The enhancement of input-output based employment assessment tools for EU operations in sub-Saharan Africa

STRENGTHEN2: Employment impact assessment to maximise job creation in Africa

Authors / Xiao Jiang

Massimiliano La Marca

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▶ Non-technical summary

STRENGTHEN2 is a joint initiative of the European Union and the ILO that focuses on job creation through investments. An important component of the STRENGTHEN2 project is to facilitate exchanges among Development Finance Institutions (DFIs) on how to measure the employment impact of investment while also contributing to the improvement and harmonization of such assessment practices across these institutions. Input-output analysis is the foundation for most employment impact assessment tools used by DFIs. The purpose of this note is to conduct a constructive critical review of the input-output framework as an employment impact assessment tool, and propose several ways to enhance this methodology, with a particular focus on improving employment impact assessment capacity for investment operations in sub-Saharan African countries and making specific recommendations with respect to workstreams for the STRENGTHEN2 project.

The “input-output based employment assessment tool” refers to the broad category of employment assessment tools that apply a multiplier model to Input-Output Tables (IOTs) and Social Accounting Matrices (SAMs) and estimate employment impacts. While the multiplier model benefits from the straightforwardness of its assumptions and transparency of its results, it suffers from i) data limitations, ii) the generalization of some key assumptions, and iii) a rigid causal structure. These shortcomings can limit the applicability and reliability of the basic multiplier model for assessing the actual extent and multidimensional aspects of employment impacts of economic policies and specific investments.

To overcome some of the aforementioned shortcomings and enhance the I-O based employment assessment tools, this note proposes two workstreams that can run simultaneously. The first workstream focuses on data enhancement. While there exist many sources for obtaining the data (IOTs and SAMs) to conduct I-O analysis, the most widely used data source for constructing employment assessment tools is the Global Trade Analysis Project (GTAP) database, which contains a set of harmonized 65-sector SAMs for about 141 regions of the world. Besides the wide region and sector coverage, the GTAP data contains breakdowns in skill levels and occupational profiles of labour income, which is a unique advantage of this dataset. Furthermore, it contains CO2 emission data by sector, which enables environmental oriented analysis. To further enrich the labour aspect of the data, part of this workstream capitalizes on the rich labour statistics from ILO’s ILOSTAT database and expands the GTAP-consistent sectoral employment data to include employment status (formal and informal), gender and age. The other part of the workstream expands the SAM from the GTAP database by incorporating additional household income and consumption details. The enhancement of employment data enables the ability to capture and assess the multidimensionality of employment. The enhancement of the income and consumption aspects of the SAM will result in more accurate assessments of induced (consumption) effects and extend the scope of the assessments to include distributional outcomes.

The second workstream focuses on extending the analytical framework, and this can be done in successive stages and provide a running model that can be readily used for employment impact assessments. In a first stage of expansion, the model is still a static one but it allows for price effects, sectoral constraints, and economy-wide capacity effects in terms of easing constraints and reducing cost of intermediate inputs. The initial shock on capacity (e.g., the increase of electricity supply due to an energy project) is treated exogenously in this model, which means it is provided by sources outside of the model (such as the project data or assumptions). The resulting model from this stage is most suitable for estimating effects over a short to medium term where prices are allowed to adjust. The model requires limited project specific data and can be used to assess a large number of projects.

The model in the second stage adds the special feature – the time dimension. It is capable of spreading the effects of a project along a timeline by sequencing the investment process over time. With information on the time horizon of the project and the sequencing of the components of an investment project, the model can be calibrated and matched to the real time horizon of the investment project. Hence, the model can be used to track the employment effects over time.

The model in the third stage explicitly models the investment and accumulation process, and labour productivity and sectoral supply capacity will evolve with such a process. Therefore, unlike the model from the first stage, the capacity effects in this stage are generated endogenously within the model by the investment process. The resulting model from this stage is most suitable for estimating effects over the medium to long term where labour productivity and sectoral capacity can adjust endogenously. However, since the model from stages 3 would require more project specific and national account data, it will be more suitable for in-depth studies.

Contents

▶ 1. Introduction

STRENGTHEN2 is a joint initiative of the European Union and the ILO that focuses on job creation through investments with the geographic focus on sub-Saharan African countries. An important component of the STRENGTHEN2 project is to facilitate exchanges among development finance institutions (DFIs) on how to measure the employment impact of investment while also contributing to the improvement and harmonization of such assessment practices across these institutions. In this note, the terminology "input-output based employment assessment tool" refers to the broad category of employment assessment tools that apply the multiplier model to Input-Output Tables (IOTs) and Social Accounting Matrices (SAMs) to estimate employment impacts. The multiplier model, often referred to as I-O framework even when applied to SAMs, is the main type of tool used by DFIs to assess the employment impact of their operations. This model has the advantage of relying on straightforward assumptions and producing transparent and easy-to-interpret results. More importantly, it is able to estimate economy-wide indirect and induced employment effects, which are especially relevant in the employment impact evaluation of policies and projects. However, the model also suffers from series of well-known shortcomings. The purpose of this note is to conduct a constructive critical review of input-output analysis as an employment impact assessment tool and propose several ways to enhance this methodology, with a particular focus on improving employment impact assessment capacity for investment operations in sub-Saharan African countries.

This methodological note is structured as follows. Section 2 provides a critical review for the basic multiplier methodology based on IOTs and SAMs with a special focus on its application to employment impact assessments. Section 3 tackles the enhancement of data. It assesses the feasibility and efforts needed to extend the I-O and SAM tables in order to incorporate additional data on gender, age, employment status (formal vs informal), and household income and consumption breakdowns (rural vs urban, household income by deciles), so that assessing these aspects of employment outcomes including addressing the quality of employment becomes possible. Section 4 proposes an enhanced framework for employment impact assessments. The starting point is an illustration of the basic version of an economy-wide model based on the GTAP SAM that is able to capture effects that are not or inadequately addressed by existing I-O based tools/models such as the price effects, agricultural constraints, and capacity effects at the sector level. Section 5 concludes.

▶ 2. Multiplier Analysis: a critical review

This section discusses the three main types of shortcomings from the basic fixed coefficient multiplier technique, namely data limitation, generalization of some key assumption and rigidity of the underlying causal structure.

2.1 Data limitation

The fixed coefficient multiplier technique can be applied to three types of datasets: input-output tables (IOT), supply and use tables (SUT) and social accounting matrix (SAM). The IOT is a compact matrix representation of the economy's monetary transactions between productive sectors, final demand of products and generation of income. It captures the sectoral composition of the GDP components such as consumption, government spending, investment and trade on the expenditure side, and taxes and value-added on the income side. The SUTs represent explicitly the supply (or production) of goods and services by industries, and the use (or demand) of products by industries and institutional sectors such as households, government and the rest of the world. The SUTs are compiled from the source data and are nowadays considered the best instrument for estimating national account aggregates. The focus of both IOT and SUT is on the interindustry transactions and composition of supply. Therefore, the generation and uses of incomes are left at an aggregate level and remain unexplained when the tables are used for multiplier analysis. A SAM links together the macro-statistics of national accounts with the micro-statistics of labour market, household income and other social statistics; in other words, it includes extended institutional sectors' transactions to represent the flows of generation, distribution and use of income of selected socioeconomic groups. This additional information can be used to expand the scope of the multiplier analysis (ILO, 2018) (Eurostat, 2008).

The IOTs and SUTs are highly standardized internationally (except for the sector classifications) but a SAM contains a lot of idiosyncratic elements depending on who is compiling it and its analytical purpose. Since this note focuses only on tools based on IOTs and SAMs, the similarities and differences between them are illustrated and elaborated in appendix A. Essentially, one can consider the IOT as part of the SAM, and while one can always recover the IOT from a given SAM, the reverse is not possible (European Commission, 2003). There exists a handful of international databases for IOTs and SAMs. Most of the existing employment assessment tools rely on the Global Trade Analysis Project (GTAP) database, which provides harmonized SAMs for 141 regions and each with 65 sectors.[1]

There are two aspects of the data issue. First the data relied on might not have the necessary information to answer the employment-related questions at hand. Most of the SAMs and IOTs do not come with data on physical employment, thus any assessment of quantity of employment will require the compilation of data on physical employment by sectors in the IOTs and SAMs. Furthermore, in order to answer questions related to various aspects of employment such as age, gender, wage, and informality, one has to compile and harmonize additional data. Another related major shortcoming, which is more specific to the GTAP SAM, is that sometimes the household income and consumption data is not broken down by any characteristics such as rural-urban or income class by deciles. The lack of information on the breakdown of household income and consumption makes the assessment of employment impact of induced (consumption) effects less accurate; and it makes the tool silent on the distributional effects of an intervention, which is sometimes considered as an indicator for the qualitative aspect of employment.

The second aspect of the data issue is related to the highly aggregated nature of IOT, SUT, and SAM for most countries. The sectors in those databases are often highly aggregated, especially for developing countries. For example, a construction sector in the GTAP SAM includes many different types of activities, but often the analysis focuses on a very specific sector such as road construction or bridge construction. The assumption that the sectoral details of a very specific sub-sector (such as hydropower plant construction) are identical with a highly aggregated sector (such as general construction) is a strong one. Furthermore, given the assumption of fixed coefficients, especially in terms of fixed labour intensity in each sector, the variations in the types of construction method (e.g., labour-based vs conventional) are not captured in this data. This aspect of the data issue is much harder to address. A solution will involve surveying and collecting much more detailed interindustry and within sector data.

[1] While there exists several harmonized international databases for IOTs and SAMs such as the EORA, WIOD, Exiobase, AIIOTs etc., the GTAP remains to be the database with highest sector and decent country coverages. However, some of the GTAP IOTs for developing countries are imputed rather than based on actual national statistics.

2.2 Multiplier method and its assumption

One of the limitations of the basic multiplier analysis comes from applying the assumption of fixed coefficients across the entire system. Relations amongst different variables in an I-O or SAM multiplier model are captured by a set of ratios or "coefficients". These are assumed to be fixed parameters and therefore unaffected by the changes in the variables. For example, the relationship between input demand and output production is captured by the "technical coefficients", the relationship between labour demand and output is captured by the "labour coefficient", and the relationship between income and consumption is captured by the "propensity to consume", and so on. These coefficients define the structure of the economy, and the system becomes "linear", which implies that the impact of a shock is proportional to the shock itself. This proportional relationship is captured by the "multipliers" which measure how much output or employment is generated in the system as the total effect following a unit of change of final demand for products (typically investment or exports). It is important to clarify here that since the proportional relationship is fixed by fixed coefficients, then multipliers are always fixed at same values too in this framework, regardless of the type or the size of the shock.

Moreover, the multiplier model is used to analyse the effects of changes (or shocks) on *quantities*. Prices and wages may be independently determined and do not affect quantity outcomes.[2] This price independence and reliance on fixed coefficients greatly simplify the analysis and its interpretation: The impact of a demand shock propagates throughout the system generating additional product and employment demand via the backward linkages in production and possibly increases in income and consumption. Such linkages are represented by the fixed coefficients and magnify the effects of the original demand increases generating additional indirect and possibly "induced" effects. Thus the multiplier model excludes price changes and its effects on the economy. The assumption of fixed prices (or rather independence of impact on quantities from prices) to some degree clearly limits the applicability or reliability of the model because changes in prices may affect final product demand in relevant ways. For example, an increase in the price of domestically produced goods will incentivize producers and consumers to substitute them with imports, and this change in behaviour can be swift.

The fixed coefficient assumption may be used in the context of short-term analysis and are more plausible when applied to production coefficients than to consumption coefficients because consumers tend to adjust their behaviours more swiftly in response to changes in price and income. One can imagine that if any of those coefficients change, estimations based on an input-output analysis would become less accurate. For example, if there is an increase in labour productivity, the actual labour coefficients would be lower than the ones in the I-O multiplier model, and the model would overestimate the employment effects. Furthermore, if household consumption of products not only respond to the income according to fixed linear consumption propensity, but also responds to prices and/or other household characteristics (rural-urban or income deciles), then the consumption effect would not be proportional to the income rise. Therefore the I-O multiplier model would tend to overestimate the household consumption (or induced) effects on output and employment. Finally, in the medium-to-long run, investment and capital accumulation allows for technical change which implies changes in the input-output production coefficients. Therefore, the estimated output and employment multipliers become less accurate over a longer time horizon (Gibson, 2011).

2.3 Rigidity of causal structure

The causal structure behind a typical I-O fixed coefficient multiplier model is simple: an increase (or decrease) in final demand in a sector will stimulate (or suppress) production in all other sectors in order to meet the increased (or decreased) demand for intermediate inputs for that particular sector. The change in output also results in changes in employment via fixed labour coefficients. The simplicity of the causal structure is both an advantage and a limitation. It is simple and transparent, so it is easy to understand and well-suited for informing non-specialist audiences. However, the rigidity of the causal structure reduces its ability to investigate issues with more complicated causal relations. Examples are:

a. Especially for developing countries, many sectors might face severe capacity constraints in terms of natural resources, skilled labour, capacity of local enterprises, or insufficient capital investments (e.g., building supplies like cement and land of comparable quality). The agricultural sector is a good example because its productive capacity is often constrained by the availability of fertile land and capital stock. The I-O framework simply cannot

[2] The I-O model can be specified in terms of values (quantities times prices) and the multipliers can refer to the total change in the values of gross production induced by the change of the value of final demand of products. This leaves the distinction between price and quantities unexplained and then requires the assumption of fixed prices to interpret the results.

take these sector constraints into account because in this framework output always expands as to accommodate demand. In other words, demand is the only constraint in the typical multiplier model, which is the most widely applied type of multiplier model for employment assessment. This is also why many I-O based analysis tends to heavily overestimate the amount of employment generated in the agricultural sector because agriculture is treated as any other sector, whose supply simply adjusts to accommodate any demand changes without any constraints; and at the same time agricultural production tends to be highly labour-intensive, hence the estimated employment effect tends to be very large.

b. The purely demand-driven causal structure also prevents the model itself from analyzing many effects of capacity changes. Capacity affects supply either directly or indirectly via price and productivity, but a typical I-O model can only accommodate changes in demand. Hence, in this case, the employment effects of a capacity expansion will be omitted in a standard I-O analysis. While there are works that add a capacity module to the I-O model by letting the final demand grow with capacity, such construct is inconsistent with the general I-O framework.[3]

c. In actual economies, there are many other mechanisms that play out together with demand effects. Besides price and capacity effects, status of employment, workers' bargaining power, migration decisions and wage adjustment mechanisms will determine the employment outcomes. The multiplier model by focusing exclusively on the linear propagation of changes in demand in the economic system may only provide a partial view or assessment for the actual impacts.

[3] For example, it is hard to justify theoretically that capacity growth would lead to final demand growth. Instead, it should lead to output (or supply) growth, which is unfortunately an endogenous variable in I-O analysis.

3. Data Enhancement

While the existing structure of the data might not be sufficient to answer the questions one might have, efforts can be made to harmonize and integrate additional data into the existing IOT, SAM and employment data. To overcome the aforementioned data limitations in the conventional I-O framework and allow the assessment of various aspects of employment outcomes including the quality of employment, additional data need to be collected and integrated into the basic IOT and SAM structures. For instance, consumption and expenditure accounts in a SAM can be expanded to acquire the induced consumption effects more accurately. The employment data in hand is compiled by ImpactEcon based on the ILOSTAT, which is an extension of the GTAP data, thus it already has by-sector breakdowns in skills (high and low) and occupational categories (five of them), hence the skill and occupational dimensions of the employment are ready to be explored. In addition, there is the possibility of enhancing the data to include employment status (formal and informal), gender and age, while preserving the sector details in the GTAP data. The main challenge for the data work is to obtain detailed labour and household statistics by sector and to harmonize them with the sectors in the IOT or SAM. Incorporating additional household data requires the rebalancing of the SAM. Before assessing the difficulty associated with each enhancement, table 1 provides an overview of data availability for SSA countries covered by GTAP.

The first two columns of the table indicate the names of the SSA countries included in the GTAP database, and the variables intended to be incorporate as part of the data enhancement effort are listed on the top row. The letter "Y" indicates the availability of the data at detailed sector level (ISIC level 2) for the first three variables; and for the last variable, it simply indicates the availability of the data, which will be discussed in more detail later. Yet, there exists the possibility that a country one wants to assess is not included in the GTAP database.[4] In that case, one shall consult with the EORA database, which provides IOTs for a wider sample of countries. However, the EORA sectors are highly aggregated and with only IOT available (rather than SAM) one is limited to the basic multiplier I-O framework. Another alternative is to compute the multipliers using the aggregated regional SAM provided in the GTAP database and apply these multipliers to the countries that belong to the region.[5] Obviously, results obtained from this method will be based on regional averages. Compiling a SAM based on an existing IOT is always a possibility, but the process can be labour-intensive.

The data on employment status is compiled by the INWORK unit of the ILO's WORKQUALITY department for their analysis of the impact of COVID-19 on the informal economy. The dataset provides 1) formal and informal employment numbers, and 2) the number of employees of formal and informal status, for each sector at ISIC level 2. An advantage of this dataset is that it has been harmonized across countries and sectors, hence the only work left to do is to match the data from the ISIC level 2 (99) industries to the 65 GTAP sectors, and the basic concordance table is provided in the GTAP 10 documentation.

[4] SSA countries that are not included in the GTAP database: Angola, Burundi, Central African Republic, Chad, Congo, Eritrea, Gabon, Gambia, Lesotho, Liberia, Mali, Mauritania, Niger, Sierra Leone, Somalia, and Democratic Republic of Congo.

[5] This is the method used by both the Joint Impact Model (JIM) and the Program for Infrastructure Development Program (PIDA) job creation toolkit, both are employment impact assessment tools based on I-O multiplier analysis and GTAP SAMs.

▶ **Table 1. Data availability by country**

GTAP Countries	Country Name	Status (Formal & Informal)	Gender	Age	Household Income and Consumption
ben	Benin				
bfa	Burkina Faso	Y	Y	Y	Y
cmr	Cameroon				
civ	Côte d'Ivoire	Y	Y	Y	Y
gha	Ghana	Y	Y	Y	Y
gin	Guinea				
nga	Nigeria		Y	Y	Y
sen	Senegal				Y
tgo	Togo	Y	Y	Y	Y
eth	Ethiopia	Y	Y	Y	Y
ken	Kenya				Y
mdg	Madagascar	Y	Y	Y	
mwi	Malawi				Y
mus	Mauritius	Y		Y	
moz	Mozambique	Y	Y	Y	Y
rwa	Rwanda	Y	Y	Y	Y
tza	Tanzania	Y	Y	Y	Y
uga	Uganda	Y	Y	Y	Y
zmb	Zambia	Y	Y	Y	Y
zwe	Zimbabwe	Y	Y	Y	Y
bwa	Botswana		Y	Y	Y
nam	Namibia	Y	Y	Y	Y
zaf	South Africa				

Source: Own research.

Gender and age data can be obtained from ILO's microdata repository, in which one can request the data at ISIC level 2 product classification (99 possible industries). However, the resulting dataset would not be harmonized, and a considerable amount of data work is needed to clean and harmonize the dataset. The ILO's microdata repository reports data is mostly based on labour force surveys. For any sector in any country and year, data might be missing for two reasons. First, there is simply no survey data; and second, the survey data does not pass the "reliability test", that is the underlying sample size is less than five. Therefore, for the gender data, the available sectors would be different cross years, countries and indicators (total, male and female). Since the focus is on gender ratio in each sector and it is assumed to be stable over time, only data from the most recent year will be used. Some of the missing data in the indicators can be filled by imputation. For example, if total and female employment numbers are available, one can impute the male employment by subtraction. In the end, one has to handle the missing data, clean, and harmonize the data with GTAP sector country by country. One faces similar challenges with the age data, but there is an additional challenge: for each year, country, and sector, the age data supposes to have breakdowns in 4 bands: 15-24, 25-54, 55-64, 65+, and data for any of these age bands can be missing at sector level. This indeed increases the difficulty with missing data handling and harmonization. The rule for handling missing data will vary from country to country, but the fallback strategy will be to rely on the alternative dataset from ILOSTAT which has higher level of sector aggregation (18 economic activities) but significantly fewer missing data.

The household income and consumption data in the GTAP SAM is simply a row and a column; in other words, there is no breakdown by household types such as rural-urban, or income class (by quintiles or deciles depending for example). There are three main reasons for having breakdowns in household income and consumption data for the purpose of employment impact assessments. First, by having more detailed information on household income and consumption, one is able to better capture the consumption induced effects of employment because without this, one has to assume that the propensity to consume is fixed across sectors for all households (wage earners) in each sector, which is extremely unrealistic. Second, once the I-O based tool is enhanced by using more advanced modelling that takes price effects, sector constraints, and longer-term capacity effects into account, the distribution of income would affect output and employment, and price will play a role in household's consumption behaviour. Hence the employment outcome will be sensitive to how income is distributed and spent across household types and sectors. Third, the distributional outcome of an intervention is sometime viewed as an indicator for the "quality" of jobs. Thus, by having household income and consumption details, it enables the assessment of the effects of an intervention on income inequality in addition to employment.

The task of incorporating household income and consumption details by household type is more complicated than the task of enhancing the data to include employment status, gender and age, because the latter essentially involves splitting each sector's employment number by status, gender and age using additional data. To incorporate household details in income and consumption, one has to expand the SAM table using additional data, and to rebalance the GTAP SAM using the cross-entropy[6] method so that column sums and row sums are equal after the expansion. In order to do so, one has to make sure that similar information, such as other versions (non-GTAP) of the SAM with household income (by quintiles or deciles depending on the data source) and consumption breakdowns, must exist elsewhere. The last column of table 1 shows the availability of such information across countries. Given how specialized and technical this line of task is, it might be optimal to work closely with data specialists who are experienced with working with SAMs as well as GTAP data.

Lastly, decisions have to be made with regard to the countries where the data is simply not available at ISIC level 2 product classification for employment status, gender, and age. If the analysis must cover these countries, one might have to use data with a much higher level of sector aggregation, with the cost being the lack of sector details (e.g., all manufacture sectors would have the same gender and/or age and/or informal ratios).

[6] The cross entropy is a flexible technique (relative to more conventional methods such as the RAS) that is able to update and balance IOT and SAM while accommodating the expansion of columns and rows simultaneously.

4. Extension of Analytical Framework

The limitations of the multiplier model are rather known to researchers and analysts, but they are sometimes overemphasized to dismiss the building blocks of the I-O framework altogether. The assumptions of the multiplier framework are typically taken as a block and the framework is contrasted with Computable General Equilibrium models (CGEs), which are based on more and sometime idiosyncratic assumptions. The advantages of the I-O model in terms of simplicity of computation and interpretation of results have been traditionally compared to the stronger theoretical soundness but also the higher complexity of CGEs.[7] The standard CGEs all share some common core features and are based on some simple principles of price-induced substitution between production factors and demand of products. For this reason, it is often claimed that they capture the inherent adjustment mechanism of market economies. On the other hand, CGEs vary in the level of complexity and rely on hierarchical functional structures that are needed to meet selected desired properties. Such complexity combined with the selective use of mathematical specifications lead to difficulties in modelling real world phenomena and interpreting the results. This has also generated distrust in this class of models which have been often referred to as "black boxes". This makes the transparency of adjustment mechanisms and straightforwardness of the assumptions a pronounced advantage for the I-O model over CGE model.

The standard CGEs get around the limitation of the I-O framework, such as price independence of quantities, unconstrained supply and fixed coefficient, by relying on perfect price adjustment and market clearing, market symmetry, substitution on the product and factor markets and supply determination of aggregate production and employment. However, these features make this class of models less suitable for impact assessment than the standard I-O framework, especially for low-income developing economies. The core features of the standard CGEs are supposed to represent a "first approximation" of the actual working of market economies and imply perfect competition, price adjustment and substitutions possibilities in the use of capital and labour. These features are often not met in actual economies in the relevant time frame of a policy or investment project. Moreover, standard CGEs assume the full use of the available factors of production which are, most of the times, already productively employed in the system. This implies that an investment project that is believed to lift production bottlenecks and improve the capacity of the system to fully employ resources will have very limited aggregate effects in these models.

Therefore, some of the building blocks of the standard I-O framework still represent the best possible assumptions in a context of limited information and necessary parsimony to generate factual results that can be easily interpreted. The assumption of (i) fixed production (input-output) coefficients remain the best hypothesis if they are interpreted as representing the actual average production structure in each industry. Such structure is determined by the available technology and the existing capacity of the firms operating in the sector.[8] The effects of prices on such structural aspect can be minimal in the short-to medium-run. On the other hand (ii) price effects can be more pervasive in other parts of the system such as in final consumption and demand for imports or exports. They can generate substitution between products of different kinds and between domestic and foreign products in both intermediate and final uses. Price effects can also affect the distribution of income by determining the purchasing power of different labour incomes and determine the level and composition of demand. Therefore, price induced substitution can interact with product demand and the income distribution across different classes of labour and households in a short timeframe. Finally, (iii) a demand constrained system can be characterized by having some supply side constrained sectors. These constrains can reflect the actual structure and capacity of the economy to generate income, production and employment induced by demand in both constrained and unconstrained sectors.

The computational model developed at the ILO, currently referred to as Simulation Model for Sustainable Development (SMSD), is based on a framework that adopts elements of the I-O modelling framework while incorporating additional features such as price effects and capacity constraints. The model has been applied in a few country pilots and case studies (La Marca and Jiang, 2021, 2020) and can be adapted to meet the needs of the impact assessment analysis as it has the flexibility to: (a) incorporate factual features of low-income developing economies with chronic underemployment and commodity dependence, (b) achieve internal consistency between the real time horizons of the impacts of the shock to be

[7] The term CGE is nowadays almost exclusively associated with standard CGEs and therefore bears their reputation of theoretical orthodoxy, complex implementation and interpretation of results and limited applicability to real world assessment of employment impacts.

[8] The existing capacity of the producing units depends on past investments and knowledge.

assessed and the model presumptive *adjustment time*, and (c) maintain a close correspondence between the model and internationally agreed statistical concepts and definitions.

There can be successive phases of model development that underline the progressive incorporation of building blocks that augment the scope and reliability of the model. The model at stage 1 is a static one with sectoral constraints. At stage 2, the model is a dynamic one with sequential impact and effects. Finally, the model at stage 3 incorporates capital accumulation and productivity change. The model at stages 1 and 2 requires limited project specific data and can be used to assess a large number of projects. The model at stages 3 requires more project specific and additional national account data and can be suitable for in-depth studies. Successive stages increase both the complexity and data requirements of the model and allow for more detailed assessment of how the project affects capacity, productivity and employment in the long run.

Stage 1. Static model with sectoral constraints

A static SAM-based model with selected supply and demand constrained sectors and endogenous prices can overcome some of the aforementioned shortcomings of the I-O framework. The model at this stage can efficiently use the GTAP database structure and other available SAM information and model explicitly: the distinction between uses of domestic and imported products in intermediate and final consumption, the effects of taxes on quantities and the price system, the distinction between government and household demand, and savings.

Unlike the I-O based multiplier model, the model can include sectoral supply constraints. The supply constraints can be due to natural resources, capital goods supply or other necessary input (such as land and capital) in individual sectors. An agricultural or energy supply constraint not only limits outputs in those sectors, but also imposes a limit to the use of their products as intermediate inputs in other sectors as well as final consumption, even if some import substitution is possible. Under these circumstances, an increase in demand for agricultural goods cannot be satisfied by additional agricultural supply, but the agricultural price adjustment will reduce and reallocate demand between uses.[9] Consequently, price effects of agricultural products have a cost effect on those sectors that require that product.

This mechanism is particularly relevant for products that are used universally in all production process. Energy, for instance, is limited by supply capacity and its output is used as intermediate inputs for all other sectors. An increase of the energy price will affect the output and employment of all sectors as they cannot fully substitute away their energy demand with foreign imports. Price effects cascade via traditional I-O backward linkages and interact with product final demand and real income distribution. If an infrastructure project expands the energy supply in the system, the capacity effects go beyond the energy sector itself and generate a capacity expansion and/or a price reduction in all other sectors. This allows to combine product demand expansions with economy-wide capacity effect and assess their impact on output and employment.[10]

The model with sectoral supply constraints alone would generate lower output and employment effects than the conventional input-output multiplier analysis with unconstrained supply for two reasons. First, the effects of domestic supply constraints on total output and employment are milder since the constrained sectors cannot increase their production. Second, a price increase of products from those constrained sectors induces more imports but also generates negative, demand-reducing, effects on this and other products. However, supply constraints can be relaxed with increases in capacity which expand demand, reduce prices, and generate additional output and employment.

Concerning data requirement, the model at this stage only needs the GTAP SAMs and a set of elasticities that are either provided by the GTAP database, estimated, or obtained from the literature and adjusted within a reasonable range. In absence of detailed project expenditure breakdowns, the PIDA Standard can be used.[11] Furthermore, when assessing projects that expand the capacity in the supply-constrained sectors (e.g., the construction of a power plant that expands the supply of electricity, notably in the field of renewable energy), the model can benefit from accessing actual or reasonably estimated data on the industry structure and the capacity effect using sample surveys or secondary literature. Finally, in absence of this kind of data, it is possible to assume a range of possible capacity effect (e.g., an additional 1 to 5 per cent) in that sector and estimate the range of impacts across the whole economy. A final alternative is adopting some of the coefficients estimated and used in other employment assessment tools such as the Joint Impact Model (JIM)

[9] It is still possible to allow agricultural output to grow (or decline) at an empirically extrapolated rate if the time horizon of project to be assessed is long.

[10] At this model stage an expansion of capacity in the supply constrained sectors is exogenous. This means that the capacity will expand based on the project data or document. In stage 3, the model allows the supply capacity of a sector to change with the endogenously determined investment in that sector.

[11] The PIDA Standard is a set of cost breakdowns across sectors based on the type of project according to expert knowledge from PIDA.

and the tools used by World Bank Group's International Finance Corporations (IFC) for assessing the capacity effect in the supply-constrained sectors.

Stage 2. Dynamic model with sequential impact and effects

The model at stage 1 is static, which means that the results are generated instantaneously after a shock and there is no explicit time dimension. In reality, each project rolls out over a time horizon, and its economy-wide effects take time. At stage 2 the model should be able to sequence the components of a project and generate results along a given timeline. This has the advantage of allowing for endogenous changes in prices and quantities *over time*, and permits matching of model time dimension with the actual time horizon of project development. For instance, the investment project may consist of a sequence of phases that become sequential inputs into the model and each phase can have effects that are spread over time. In other words, the model at this stage can accommodate the need of aligning model adjustment time to the *real time* horizon of the investment. The model at this stage goes beyond the static nature of the model at the previous stage. This is particularly relevant for big projects that are implemented over a long period of time with pronounced capacity effects. The ability of assessing the employment impacts over time adds additional realism to the model because in reality the economy-wide effects of any investment project or policy are always played out sequentially throughout time; moreover it distinguishes permanent employment effect from the temporary effects in a clear and intuitive way.

In terms of data requirement, the only additional data needed for the model at this stage is the time horizon of the project, the sequencing of its components (e.g., 50 per cent of construction in the first year, 30 per cent of operation in the second year etc.). This information can be based on past research and knowledge.

Stage 3. Productivity change and capital accumulation

The model at this stage taps into the long-run effects of an investment project. Over the long term, there will be changes in labour productivity (technical change) in addition to the price effects; and furthermore, those constrained sectors would expand endogenously given the pattern of investment (capital accumulation). The effect of investment on labour productivity is known as the Kaldor-Verdoorn effect, which can be measured empirically if time series on labour productivity and investment are available or it might be approximated by existing measures for developing countries. To model the investment behaviour and capture the endogenous expansion of capacity caused directly by the investment, a capital accumulation process has to be introduced, and such process can be represented by introducing investment functions that depend on sectoral profitability or demand. These functions can quantify how much additional capital formation can expand capacity in supply constrained sectors; and, via the Kaldor-Verdoorn effect, how much labour productivity growth there will be.

It is perhaps important to point out that, while the static model in stage 1 is likely to result in lower estimated employment impacts due to sector constraints and price effects when compared with the conventional I-O multiplier model, the employment estimate from this stage of the model is likely to be higher than stage 1 because it takes into account capital accumulation and endogenous capacity expansion in the long run.[12] The result here is particularly relevant for projects whose objective is to transform the economic structure and create jobs in the long run.

There are two additional data requirements for the model at this stage. First, time series data of sector labour productivity will be needed to estimate the Kaldor-Verdoorn coefficient. Although the sectors are more aggregated, the Expanded Africa Sector Database (EASD) from UNU-MERIT provides such data for a large sample of African countries. Second, it requires information on the composition of investment by product demanded and by investing sector. These data are often collected by statistical offices although it is rarely published. Given the fact that the availability of the capital coefficient data can be limited, the model can from this stage be applied in a handful of in-depth studies.

[12] If labour productivity grows too much faster than aggregate demand, it might result negative employment impact due to the labour replacing mechanism.

▶ 5. Concluding Remarks

The multiplier model, often referred to as I-O framework, is the main type of tool used by DFIs and other development agencies to assess the employment impacts of interventions such as investment operations and policy interventions. While the multiplier model benefits from the straightforwardness of its assumptions and transparency of its results, it suffers from i) data limitations, ii) the generalization of some key assumptions, and iii) a rigid causal structure. These shortcomings can limit the applicability and reliability of the basic multiplier model in assessing the actual extent and multidimensional aspects of employment impacts of economic policies and specific investments.

To overcome some of the aforementioned shortcomings and enhance the I-O based employment assessment tools, this note proposes two workstreams that can run simultaneously. The first workstream focuses on data enhancement. Part of this workstream capitalizes on the rich labour statistics from ILO's ILOSTAT and expands the by sector employment data to include employment status (formal and informal), gender and age. The other part of the workstream expands the SAM from the GTAP database by incorporating additional household income and consumption details. The enhancement of employment data enables the ability to capture and assess the multidimensionality of employment, and the enhancement of the income and consumption aspects of the SAM will result in a more accurate assessment of induced (consumption) effects and extend the scope of the assessment to distributional outcomes.

The second workstream focuses on extending the analytical framework, and this can be done in successive stages and provide a running model that can be readily used for employment impact assessments. The model in the first stage is a static one that allows for price effects, sectoral constraints, and economy-wide capacity effects in terms of easing constraints and reducing the cost of intermediate inputs. The model in the second stage incorporates a time dimension and spreads the adjustment effects on a time horizon that can be calibrated and matched to the real time horizon of the investment project. The model in the third stage explicitly models the investment and accumulation process, and labour productivity by sector will evolve in the process. In other words, the model at this stage would feature endogenous technical change and capacity expansion on a long time-horizon, more suitable for assessing long-run impacts of interventions. This line of models complements the existing I-O multiplier-based employment assessment tools and aims at assessing the economy-wide employment effects over the medium to long term. The model can be easily transformed into a user-friendly tool with some interface development and trainings. Potential users would be the institutions (such as the DFIs and EU) that are interested in assessing employment impacts in the medium to long term.

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Appendix A

The fundamental similarities and differences between IOT and SAM are perhaps best illustrated using numerical examples. Both examples come from Miller and Blairs (2009). Table A1 below is an IOT for a simple and hypothetical economy with three industrial sectors, two primary factor inputs, and one type of final demand (household consumption).

Table A1. Input-Output Table Representation

	Nat. Res.	*Manuf.*	*Services*	*Households*	*Total Output*
Natural Resources	50	30	0	60	140
Manufacturing	60	40	40	40	180
Services	0	0	0	100	100
Value Added					
Labor	10	70	10		
Capital	20	40	50		
Total Input	140	180	100		

Source: (Miller & Blair, 2009)

The input-output table depicts the monetary transactions between industrial sectors (natural resources, manufacturing, and services) to all economic actors (industrial sectors, capital, labour, households). The first three rows and columns form the intermediate input matrix, illustrating transactions amongst industrial sectors themselves. The labour and capital rows below the intermediate input matrix illustrate payments from industrial sectors to those primary factors of production as renumeration for their contribution to the production of the outputs. And the household column to the right-hand side of the intermediate input matrix illustrates payment flows from households to industrial sectors as their consumption demand. For each industry, the total input value would equal to the total output value. Notice that in A1, the fourth quadrant of the IOT is empty, that is there is no recorded transactions between households and capital for example. This is one of the main differences between the IOT and SAM.

Table A2. Social Accounting Matrix Representation

	Expenditures						
	Nat. Res.	Manuf.	Serv.	Labor	Capital	Households	Total Output
Income							
Natural Resources	50	30	0			60	140
Manufacturing	60	40	40			40	180
Services	0	0	0			100	100
Labor	10	70	10				90
Capital	20	40	50				110
Households				90	110		200
Total Inputs	140	180	100	90	110	200	

Source: (Miller & Blair, 2009)

Table A2 above is an illustration of the SAM representation of same hypothetical economy. There are two main differences between A1 and A2. First, for a SAM (A2), the row and column must have same accounts, whereas for an IOT (A1), they are different beside the industrial sectors. Furthermore, the SAM accounts follows the double-entry bookkeeping accounting rule where the expenditure (the column) will always equal to income (the row), hence the column and row sums are always equal. Second, a SAM record all the transactions amongst economic actors (accounts) where as an IOT only record transactions between economic actors and industrial sectors. For example, the forth quadrant of the SAM is filled with transactions from primary factors (labour and capital) to households, hence the generation of income from factor payments to households is present in the SAM. However, this information is nowhere to be found in an IOT. While an actual SAM is most likely much more complicated than Table A2 with detailed information on savings, investment, international trade, transportation margins, government, taxes etc., the fundamental differences between SAM and IOT will be the same as the two discussed above.

Contact details

International Labour Organization
Route des Morillons 4
CH-1211 Geneva 22
Switzerland

T: +41 22 799 7403
E: jiangx@ilo.org
E: STRENGTHEN2@ilo.org

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