over the five years. In addition, according to the National Bank of Ethiopia (2019), there is an increase in Ethiopia's household expenditure. This increase is mainly due to the high growth of private consumption expenditure by around 79.1 percent annually and 68.7 percent over the five years. The public expenditure contracted by 9.1 percent in 2019 annually but expanded by 71.4 percent over the five years. This increase resulted in a decline in the share of savings in the economy.

Moreover, the share of private households' expenditure in GDP is relatively higher than the share of saving, as shown in figure 5. Mainly, the share of private household expenditure in GDP increased in Ethiopia from mid-2016. The share of savings in Ethiopia declined starting from mid-2018. The share of government expenditure in GDP increased highly in 2016 but gradually declined over the five years. Moreover, the global share of private household and government expenditure fluctuated over the five years. Starting from mid-2018, the share of government and private household expenditure increased highly relative to the share of savings in GDP. Thus, these changes in household expenditure are captured in the analysis to estimate the new database.

Figure 5. Annual percentage change in the share of household expenditure and savings in GDP, 2014-2019



Source: World development indicators(WDI), World bank 2019

According to the WBG (2016), the Ethiopian economy is currently based on a public-led investment strategy that is financed by both internal and external financial sources. This has two opposite implications; first, increased public expenditure means improved infrastructure and facilitating productivity. On the contrary, high public sector engagement through increased expenditure may lead to an overcrowding effect in the private sector. Since public spending is mainly financed by tax revenue which imposes higher burden on private sector investment. Hence, public expenditure has a significant influence on the overall economic performance and dynamics. Similarly, the private household expenditure influences the economy mainly the productivity of firms through changes in the final demand for goods and services.

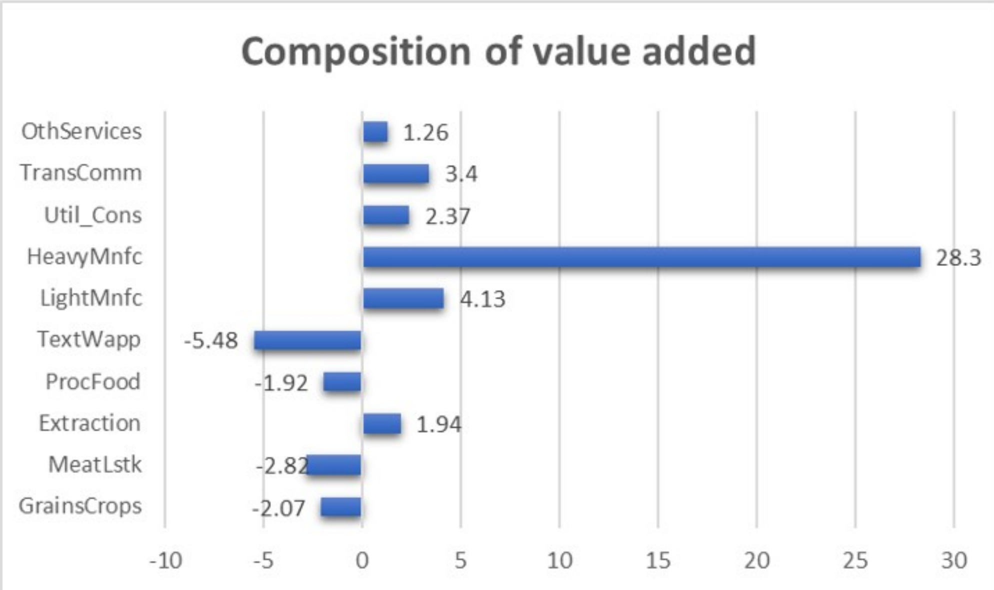
Furthermore, the government's final expenditure captures the public demand for commodities and domestic and foreign transfers. Thus, the change in public demand influences the revenue of production sectors. Hence the changes in private and public expenditure have a stimulating role on the economy. So, the five-year average percentage change in the private and public expenditure is comprised in the experiment. However, private and government consumption expenditure are endogenous variables in the standard GTAP CGE model. So, to implement the shock, the experiment followed two steps. Primarily, the private and public expenditures are set to be exogenous for all regions. Then, all regions' private and government consumption distribution parameters are set as endogenous to adhere to the macroeconomic closure. After implementing the swap, the real average percentage change between 2014 and 2019 is introduced into the original model to estimate the new SAM. Then, the other endogenous economic variables will adjust based on the new value of private households and government expenditure.

IV. Discussion on Ethiopian economic structure in 2019

A new macroeconomic database is estimated after updating the 2014 database by implementing an exogenous shock to the model. The aggregated macroeconomic database, i.e., the aggregated SAM, is summarized in table A.2. This detailed database can be used to describe the changes in Ethiopia's economic structure within five years. Therefore, this section will describe the significant changes in the shares and magnitude of economic sectors by comparing the SAM in 2014 with the SAM in 2019. First, the Gross Domestic Product (GDP) quantity index increased by 3.24 percent (0.64 CAGR) over the five years. This growth is augmented by increased value-added in the manufacturing and service sectors, as shown in figure 6.

The gross value-added in the heavy manufacturing sector substantially increased by 28.3 percent over the five years. This is followed by the transportation, communication and light manufacturing sector with an increase of 3.4 and 4.13 percent, respectively. On the contrary, the value-added in the agriculture sector has shown relatively lower advancement over the five years. The Grains Crops and livestock sector mainly recorded a decrease in value-added by -2.07 and -2.82 percent. This development in the industrial sector is due to the second growth and transformation plan (GTPII) (2015/16-2019/20) that promotes industrialization as the vital ingredient of structural transformation.

Figure 6. Changes in the composition of value-added in Ethiopia 2014-2019

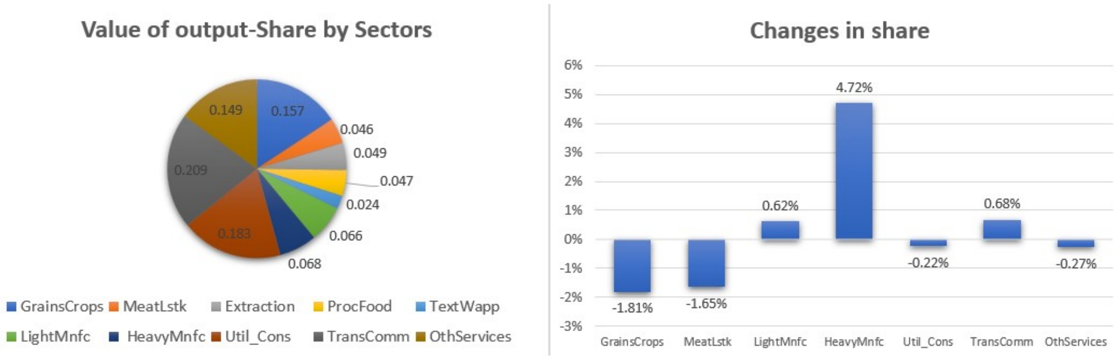


Source: Ethiopian social accounting matrix(SAM) 2019

This plan is centered on public-led investment in industrial and service sectors to boost productivity, such as construction of industrial parks. More specifically, the aim of GTP II is to increase efficiency by enhancing quality, productivity and competitiveness in agroindustry, manufacturing, and service sector. Following this, the manufacturing and service sector's industrial output share increased in comparison to the agriculture sector, as shown in the figure 7 below.

The transportation and communication sector followed by the utilities, construction and other services sectors take a higher share in the total value of output. The transportation and communication sector, which is dominated by the public sector, is one of the sectors that are expected to sustain economic growth. Mainly because the transportation and communication sectors are one of the sectors that facilitates both national and international trade and production process. Hence, the increased public expenditure on infrastructure and financial resource improvement induced growth in this sector. However, the share of utility and construction decreased slightly by -0.22 percent over the five years. Nevertheless, this sector remains one of the main contributors to the gross output of the economy.

Figure 7. Total output share by production sectors in Ethiopia 2019



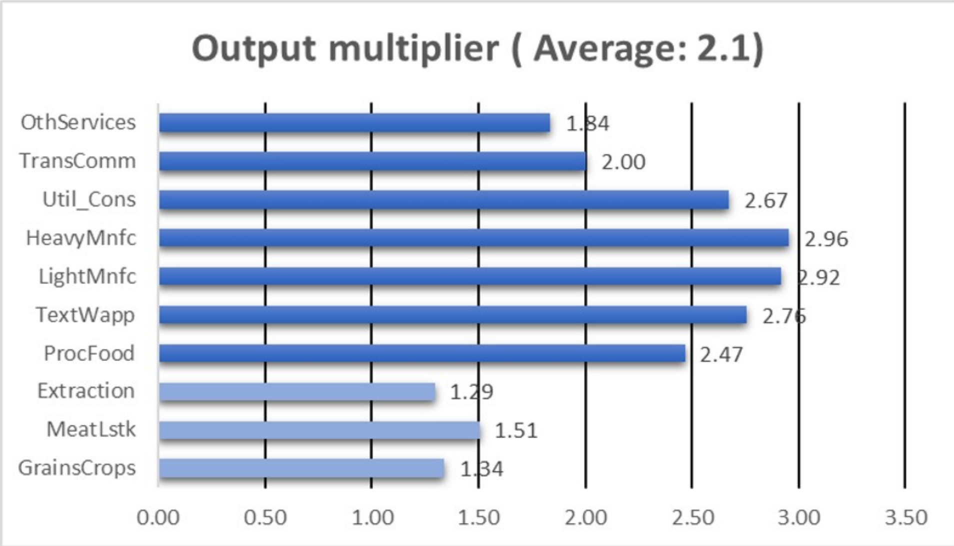
Source: Ethiopian social accounting matrix(SAM) 2019

Furthermore, the heavy manufacturing sector increased its share by 4.72 percent. Similarly, the transportation and communication sector slightly increased its share by 0.68 percent over the five years. On the contrary, the agriculture sector's share in total output decreased slightly over the five years. For instance, the grains and crops sector share declined by -1.81 percent within the five years, as shown in figure 7. However, besides the decline in its share of total output, the sector remains the third-highest contributor to the economy's total output.

Industrial production is affected by the market price, final demand, cost of input, public policy, and other several factors. In addition, the increase in industrial output can be triggered by increased intermediate demand. This increase arises form increased interlinkage between production sectors. Thus, the increase in total output of one industry can have a multiplier effect on the overall economy and particular interlinked production sector. For instance, an increase in the manufacturing sector output has a multiplier effect on the aggregate output. Additionally, it has an inducing effect in other sectors like agriculture sector. This effect is termed as the backward linkage between sectors.

So, after assessing the shares and changes in total output of sectors, linear multiplier analysis is employed to determine the interlinkage between sectors and the multiplier effect of production sectors. So, the supply use table A.1, that captures the flow of goods and services between sectors, is employed to implement a simple linear multiplier analysis. Initially, inferring from the output multiplier effect in figure 8, the manufacturing sector, followed by the service sector, has relatively higher output multiplier effect on the economy.

Figure 8. Output multiplier by production sectors 2019

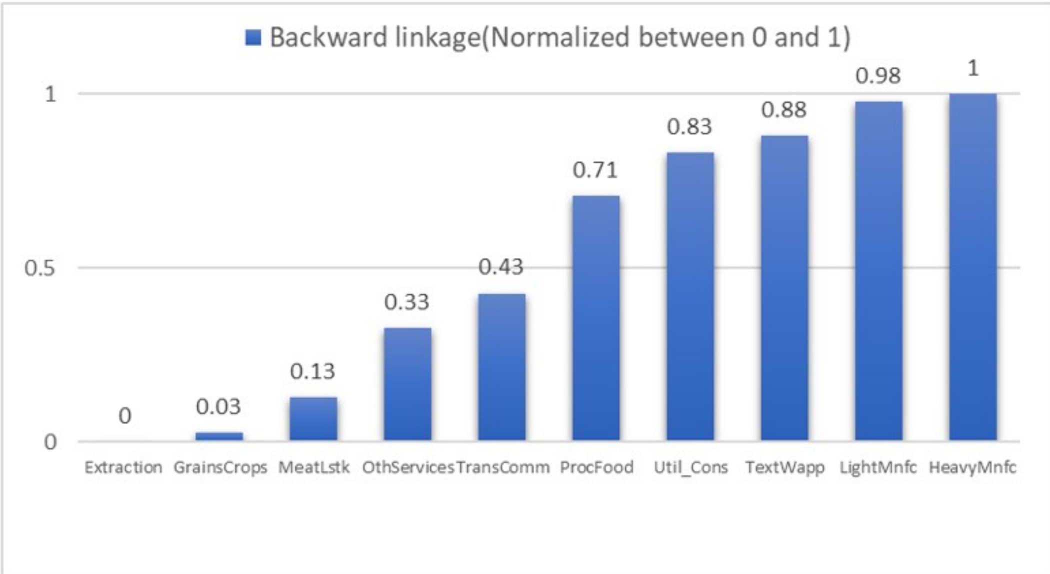


Source: Ethiopian social accounting matrix(SAM) 2019

More specifically, the heavy and light manufacturing sectors have output multiplier of 2.96 and 2.92, above the average. This implies that a unit increase in the final demand for heavy manufacturing output leads to an increase in total output by 2.96 percent. Similarly, the textile apparel and food processing sectors have an above-average output multiplier effect of 2.76 and 2.47. This result implies that the industrial sector has a higher impact on the economy's aggregate output in 2019. Moreover, the service sector, mainly the utility and construction sector, has relatively higher impact on the economy, with an output multiplier of 2.67, exceeding the average. Whereas the other service sectors have below average output multiplier effect. Similarly, the agriculture sector has a lower multiplier effect on the total output of the Ethiopian economy. The grains and crops sector has an output multiplier of 1.34, below the average as of 2019.

Moreover, the manufacturing sector has a strong backward linkage, as indicated in figure 9. The heavy manufacturing sector has relatively the strongest backward linkage in inducing output levels in other sectors. Similarly, the light manufacturing, textile and apparel, utilities and construction sectors have relatively higher backward linkage. This implies that increased productivity in the manufacturing sector leads to an increase in intermediate input demand from other sectors, such as the agriculture sector. As a result, this increase in the demand of intermediates leads to higher output in other production sectors. On the contrary, the agriculture sector has a relatively weak backward linkage below 0.5. Mainly the extraction sector is the sector with the weakest backward linkage. This is because the mining and extraction sector is in its infancy due to technical and institutional barriers. At the same time, the grains crops, and livestock sectors have backward linkage of 0.03 and 0.13, which is still minimal compared to other sectors.

Figure 9. Backward linkage of production sectors 2019



Source: Ethiopian social accounting matrix(SAM) 2019

In the standard CGE model, producers minimize their costs to increase net revenue received from sales of goods and services. Mainly producers minimize costs such as labor, capital, raw materials, consumable final products, and other overhead costs used for the production process. Thus, the cost structure of producers provides insight into the composition of fixed and variable costs and associated final prices of goods and services. In general, all firms incurred an increase in total cost over the five years as shown in Table 2 below. The heavy manufacturing firm followed extraction, transportation and communication sector incurred relatively higher cost increase of 7.35, 3.82 and 3.37 percent. On the contrary, the total cost increase in the grains crops and livestock sector is relatively lower.

TABLE 2

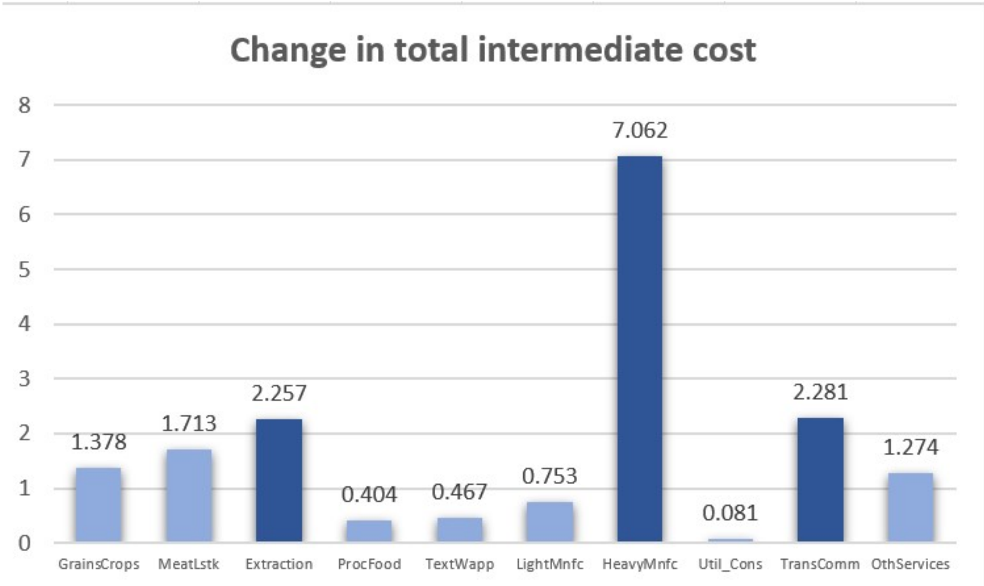
Changes in total cost by production sector 2014-2019

Production Sectors	Total cost (CAGR)
Grains and Crops	0.84%
Meat and Livestock	1.10%
Mining and Extraction	3.82%
Food Processing	1.54%
Textile and Apparel	1.21%
Light manufacturing	3.32%
Heavy manufacturing	7.35%
Utility and construction	2.45%
Transportation and communication	3.37%
Other services	2.35%

Source: Ethiopian social accounting matrix(SAM) 2019

More specifically, firms incur two types of cost, and they are the primary factor cost and intermediate input cost. So, starting from the intermediate input cost, production sectors use final goods and services as an input for production process. Provided by the estimated data, the average change in the total intermediate cost is displayed in figure 10. In general, all production sectors incurred an increase in intermediate costs over the five years. More specifically, the heavy manufacturing, extraction and transportation communication sector faced a higher percentage increase in total intermediate cost. As discussed previously, the industrial and service sector recorded higher industrial output. However, this increase is accompanied by an expansion of total cost. Mainly this expansion of cost includes the purchase of intermediate inputs from other sectors, leading to higher interlinkage with other sectors. On the contrary, the agriculture sector incurred relatively slight increase in the intermediate costs. Mainly the grains and crops sector incurred a minimal increase in the total intermediate input cost i.e., 1.38 percent. Similarly, the total intermediate cost in the food processing and textile industry slightly increased by 0.4 and 0.46 percent on average.

Figure 10. Compounded annual growth rate in the total intermediate cost 2014-2019



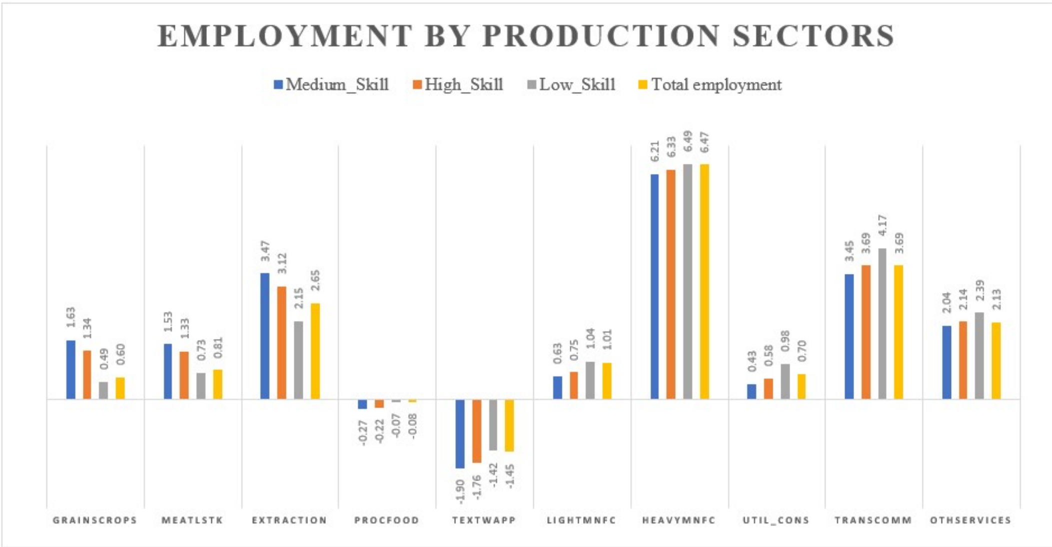
Source: Ethiopian social accounting matrix(SAM) 2019

In addition, producers incur primary factor costs as part of the production process. As discussed in the previous section, each primary factor input is aggregated based on the constant elasticity of the substitution (CES) function. Thus, depending on the elasticity parameter, the composition of primary factors may differ amid price changes and technological shifts. The primary factor of production includes labor, capital, land, and natural resource.

First, there is an overall increase in labor cost over the five years. Note that, in the standard GTAP CGE model, the total supply of labor is calculated based on the total salaries paid by producers. Thus, the changes in total employment corresponds to the changes in labor cost incurred by production sectors. So according to figure 11 below, the average total labor cost increased in all sectors except the textile, apparel, and food processing sector. In addition, the total employment in the heavy manufacturing, extraction, transportation, and communication sectors increased. In particular, the high, medium, and low skilled labor costs increased by 6.33, 6.21, and 6.49 percent in the heavy manufacturing sector.

Moreover, the labor cost of low-skilled workers is relatively higher in the light manufacturing, utilities, construction, transportation, communication, and other service sectors. Thus, there is an increase in low-skilled employment in the manufacturing and service sectors. On the contrary, there is a relatively higher increase in medium-skilled labor costs in the agriculture sector, mainly in the extraction sector.

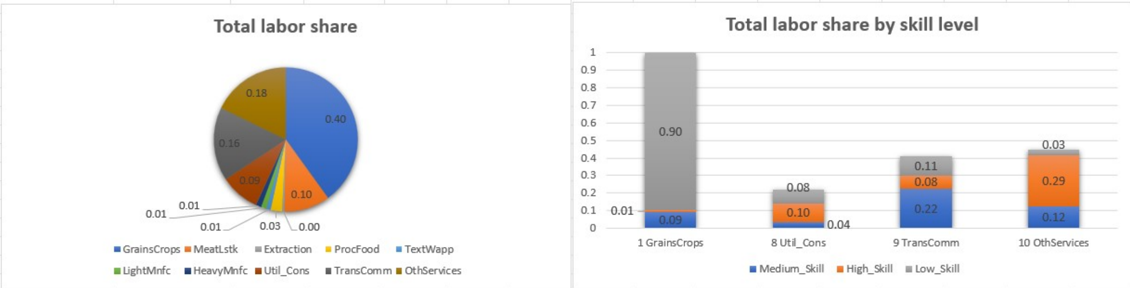
Figure 11. Changes in employment by production sectors and skill level 2014-2019



Source: Ethiopian social accounting matrix(SAM) 2019

Previously, the agriculture sector employed high percentage of low-skilled workers, such as farm workers. However, this result indicates a flow of low-skilled workers to the service and industrial sectors. This is due to low productivity in the agriculture sector, leading to lower labor demand. On the other hand, given that labor is mobile, relatively higher wage in the manufacturing and service sector leads to higher labor supply. In addition, the current shift in the labor market from agriculturally based to an agroindustrial-based market contributes to the current shift in the labor market. Since this expansion of agro-based industries induces the demand for more labor as a factor of production. Moreover, due to the technological shift in the industrial and service sector, there is higher demand for medium and high skilled workers. However, the total share of labor employed in the agriculture sector remains high in 2019, as depicted in figure 12 below.

Figure 12. Share of total labor employed by production sectors in 2019



Source: Ethiopian social accounting matrix(SAM) 2019

Mainly, 40 percent of the population is still employed in the grains and crops sector. This is followed by the transportation communication and other service sectors with a share of 16 and 18 percent, respectively. In particular, the share of workers with low skill levels is relatively high in the grains and crops sector. Whereas in the transportation communication and utilities construction sector is dominated by medium skilled workers. In addition, the share of high skilled labor cost is relatively higher in other services sector. Since, most official, managers and technicians are situated in the business, educational and public institutions.

In addition to labor, producers incur a capital cost of production. So, Table 3 indicates the average change in the total capital cost incurred by producers over the five years. The heavy manufacturing sector had relatively highest average increase in total capital cost, i.e., 6.21 percent. Similarly, the service sector, mainly the transportation and communication sector, incurred a higher capital cost of 3.47 percent. This is due to increased investment in capital goods such as machinery, vehicles, buildings and other equipment's.

TABLE 3

Changes in capital cost by production sector 2019

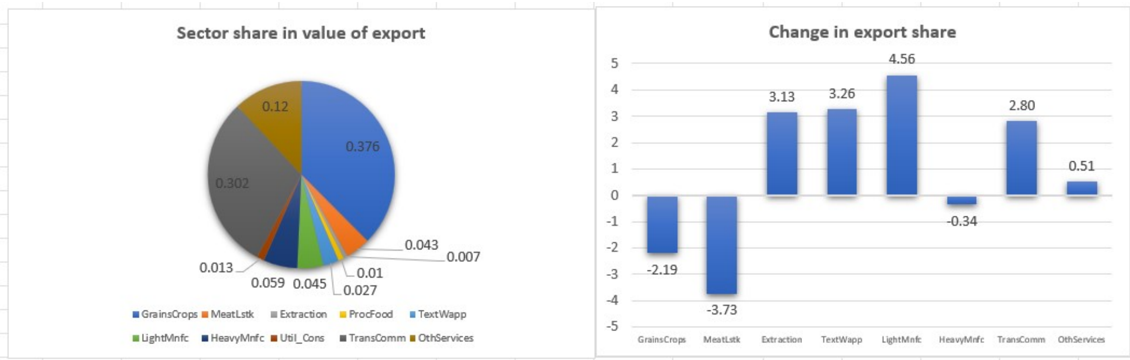
Production Sectors	Capital Cost(CAGR)
Grains and Crops	1.58%
Meat and Livestock	1.49%
Mining and Extraction	3.41%
Food Processing	-0.25%
Textile and Apparel	-1.86%
Light manufacturing	0.65%
Heavy manufacturing	6.21%
Utility and construction	0.43%
Transportation and communication	3.47%
Other services	2.03%

Source: Ethiopian social accounting matrix(SAM) 2019

These results indicates that, with a higher share in value-added, the manufacturing sector has a relatively lower contribution to employment. In addition, the share in the export value of the industrial sector is relatively low. Mainly, the export share of the heavy manufacturing sector declined by -0.34 over the five years. This is because heavy manufacturing sector exports are characterized by the low value of products that are exported to low/middle-income markets (Oqubay et al., 2018). On the contrary, the export share of the light manufacturing, textile apparel, and food processing sectors improved over five years. Overall, the agriculture sector takes the highest share of the total value of exports in 2019, as shown in figure 13. The grains and crops sector mainly takes the highest export share of 37.6 percent, contributed by high coffee exports. However, this sector incurred a decline in its share in export value since 2014.

Moreover, the total value of merchandise imports has shown a decline over the five years. This is mainly due to the current policy in Ethiopia that aims to improve the balance of payment by placing export-oriented trade policy. However, due to comparative advantage, there is still an external dependency on imported

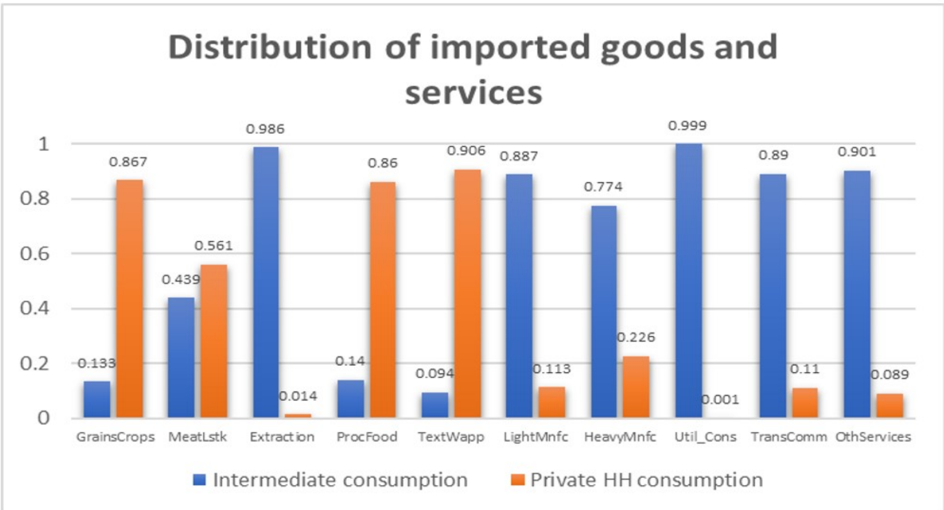
Figure 13. Share in the total value of exports in 2019



Source: Ethiopian social accounting matrix(SAM) 2019

goods and services for direct and intermediate consumption. As shown in figure 14, high share of imported grains and crops, processed food, textile, and apparel products are consumed by private households. Whereas imported heavy and light manufactured, utilities construction commodities, and other services are highly dominated by intermediate consumption.

Figure 14. Distribution of imported goods and services -2019



Source: Ethiopian social accounting matrix(SAM) 2019

Households maximize their utility by combining the preferred goods and services. So, there is a flow of final produced goods and services to the households for direct and indirect consumption. In addition, the final demand for goods and services can vary amid price and income change, given the utility functional form. So, determining the demand for goods and services changes helps track household behavioral changes since 2014. Starting with the change in factor income, the total factor return increased over the five years. In particular, the factor return of labor, natural resource and capital has shown a positive increase within five years, as depicted in the Table 5.

The return of capital and natural resource increased by 12.39 (2.36-CAGR) and 40.12 (6.98-CAGR) percent respectively. There is a higher increase in the return of natural resources since an increase in industrial production induces the demand for the scarce natural resources like energy. Moreover, the increase in the factor income of medium skilled labor is relatively higher with an increase of 12.66 (2.41-CAGR) percent.

Table 4

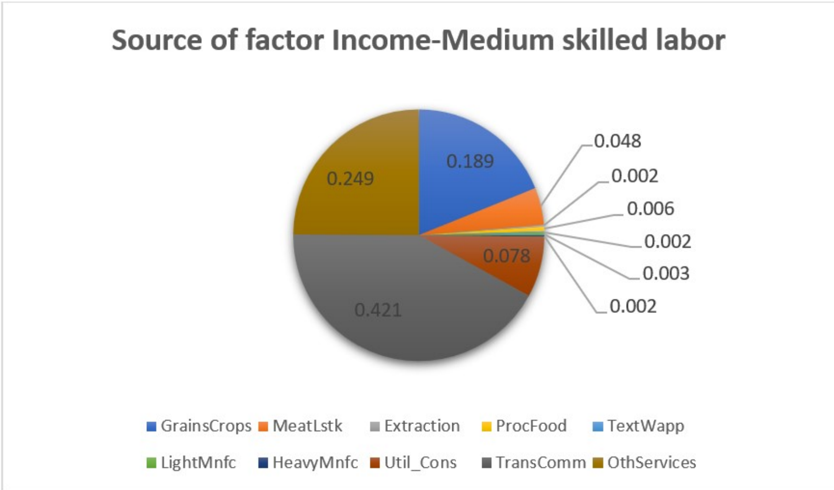
Changes in total factor income

Factor income				
Primary factors of production	2014	2019	Percentage change	CAGR
Land	2134.24	2103.92	-1.42	-0.29
Medium_Skill	4715.87	5312.75	12.66	2.41
High_Skill	4704.57	5195.44	10.43	2.00
Low_Skill	15120.61	15817.74	4.61	0.91
Capital	23774.81	26721.18	12.39	2.36
NatRes	561.14	786.25	40.12	6.98
Total	51011.24	55937.28	9.66	1.86

Source: Ethiopian social accounting matrix(SAM) 2019

More specifically the increased factor income of medium-skilled workers is sourced from the service sector. This due to the labor composition of transportation and communication sector, that is dominated by medium-skilled workers. As shown in figure 15 below, the primary source of the medium-skilled worker's income is the transportation, communication and other services sectors.

Figure 15. Source of factor income of labor with medium skill level -2019

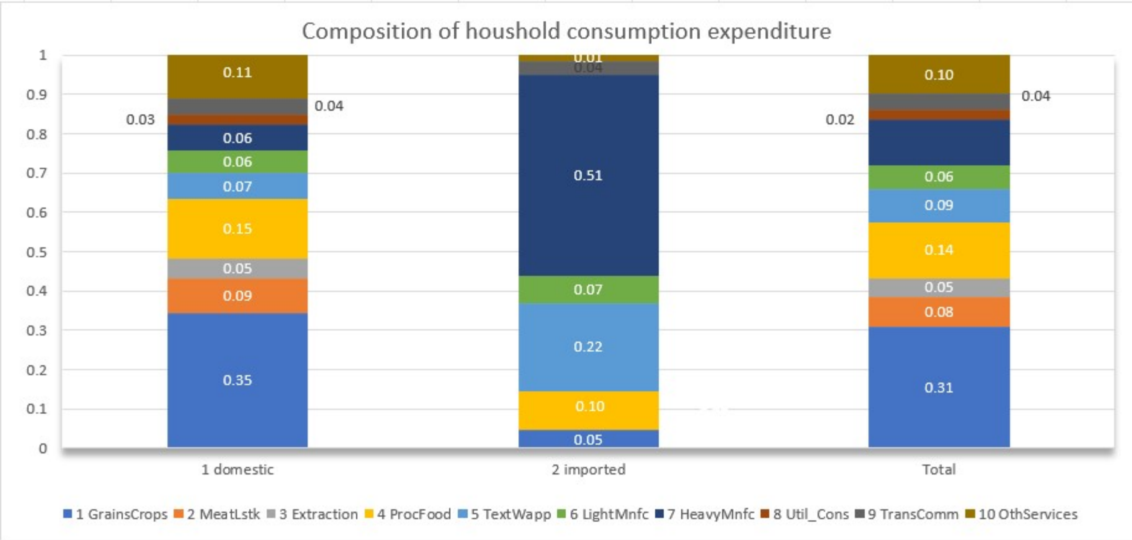


Source: Ethiopian social accounting matrix(SAM) 2019

The changes in household income impacts the composition of total private and government consumption expenditures. According to Engel's law, the income level determines the proportion of income devoted to food and non-food commodities, mainly for developing countries. As shown in figure 16, the total consumption expenditure is dominated by grains and crops followed by processed food products with 31 and 14 percent share. This implies that households still allocate most of their income for food purchases, despite the increase in income. This is because Ethiopia remains a low-income and populous country with below-average per capita income.

Furthermore, the household total consumption basket comprises domestic and imported goods. The total domestic consumption mainly comprises grains, crops and processed food. In contrast, heavy manufacturing and textile and apparel commodities dominate the total imported consumption.

Figure 16. Composition of household consumption expenditure 2019



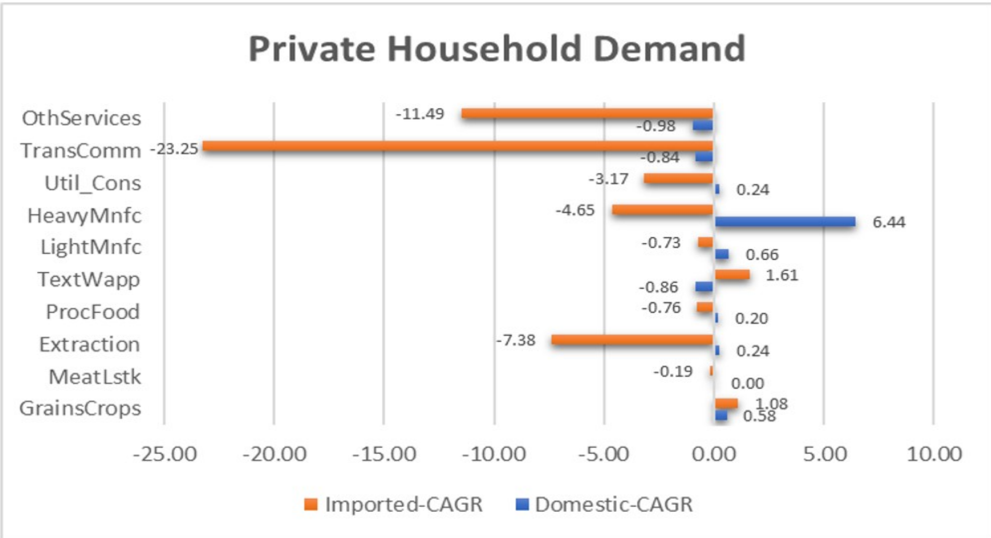
Source: Ethiopian social accounting matrix(SAM) 2019

Moreover, given that household consumption allocation is aggregated based on the CES function, there is substitutability between imported and domestic goods and services. Thus, the composition of consumption mainly depends on the own-price elasticity and the Armington elasticity parameters. Thus, these parameters determine the magnitude of changes in the quantity demand due to price and income changes. Inferring from the estimated data, the private household total domestic demand for some commodities increased over the five years. Mainly the demand for heavy manufacturing, light manufacturing, utilities, and construction products increased over the five years. In particular, the domestic demand for heavy and light manufacturing products increased by 6.44 and 0.66 percent.

Furthermore, the domestic demand for utilities and construction commodities slightly increased by 0.25 percent on average. This is due to increased demand for construction materials amid large scale construction projects driven by public investment and housing demand. On the contrary, the domestic demand for the other services sectors slightly decreased by -0.98 percent.

The private household's imported demand for most products significantly declined over the five years. Mainly import demand for transportation and communication, other services, extraction, and heavy manufacturing products declined by -23.25, -11.49, -7.38, and -4.65 percent, respectively. While the import demand for light manufacturing, and grain crops products slightly increased over the five years.

Figure 17. Change in private household demand 2014-2019

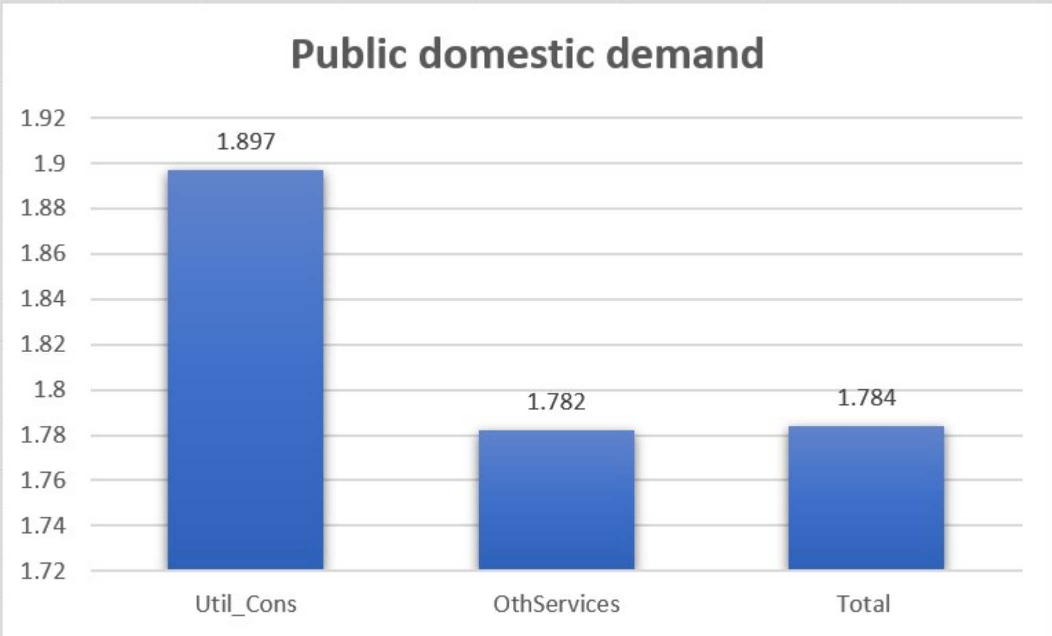


Source: Ethiopian social accounting matrix(SAM) 2019

Moreover, the public sector demands goods and services for the provision of public services, such as building infrastructure. Hence the overall public demand slightly increased by 1.784 percent over the five years. Mainly public domestic demand from the service sector, i.e., utilities, construction, and other service sectors increased by 1.89 and 1.782 percent, as shown in figure 18.

Overall, the decline in private household demand are due to the persistent increase in the prices of goods and services. More specifically, the decline in the import quantity demand is due to the increased prices of imported commodities. This increase in import prices is induced by the trade policy and exchange rate devaluation that aims to improve the balance of trade (BOP). Thus, despite the increase in the total income, the purchasing power of households declined due to the high tariff rate.

Figure 18. Change in public household demand 2014-2019



Source: Ethiopian social accounting matrix(SAM) 2019

Furthermore, the increase in the price of imported goods leads to the substitution effect; that is, domestic commodities substitute imported commodities. For instance, this effect is observed for manufactured commodities, given that there is an increase in the demand for domestic manufactured commodities but a decline in the demand for imported manufactured commodities. Thus, this shift in the demand of manufactured commodities is a result of substitution effect as well as other policy interventions .

On the other hand, the public expenditure in specific sectors increased to achieve the targets defined in the second growth and transformation plan. This is augmented by increased public-led investment in specific pro-poor sectors such as the health and social sector, capital stocks, and in operation and management sectors.

V. Conclusion

A detailed and updated database is a crucial component in several policy analyses. In general, estimating a country-level Social Accounting Matrix (SAM) helps assess the structure of an economy for a given time. Thus, this study estimated country-level SAM by using an economic model. Mainly, the general equilibrium model is used to estimate global SAM for Ethiopia, updated to 2019. This estimation method introduces an exogenous shock to the model to update the 2014 global SAM. Then a multi-step Gragg's solution method is used to estimate an accurate new database. This estimated SAM provides disaggregated data with ten production sectors, six factors of production, and two regions. This experiment indicates that the CGE model helps to estimate a reliable and detailed database based on economic structural equations and behavioral parameters. In addition, the model places economic theory at the center of the estimation process. This is useful in showing how economic sectors are interlinked and the consequent reaction of sectors to a specific external shock in the economy. Furthermore, this estimation method provides a reliable and flexible way of incorporating the available information while adhering to macroeconomic closures.

After estimating the 2019 SAM for Ethiopia, the new database is used to describe the changes in the Ethiopian economic structure. The results show that there has been an improvement in the real GDP of Ethiopia since 2014. This improvement is attributed to the GTP II, which sets industrialization at the heart of the development plan. Thus, the improved growth is driven by increased productivity in the service and manufacturing sectors. Mainly heavy manufacturing, transportation, and communication sectors take a higher share in the value-added composition of the economy. On the other hand, the agricultural sector's value-added declined over the five years. However, the agriculture sector remains one of the sectors with the highest share of total industrial output. In addition, the industrial sector's performance is relatively lower compared to other countries. Mainly, the industrial sector contributes less to total exports and employment in Ethiopia. On the contrary, the agriculture sector, followed by the service sector, employs a large percentage of the population in the country. Furthermore, the industrial sector incurred a higher increase in total cost within the five years. This increase is due to the increased demand for intermediate input and capital costs motivated by expansionary public policy. Thus, this increase in cost raises the question of sustaining the current performance in the long term. Mainly when considering the current export performance and the increasing debt-to-GDP ratio in the country.

Households' factors return for labor, capital, and natural resource increased over the five years. In particular, the increased production in the industrial sector led to higher demand for natural resources. Similarly, middle-skilled workers' income, mainly sourced from the service sector, increased. The overall increase in labor demand is due to the expansion of production activities in the industrial and service sector. Moreover, the total employment composition change indicates a flow of labor from the agriculture sector to the industrial and service sector. This is an outcome of the increased investment in these sectors that increases labor demand and factor return. Moreover, there are adjustments in the private and government consumption demand due to income and price effects. Additionally, the outward-looking trade policy played a significant role in changing the composition of household consumption basket. For instance, the private household domestic demand for goods and services has slightly increased for some products. On the contrary, the demand for imported goods has declined for most goods and services. As a result, there is an improvement in the merchandise balance of payment while the total trade balance remains negative. On the other hand, the public demand for utilities, construction, and other service increased due to high public investment.

In general, the changes in the economy's structure indicate a forthcoming transition of the Ethiopian economy from an agriculture-based to industry and service-based economy. However, the agriculture sector remains the dominant sector with a relatively higher employment rate and export earnings. Moreover, the industrial sector improvement is somewhat inadequate to assist growth due to poor export performance, institutional infrastructure, and employment. Thus, there is a significant trade-off in distributing resources between sectors to alleviate poverty and sustain growth. So this necessitates public policy and budgetary improvements to ensure a smooth economic transition.

Moving forward, this methodology can be applied to estimate SAM for other countries, given the database and simulation software availability. In addition, this model can be extended with more sector-specific disaggregations such as GTAP-E, GTAP-power, GTAP-water, and other CGE models to estimate a more detailed database. Furthermore, the current standard GTAP CGE model was revised in 2017 with new features of non- homothetic final demand, welfare decomposition, and production (Corong et al., 2017). Thus, this revised GTAP CGE model can be employed to estimate a more comprehensive database.

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Appendix

Appendix A

Summary of flows of goods and services

TABLE A.1

Summary on flows of goods and services

Supply-use table	1 GrainsCrops	2 MeatLstk	3 Extraction	4 ProcFood	5 TextWapp	6 LightMnfc	7 HeavyMnfc	8 Util_Cons	9 TransComm	10 OthServices
7 GrainsCrops	1332.77	234.64	0.11	394.07	96.02	0.8	1.07	291.22	40.01	657.97
8 MeatLstk	0.21	167.99	0.01	70.89	156.06	254.8	11.42	3.64	49.2	670.08
9 Extraction	0.06	0.05	0.35	13.27	0.22	9.96	176.62	3216.26	6.4	101.09
10 ProcFood	0.02	3.13	0.13	223.19	0.04	0.07	0.04	0	2.19	385.41
11 TextWapp	0.09	0	0.04	0.01	33.53	2.72	1.99	4.98	27.86	238.59
12 LightMnfc	182.75	6.75	6.49	16.52	11.96	261.96	275.63	2482.56	1388.11	1110.47
13 HeavyMnfc	645.81	5.95	53.44	54.84	38.77	313.24	1055.11	3127.04	1958.49	1371.09
14 Util_Cons	0.19	1.99	8.27	39.38	11.56	67.72	154.37	4176.93	130.62	157.75
15 TransComm	910.21	997.09	661.9	2950.82	2001.91	5938.5	5050.87	1076.49	1217.31	548.88
16 OthServices	2.25	7.99	57.57	231.24	28.97	57.7	122.67	119.48	5897.91	903.81
Total	3074.36	1425.58	788.31	3994.23	2379.04	6907.47	6849.79	14498.6	10718.1	6145.14

TABLE A.2

Summary of Ethiopia's aggregate SAM 2019

AGG_SAM	comm_GrainsCrops	comm_MeatLstk	comm_Extraction	comm_ProcFood	comm_TextWapp	comm_LightMnfc	comm_HeavyMnfc	comm_Util_Cons	comm_TransComm	comm_OthServices
comm_GrainsCrops	0	0	0	0	0	0	0	0	0	0
comm_MeatLstk	0	0	0	0	0	0	0	0	0	0
comm_Extraction	0	0	0	0	0	0	0	0	0	0
comm_ProcFood	0	0	0	0	0	0	0	0	0	0
comm_TextWapp	0	0	0	0	0	0	0	0	0	0
comm_LightMnfc	0	0	0	0	0	0	0	0	0	0
comm_ HeavyMnfc	0	0	0	0	0	0	0	0	0	0
comm_Util_Cons	0	0	0	0	0	0	0	0	0	0
comm_TransComm	0	0	0	0	0	0	0	0	0	0
comm_OthServices	0	0	0	0	0	0	0	0	0	0
activ_GrainsCrops	1332.77	234.64	0.11	394.07	96.02	0.8	1.07	291.22	40.01	657.97
activ_MeatLstk	0.21	167.99	0.01	70.89	156.06	254.8	11.42	3.64	49.2	670.08
activ_Extraction	0.06	0.05	0.35	13.27	0.22	9.96	176.62	3216.26	6.4	101.09
activ_ProcFood	0.02	3.13	0.13	223.19	0.04	0.07	0.04	0	2.19	385.41
activ_TextWapp	0.09	0	0.04	0.01	33.53	2.72	1.99	4.98	27.86	238.59
LightMnfc	182.75	6.75	6.49	16.52	11.96	261.96	275.63	2482.56	1388.11	1110.47
activ_ HeavyMnfc	645.81	5.95	53.44	54.84	38.77	313.24	1055.11	3127.04	1958.49	1371.09
activ_Util_Cons	0.19	1.99	8.27	39.38	11.56	67.72	154.37	4176.93	130.62	157.75
activ_TransComm	910.21	997.09	661.9	2950.82	2001.91	5938.5	5050.87	1076.49	1217.31	548.88
activ_OthServices	2.25	7.99	57.57	231.24	28.97	57.7	122.67	119.48	5897.91	903.81
Land	1669.03	434.89	0	0	0	0	0	0	0	0
Medium_Skill	965.48	243.01	10.52	26.81	9.76	12.54	12.84	377.92	2355.08	1298.78
High_Skill	107.51	27.86	52.7	16.17	5.91	7.59	7.76	1094.89	801.67	3073.39
Low_Skill	9471.14	2442.17	64.99	636.31	234.96	300.68	305.59	860.92	1184.66	316.33
Capital	2460.03	630.33	3843.87	677.51	45.79	214.52	461.04	3821.53	8575.03	5991.53
NatRes	0	0	786.25	0	0	0	0	0	0	0
Household										
Import										
PRODTAX	0.02	0	0	0.07	0.14	-1.57	-0.5	16.52	-30.1	9.44
GOVT	0	0	0	0	0	0	0	0	0	0
Transpt_ETH										
CGDS										
Total	17747.57	5203.84	5546.64	5351.1	2675.6	7441.23	7636.52	20670.38	23604.44	16834.61

AGG_SAM	activ_GrainsCrops	activ_MeatLstk	activ_Extraction	activ_ProcFood	activ_TextWapp	activ_LightMnfc	activ_HeavyMnfc	activ_Util_Cons	activ_TransComm	activ_OthServices
comm_GrainsCrops	1332.77	234.64	0.11	394.07	96.02	0.8	1.07	291.22	40.01	657.97
comm_MeatLstk	0.21	167.99	0.01	70.89	156.06	254.8	11.42	3.64	49.2	670.08
comm_Extraction	0.06	0.05	0.35	13.27	0.22	9.96	176.62	3216.26	6.4	101.09
comm_ProcFood	0.02	3.13	0.13	223.19	0.04	0.07	0.04	0	2.19	385.41
comm_TextWapp	0.09	0	0.04	0.01	33.53	2.72	1.99	4.98	27.86	238.59
comm_LightMnfc	182.75	6.75	6.49	16.52	11.96	261.96	275.63	2482.56	1388.11	1110.47
comm_ HeavyMnfc	645.81	5.95	53.44	54.84	38.77	313.24	1055.11	3127.04	1958.49	1371.09
comm_Util_Cons	0.19	1.99	8.27	39.38	11.56	67.72	154.37	4176.93	130.62	157.75
comm_TransComm	910.21	997.09	661.9	2950.82	2001.91	5938.5	5050.87	1076.49	1217.31	548.88
comm_OthServices	2.25	7.99	57.57	231.24	28.97	57.7	122.67	119.48	5897.91	903.81
activ_GrainsCrops	0	0	0	0	0	0	0	0	0	0
activ_MeatLstk	0	0	0	0	0	0	0	0	0	0
activ_Extraction	0	0	0	0	0	0	0	0	0	0
activ_ProcFood	0	0	0	0	0	0	0	0	0	0
activ_TextWapp	0	0	0	0	0	0	0	0	0	0
LightMnfc	0	0	0	0	0	0	0	0	0	0
activ_ HeavyMnfc	0	0	0	0	0	0	0	0	0	0
activ_Util_Cons	0	0	0	0	0	0	0	0	0	0
activ_TransComm	0	0	0	0	0	0	0	0	0	0
activ_OthServices	0	0	0	0	0	0	0	0	0	0
Land	0	0	0	0	0	0	0	0	0	0
Medium_Skill	0	0	0	0	0	0	0	0	0	0
High_Skill	0	0	0	0	0	0	0	0	0	0
Low_Skill	0	0	0	0	0	0	0	0	0	0
Capital	0	0	0	0	0	0	0	0	0	0
NatRes	0	0	0	0	0	0	0	0	0	0
Household	0	0	0	0	0	0	0	0	0	0
Import	236.68	15.59	120.41	401.79	832.84	2083.39	9035.83	779.36	1578.62	747.12
PRODTAX										
GOVT	0	0	0	0	0	0	0	0	0	0
Transpt_ETH	318.19	148.48	40.79	8.13	14.49	20.7	-1736.12	0	0	0
CGDS	-262.35	408.86	2898.67	-3781.8	-2902.03	-1372.43	-2519.83	5144.75	9061.89	539.23
Total	3366.88	1998.51	3848.18	622.35	324.34	7639.13	11629.67	20422.71	21358.61	7431.49

AGG_SAM	Land	Medium_Skill	High_Skill	Low_Skill	Capital	NatRes	household	gov	exp	lessDomTax	lessImpTax	lessTariff	lessImpCIF	Transprt_ETH	CGDS	Total
comm_GrainsCrops	0	0	0	0	0	0	12379.39	0	2575.78	-0.28	-19.32	-18.1	-218.58		0.01	17747.58
comm_MeatLstk	0	0	0	0	0	0	3081.6	0	293.25	-1.28	-4.14	-2.96	-12.63		465.73	4738.14
comm_Extraction	0	0	0	0	0	0	1830.98	0	46.53	-2.07	-15.75	-42.8	-77.61		283.11	5263.56
comm_ProcFood	0	0	0	0	0	0	5754.93	0.01	68.43	-527.36	-157.35	-80.95	-320.84		0	5351.09
comm_TextWapp	0	0	0	0	0	0	3398.75	0	182.47	-28.24	-354.39	-283.05	-549.79		0.04	2675.56
comm_LightMnfc	0	0	0	0	0	0	2418.39	0	305.4	-163.89	-653.72	-255.14	-1828.25		1875.23	5565.99
comm_ HeavyMnfc	0	0	0	0	0	0	4663.66	0	401.2	-335.3	-1423	4965.2	-14001.04		4742.01	2894.5
comm_Util_Cons	0	0	0	0	0	0	941.64	84.93	86.29	-85.83	0	0	-779.36		15673.9	4996.45
comm_TransComm	0	0	0	0	0	0	1651.95	0.02	2304.84	-127.58	-4.79	0	-1578.62		4.63	23599.8
comm_OthServices	0	0	0	0	0	0	3907.69	5629.69	824.82	-211.88	-0.09	0	-747.12		1.9	16832.7
activ_GrainsCrops	0	0	0	0	0	0	0	0	0	0	0	0	0	318.19	0.01	3366.88
activ_MeatLstk	0	0	0	0	0	0	0	0	0	0	0	0	0	148.48	465.73	1998.51
activ_Extraction	0	0	0	0	0	0	0	0	0	0	0	0	0	40.79	283.11	3848.18
activ_ProcFood	0	0	0	0	0	0	0	0	0	0	0	0	0	8.13	0	622.35
activ_TextWapp	0	0	0	0	0	0	0	0	0	0	0	0	0	14.49	0.04	324.34
LightMnfc	0	0	0	0	0	0	0	0	0	0	0	0	0	20.7	1875.23	7639.13
activ_ HeavyMnfc	0	0	0	0	0	0	0	0	0	0	0	0	0	-1736.12	4742.01	11629.67
activ_Util_Cons	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15673.9	20422.71
activ_TransComm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.63	21358.61
activ_OthServices	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.9	7431.49
Land	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2103.92
Medium_Skill	0	0	0	0	0	0	0	0	0	0	0	0	0		0	5312.74
High_Skill	0	0	0	0	0	0	0	0	0	0	0	0	0		0	5195.45
Low_Skill	0	0	0	0	0	0	0	0	0	0	0	0	0		0	15817.75
Capital	0	0	0	0	0	0	0	0	0	0	0	0	0		0	26721.18
NatRes	0	0	0	0	0	0	0	0	0	0	0	0	0		0	786.25
Household	2103.92	5312.74	5195.45	15817.75	26721.18	786.25									0	55937.29
Import	0	0	0	0	0	0	0	0	0	0	0	0	0		0	15831.63
PRODTAX							0	0	0	0	0	0	0		0	-5.98
GOVT	0	0	0	0	0	0	4855.27	0	0	0	0	0	0		0	4855.27
Transpt_ETH	0														0	-1185.34
CGDS	0	0	117.29	-10622.3	-10903.43	25934.93	11053.04		8742.62						-20943	31537.11
Total	2103.92	5312.74	5312.74	5195.45	15817.75	26721.18	55937.29	5714.65	15831.63	-1483.71	-2632.55	4282.2	-20113.84	-1185.34	25150.5	309353.25

Link: Summary of Ethiopia Aggregate SAM 2019

Link:Ethiopia global SAM 2019

Appendix B

Production sectors mapping

Table B.1

Production Sectors mapping

	GTAP sectoral aggregation		National account sectoral aggregation
Grains and Crops	Paddy Rice	'10	Cereals
	Wheat	'08	Edible fruit and nuts; peel of citrus fruit or melons
	Cereal Grains Nec	'07	Edible vegetables and certain roots and tubers
	Vegetables, fruits, nuts	'20	Preparations of vegetables, fruit, nuts or other parts of plants
	Oil seeds	'13	Lac; gums, resins and other vegetable saps and extracts
	Sugar cane, Sugar beet	'14	Vegetable plaiting materials; vegetable products not elsewhere specified or included
	Plant-based fibers	'52	Cotton
	Crops nec	'55	Man-made staple fibres
	Processed rice	'53	Other vegetable textile fibres; paper yarn and woven fabrics of paper yarn
Meat and live stock	Bovine cattle, sheep and goats	'01	Live animals
	Animal Products	'51	Wool, fine or coarse animal hair; horsehair yarn and woven fabric
	Raw Milk	'41	Raw hides and skins (other than furskins) and leather
	Bovine meat products	'50	Silk
	Meat Products	'05	Products of animal origin, not elsewhere specified or included
	Wool, Silk-Worm cocoons		
Minning and Extraction	Forestry	'03	Fish and crustaceans, molluscs and other aquatic invertebrates
	Fishing	'27	Mineral fuels, mineral oils and products of their distillation; bituminous substances; mineral ...
	Coal	'26	Ores, slag and ash
	Oil	'06	Live trees and other plants; bulbs, roots and the like; cut flowers and ornamental foliage
	Gas	'67	Prepared feathers and down and articles made of feathers or of down; artificial flowers; articles ...
	Minerals nec		
Processd Food	Vegetables oils and fats	'17	Sugars and sugar confectionery
	Dairy Products	'09	Coffee, tea, maté and spices
	Sugar	'18	Cocoa and cocoa preparations
	Food Products nec	'15	Animal or vegetable fats and oils and their cleavage products; prepared edible fats; animal ...
	Beverages and Tobacco Products	'21	Miscellaneous edible preparations
		'19	Preparations of cereals, flour, starch or milk; pastrycooks' products
		'11	Products of the milling industry; malt; starches; inulin; wheat gluten
		'04	Dairy produce; birds' eggs; natural honey; edible products of animal origin, not elsewhere ...
		'35	Albuminoidal substances; modified starches; glues; enzymes
		'09	Coffee, tea, maté and spices
		'23	Residues and waste from the food industries; prepared animal fodder
		'16	Preparations of meat, of fish or of crustaceans, molluscs or other aquatic invertebrates
		'02	Meat and edible meat offal
		'22	Beverages, spirits and vinegar
		'24	Tobacco and manufactured tobacco substitutes
Textile and apparel	Textiles	'54	Man-made filaments; strip and the like of man-made textile materials
	wearing apparel	'62	Articles of apparel and clothing accessories, not knitted or crocheted
		'63	Other made-up textile articles; sets; worn clothing and worn textile articles; rags
		'64	Footwear, gaiters and the like; parts of such articles
		'32	Tanning or dyeing extracts; tannins and their derivatives; dyes, pigments and other colouring ...
		'61	Articles of apparel and clothing accessories, knitted or crocheted
		'56	Wadding, felt and nonwovens; special yarns; twine, cordage, ropes and cables and articles thereof
		'60	Knitted or crocheted fabrics
		'59	Impregnated, coated, covered or laminated textile fabrics; textile articles of a kind suitable ...
		'58	Special woven fabrics; tufted textile fabrics; lace; tapestries; trimmings; embroidery
		'57	Carpets and other textile floor coverings
	Dwellings		

Light Mnaufacturing	Leather products	'44	Wood and articles of wood; wood charcoal
	wood Products	48	Paper and paperboard; articles of paper pulp, of paper or of paperboard
	Paper products, publishing	'49	Printed books, newspapers, pictures and other products of the printing industry; manuscripts, ...
	Metal Products	'47	Pulp of wood or of other fibrous cellulosic material; recovered (waste and scrap) paper or ...
	Motor vehicles and parts	'37	Photographic or cinematographic goods
	Transport equipment nec	'94	Furniture; bedding, mattresses, mattress supports, cushions and similar stuffed furnishings; ...
	Maufactures nec	'65	Headgear and parts thereof
		'66	Umbrellas, sun umbrellas, walking sticks, seat-sticks, whips, riding-crops and parts thereof
		'46	Manufactures of straw, of esparto or of other plaiting materials; basketware and wickerwork
		'45	Cork and articles of cork
		'43	Furskins and artificial fur; manufactures thereof
		'68	Articles of stone, plaster, cement, asbestos, mica or similar materials
		'97	Works of art, collectors' pieces and antiques
		'42	Articles of leather; saddlery and harness; travel goods, handbags and similar containers; articles ...
Heavy Manufacturing	Petroleum, coal Products	'72	Iron and steel
	Chemical Products	'73	Articles of iron or steel
	Basic Pharmaceutical Products	'76	Aluminium and articles thereof
	Rubber and plastic Products	'83	Miscellaneous articles of base metal
	Mineral products nec	'82	Tools, implements, cutlery, spoons and forks, of base metal; parts thereof of base metal
	Ferrous metals	'74	Copper and articles thereof
	Metals nec	'96	Miscellaneous manufactured articles
	Computer, electronic and optic	'79	Zinc and articles thereof
	Electrical equipment	'71	Natural or cultured pearls, precious or semi-precious stones, precious metals, metals clad ...
	Machinary and equipment	'75	Nickel and articles thereof
		'81	Other base metals; cermets; articles thereof
		'80	Tin and articles thereof
		'78	Lead and articles thereof
		'39	Plastics and articles thereof
		'30	Pharmaceutical products
		'31	Fertilisers
		'38	Miscellaneous chemical products
		'90	Optical, photographic, cinematographic, measuring, checking, precision, medical or surgical ...
		'40	Rubber and articles thereof
		'29	Organic chemicals
		'34	Soap, organic surface-active agents, washing preparations, lubricating preparations, artificial ...
		'33	Essential oils and resinoids; perfumery, cosmetic or toilet preparations
		'28	Inorganic chemicals; organic or inorganic compounds of precious metals, of rare-earth metals, ...
		'25	Salt; sulphur; earths and stone; plastering materials, lime and cement
		'36	Explosives; pyrotechnic products; matches; pyrophoric alloys; certain combustible preparations
		'84	Machinery, mechanical appliances, nuclear reactors, boilers; parts thereof
		'88	Aircraft, spacecraft, and parts thereof
		'86	Railway or tramway locomotives, rolling stock and parts thereof; railway or tramway track fixtures ...
		'91	Clocks and watches and parts thereof
		'92	Musical instruments; parts and accessories of such articles
		'93	Arms and ammunition; parts and accessories thereof
		'85	Electrical machinery and equipment and parts thereof; sound recorders and reproducers, television ...
		'87	Vehicles other than railway or tramway rolling stock, and parts and accessories thereof
		'89	Ships, boats and floating structures
Utilcons	Electricity	5	Construction
	Gas manufacture, distribution		
	Water		
	Construction		
TransCommun	Trade	SOX	Memo item: Commercial services
	Accommodation, Food and Service	3	Transport
	Transport nec	4	Travel
	Water transport	9	Telecommunications, computer, and information services
	Air transport		
	Warehousing and support activities		
	Communication		
Other Services	Financial Services nec	6	Insurance and pension services
	Insurance	7	Financial services
	Real estate activities	10	Other business services
	Business services nec	12	Government goods and services n.i.e.
	Recreational and other services	11	Personal, cultural, and recreational services
	Education	8	Charges for the use of intellectual property n.i.e.
	Human health and Social work activities		
	Dwellings		

Appendix C

Labor classification based on ISCO-08 and ISCO-88 broad skill level

TABLE C.1

Labor classification based on ISCO-08 and ISCO-88 broad skill level

Broad skill level	**ISCO-08**	**ISCO-88**	**GTAP**
Skill levels 3 and 4 (high)	1. Managers	1. Legislators, senior officials and managers	- Technicians/Assoc Professionals
	2. Professionals	2. Professionals	- Officials and managers
	3. Technicians and associate professionals	3. Technicians and associate professionals	
Skill level 2 (medium)	4. Clerical support workers	4. Clerks	- Clerks
	5. Service and sales workers	5. Service workers and shop and market sales workers	- Service/Shop workers
	6. Skilled agricultural, forestry and fishery workers	6. Skilled agricultural and fishery workers	
	7. Craft and related trades workers	7. Craft and related trades workers	
	8. Plant and machine operators, and assemblers	8. Plant and machine operators and assemblers	
Skill level 1 (low)	9. Elementary occupations	9. Elementary occupations	Agriculture and unsk
Armed forces	0. Armed forces occupations	0. Armed forces	
Not elsewhere classified	X. Not elsewhere classified	X. Not elsewhere classified	-