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Jobs in Global Value Chains

New Evidence for Four African Countries in International Perspective

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Abstract

What is the potential for job growth in Africa under participation in global value chains (GVCs)? In this study the concept of GVC jobs is introduced which tracks the number of jobs associated with GVC production of goods. A novel decomposition approach is used to account for GVC jobs by three proximate sources: global demand for final goods, a country's GVC competitiveness (measured as the country's share in serving global demand) and technology (workers needed per unit of output). Based on newly assembled data, it is shown how GVC jobs and incomes have changed over the period 2000–14 in Ethiopia, Kenya, Senegal and South Africa, compared to developments in some other low- and middle-income countries in the world. The four African countries stand out in terms of a low share of GVC jobs in the (formal) manufacturing sector, and a relatively high share in agriculture due to strong backward linkages, especially in the case of food production. All countries benefitted highly from growing global demand for final goods. At the same time it appears that technical change in GVCs is biased against the use of labour, greatly diminishing the potential for job growth through GVC participation.

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Jobs in Global Value Chains:

New Evidence for Four African Countries in International Perspective

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1. Introduction

Economists have long regarded structural change—the movement of workers from less to more productive employment, in particular in manufacturing—as essential to growth in low-income countries. Yet, Africa's industrialization trends appear to be worryingly weak (McMillan et al, 2014; Rodrik, 2016). Participation in global value chains (GVCs) is frequently highlighted as a promising route to industrialization and it features prominently in recent reports by international organisations (e.g. World Bank 2019). Concomitant there is a great interest in new empirical measures that describe the performance of countries in carrying out activities in GVCs, and a scramble for new data, in particular input-output tables, that are needed to apply the new measures.

In this paper we provide new data and a novel decomposition approach that links growth of value added and jobs in a country to its participation in GVCs. We show the usefulness of this approach for better understanding the potential for job growth under GVC trade. More specifically, we will provide an (ex post) accounting framework for GVC jobs. GVC jobs are jobs that are linked to a country's participation in production of manufacturing goods. We will account for the growth in GVCs jobs by three proximate sources: the growth of *global demand* for final manufacturing goods, growth in the *GVC competitiveness* of a country (measured as the change in the share of a country in serving global demand) and a change in *technology* (workers needed per unit of output). While essentially model-free, this empirical exercise sheds new light on the GVC debate as each element in the decomposition account has a clear interpretation.

Technology. Rodrik (2018) argues that the diffusion of production technologies through GVC participation moderates employment growth in developing countries. Producing for global markets demands increasing levels of precision and adherence to quality standards. This requires more automation and less manual work, leading to falling labour requirements in particular for less skilled workers. Technological change might ultimately even reverse patterns of comparative advantage and imply reshoring of (formerly) unskilled-intensive stages of production. Sen (2019) relatedly shows that countries with higher trade integration require fewer workers per unit of manufacturing production. Pahl and Timmer (2018) provide long-run evidence on the declining employment content of exports that also seems to support this hypothesis. If true, employment generation through GVC participation must instead come from enlarged scale of production. The scale of production in a GVC depends on the size of the end-market for a country's value added exports combined with a country's competitiveness in the GVC.

Global demand. A crucial feature of GVCs is that countries are linked to consumers through forward linkages that can span multiple countries (following Johnson and Noguera, 2012). As such, demand shocks can be transmitted through these linkages to final-good producers and also to all suppliers of intermediates, as has been documented for the crisis of 2008/2009 (e.g. Bems et al., 2011). For example insertion into a GVC that delivers to a booming economy like India or China is likely to provide higher potential for job growth than a GVC delivering to Europe. Since the crisis of 2008/09, there has been a major shift in global demand from developed countries to emerging markets. This implies that GVCs delivering to emerging markets experience most favourable expenditure growth and that different types of products might be demanded (e.g. Kaplinsky and Farooki, 2010; Gereffi, 2014). This potentially contributes to cross-country differences in job growth, depending on whether countries are integrated into GVCs ultimately delivering products to those markets. We capture this demand effect by mapping country value added to consumption of final goods in particular (regional) markets.

GVC competitiveness. The employment effect of growing final demand for the output of a GVC is moderated by the success of a country to capture income in that particular chain. This socalled GVC income share is a measure of GVC competitiveness as introduced by Timmer et al. (2013). Gereffi (2014) argues that large countries with abundant supply of labour, such as China and India, became major production centres supplying labour-intensive production stages to many GVCs. Production concentration was further enforced by lead firms' strategy to rationalize supply chains in order to deal with a smaller numbers of highly capable and strategically located suppliers. Haraguchi et al. (2017) found that the number of manufacturing jobs have not declined globally but that they are concentrated in a small number of large developing countries, see also Felipe et al. (2018). Kee and Tang (2016) relatedly show that Chinese exporters successfully competed for upstream production stages in the production of their exports, relocating more and more stages of the production chain to China. We capture these developments by tracing changes in a country's income share in a GVC.

A key ingredient for GVC analysis is a global input-output table that provides information on inter-country and inter-industry flows of goods and services. We use the WIOD (2016 release) which covers 43 countries in the world. For the purpose of this paper we add new data for seven countries that is constructed according to the methodology of the WIOD, and hence can be used in conjunction with the WIOT for global analysis. The newly constructed dataset adds four African countries (Ethiopia, Kenya, Senegal and South Africa) and three Asian countries (Bangladesh, Malaysia and Vietnam). It includes timeseries of extended national input-output tables and sectoral employment for each country. The choice of countries was determined by the aspiration to have a first overview of the position of some Sub-Saharan African countries in GVCs, in comparison with the position of other low- and middle income countries. The choice is further based on a balance between the relevance of the countries and the suitability of available official statistics for GVC measurement.

The remainder of this paper is organised as follows. In section 2, we outline our measures of GVC income and GVC jobs and provide our decomposition framework. In section 3, we discuss our data construction methodology and provide caveats for proper interpretation. We analyse incomes and jobs in the GVCs of all final manufactured goods. This is presented and discussed in sections 4 (GVC incomes) and 5 (GVC jobs). We report throughout on a set of eleven countries: two low income countries (Ethiopia, Senegal), five lower-middle income countries (Kenya, Bangladesh, Indonesia, India and Vietnam) and four upper-middle income countries (South Africa, China, Malaysia and Brazil).[1] The period under consideration runs from 2000 to 2014 which are the earliest and latest year for which data is available. Our decomposition results show that countries that are successful in creating GVC jobs do so by being linked into fast-growing end-markets and in particular through improving their competitiveness in those markets. Section 6 offers concluding remarks. Needless to say, the results presented in this paper can only be properly interpreted when considered in a wider country perspective with abundant institutional and historical detail. If anything, we hope to demonstrate the usefulness of GVC measures in the ongoing discussion on the merits of GVC participation and prospects for industrialization in Africa.

[1] According to the World Bank country classification as of 2018.

2. Methodology

2.1 Concepts and terminology

This study is concerned with the generation of value added and employment associated with the production of final goods in global value chains (GVCs). Our definition of a GVC is straightforward. We refer to the value chain of a product as the collection of all activities needed to produce it. We define it as a *global value chain* when the activities take place in at least two different countries.[2] Put otherwise, a GVC arises when a production process is fragmented across borders. To fix ideas, assume that a production process consists of two stages. A local firm produces the final good using workers (L_1), capital (K_1), and intermediate inputs (II) according to $\mathrm{FO}(L_1, K_1, II_1)$. The intermediates are produced abroad with labour in country 2 according to $\mathrm{II}(L_2, K_2)$. Combining the two stages, one can describe the vertically integrated production of the final good as $\mathrm{FO}(L_1, K_1, L_2, K_2)$. We refer to this as the GVC production function.[3] We denote the value added generated by a country in carrying out activities in the GVC by *GVC income*. The sum of value added in the two countries is equal to the final output value of the good (by definition of the accounting conventions in the system of national accounts). The jobs involved are referred to as *GVC jobs*. These GVC measures will play an important role in our empirical analysis.

In this paper, we focus on the global production of final manufacturing goods, denoted by the term "final goods" throughout the paper. Production systems of manufactures are highly prone to international fragmentation, as activities have a high degree of international contestability: they can be undertaken in any country with little variation in quality. Activities in GVCs of final goods include not only activities in the manufacturing sector, but also activities in all other sectors, such

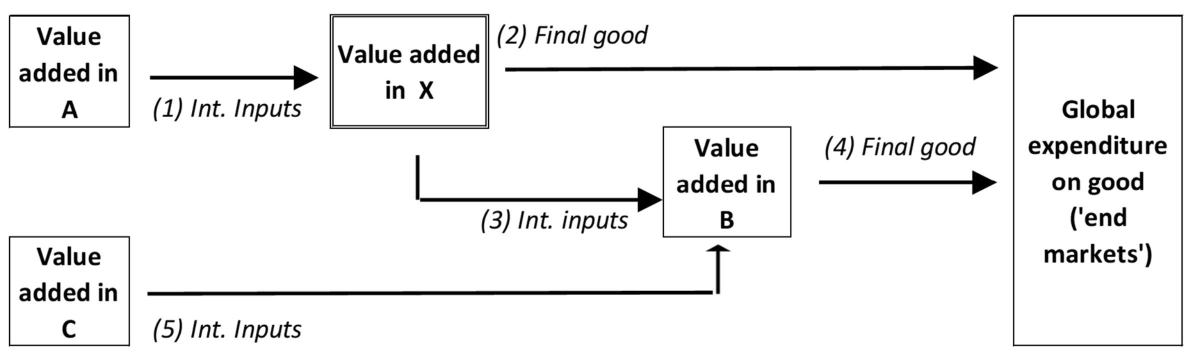
[2] Note that this definition of a GVC requires only one border crossing of products. Sometimes a more strict definition of a GVC is taken, requiring the output of the GVC to be exported as well. In this paper we do not make a distinction between final output that is produced for export or for domestic demand.

[3] Concepts like "global supply chains" or "international production chains" typically refer only to the physical production stages, whereas the value chain refers to a broader set of activities both in the pre- and post-production phases including research and development, software, design, branding, finance, logistics, after-sales services and system integration activities. The GVC value added measure will take account of the value added in all these stages of production (see Timmer et al., 2013 for more on this), but note that we do not study the activity of distributing the final good from the factory to the consumer.

as intermediate products from agriculture, mining or marketing and other professional intermediate inputs from business services.[4]

Baldwin and Venables (2013) introduced the concepts of "snakes" and "spiders" as two archetype configurations of production systems. The snake refers to a production chain organised as a sequence of production stages, whereas the spider refers to an assembly-type process on the basis of delivered components and parts. Of course, actual production systems are comprised of a combination of various types. Our method measures the value added in each activity in the process, irrespective of the configuration in the network. This is illustrated in Figure 1 that depicts four countries (A, B, C and X) that are involved in producing a particular good, say electronics. Each country delivers value added and the total of all value added across the four participants is equal to total global expenditure on this good. Note that country X delivers value added to the electronics GVC in two ways: by producing the final goods, and through delivering intermediate inputs that are used by country B in the finalization of the electronics. In turn, country X is using intermediate inputs from country A in its production processes.

Figure 1 Stylised example of GVCs incomes



We will refer to an increase in the share of a country's income in a particular GVC as an increase in the country's *competitiveness* in this GVC. GVC competitiveness is improved when a country is taking up additional activities in the chain (i.e. X takes over intermediates producing from A),

[4] It is important to note that activities in GVCs of final goods do not coincide with all activities in the manufacturing sector: some activities in the manufacturing sector are geared toward production of intermediates for final nonmanufacturing products (e.g. packaging materials for wholesaling) and are not part of manufactures GVCs.

and/or because the current activities are better rewarded. GVC competitiveness might decline when country X is losing activities (e.g. B takes over intermediates producing) or when other countries are able to produce cheaper, capturing a larger share of the global market. For example, the GVC involving countries C and B might capture a larger share of the global market when it improves its productivity relative to the GVC in which X participates it. Note that the GVC income share measures whether a country is de facto capturing a larger market share, independent of underlying productivity dynamics. It might be that a country improves its productivity by following its comparative advantage for example, but thereby giving up a certain production stage. In this case, our measure might indicate reduced GVC competitiveness as the country is capturing a smaller market share (holding everything else constant). Increasing productivity can go together with lower GVC competitiveness in case it does not lead to the capturing of larger global market shares. These different drivers of GVC jobs will be separately identified in our decomposition framework and we will show that countries that successfully combine productivity and GVC competitiveness growth may enjoy rapid job growth.

It should further be noted that our GVC income concept measures income on a territorial basis, and not at a residential basis. Value added is paid out as income to workers and capital that are involved in the production. Arguably, most of the wages will be paid to local labour. Yet, we have little information on the location of the recipients of the capital returns. The emergence of global value chains involved sizeable flows of cross-border investment, and part of the generated value-added will accrue as capital income to multinational firms. The residence of the ultimate recipients of this income is notoriously hard to track, not least because of the notional relocation of profits for tax accounting purposes (Lipsey, 2010; Guvenen et al., 2017).

At this point it may be instructive to compare our GVC income concept with more traditional indicators of trade. In particular, the GVC income concept differs fundamentally from the gross export concept. This is discussed in depth in Box 1. In brief, gross exports do not consider the imports needed to export (as pointed out by Hummels et al, 2001) and as such the indicator is not informative on the type of activities that a country is undertaking when exporting. In addition, gross exports are silent on the final destination of value added which is highly relevant when countries do not only export final goods, but also intermediates, including raw materials (as pointed out by Johnson and Noguera, 2012, see also Johnson 2014). It thus obscures the final destination of a country's value added exports that are crucial in analyzing the sources of GVC income growth as will be shown later in the empirical analysis. For example, using our WIOTs we will be able to trace the value added of country X delivered to a particular market, even when it is not directly exporting to that market, but through another country.

BOX 1 Why gross exports and GVC income are different: A hypothetical example.

In this box we provide a hypothetical example that illustrates the conceptual differences between GVC income and gross export values. We consider the effects of international fragmentation of the production process of a car. Assume that this production process is modular and consists of three activities namely part and component manufacturing, assembly of parts into the final product and services. These post-production services can be thought of as for example branding, logistics, distribution and finance activities. All activities are contestable and can be carried out anywhere irrespective of the location of other activities or the final consumer. To carry out the assembly activity in a plant, parts are obviously needed as input, but not the services. Transport costs are zero. The values added by these activities as a percentage of the output value are 10 for assembly (a), 50 for parts (p) and 40 for services (s). There are two countries A and B. Consumers in A purchase cars with total value of 100 million. Initially, all activities in the production process of these cars take place in A itself. In this case there are no exports from A to B or from B to A. As explained in the main text, the GVC income of a country is the value added of all GVC activities carried out in a country, so in this case it is 100 million in A and 0 in B. What happens to GVC income and exports when the car production process is internationally fragmenting and part of the activities sequentially are moved from A to B? This is shown in the table below.

Table Why gross exports and GVC income are different

Activities carried out in		GVC income		Exports by	
A	B	A	B	A	B
a,p,s	-	100	0	0	0
p,s	a	90	10	50	60
s	a,p	40	60	0	60
-	a,p,s	0	100	0	100

Obviously, the GVC income in A is decreasing when more activities are offshored, while GVC income in B is increasing. The total GVC income of both countries always adds up to 100 million, which is by definition equal to the value of car consumption. The export statistics for A and B however, show a rather different evolution. When assembly is offshored, A will export parts with a gross value of 50 million to B. After assembly, the parts will return but now with a gross value of 60 million as value has been added. B is exporting more than A, but still A is adding more value to the product and hence captures a larger share of the value of the final product (90 million for A while 10 million for B). Note that the value of the parts is recorded twice in the export values, creating the so-called "double counting problem" in trade statistics. When the manufacturing of the parts is off-shored as well, there is no longer export needed from A to B, and B is still exporting goods worth 60 million to A. However, now B is capturing the full value of this and GVC income increases to 60 million as well. Finally, with the offshoring of services activities, exports from B will increase in value to 100 million, as will its GVC income. In this situation domestic demand for cars in A is fully satisfied by imports from B.

The underlying assumption in this example is that all activities are traded at full cost value and recorded as such in the statistics. When these activities all take place within one multi-national enterprise (MNE), transfer pricing might drive a wedge between the value embodied in a product and its recorded export price. Moreover, assume that the MNE is headquartered in A then part of the GVC income earned with activities in B (namely the income for capital) will most likely not stay in B. This highlights the need to complement existing measurement of international transactions on the basis of geographical location with measures that centre on the ownership of firms (Baldwin and Kimura, 1998) and international finance flows. This simple example can also be easily extended by introducing demand from a third country which can be served by various constellations of the production stages across A and B. But in all cases the basic message remains the same: GVC income measures will better reflect the redistribution of income when production fragments across borders than gross trade statistics.

Source: Timmer et al. (2013)

2.2 Methodology to calculate GVC jobs

We follow the method of Timmer et al. (2013) and Los et al (2015) which show that by modelling the world economy as an input-output model, one can trace the amount of factor inputs needed to produce a final good. Starting point is the final output of a particular good (say iPhones finalized in China). A final product is consumed, which contrasts with intermediate inputs that are used further in the production process. Let $\mathbf{C_z}$ be a vector column of which the first element represents the global consumption of iPhones produced in China, and all other elements are zero. Then $\mathbf{B\ C_z}$ is the vector of intermediate inputs, both Chinese and foreign, needed to assemble the iPhones in China, such as the hard-disc drive, battery and processors. $\mathbf{B}$ is a matrix with intermediate input coefficients that describe how much intermediates are needed to produce a unit of output of a given product. A typical element $b(i,j)$ describes the amount of intermediates from country-industry i needed per unit of output in country-industry j. These intermediates need to be produced as well and $\mathbf{B^2\ C_z}$ indicates the intermediate inputs directly needed to produce $\mathbf{B\ C_z}$. This continues until the mining and drilling of basic materials such as metal ore, sand and oil required to start the production process. Summing up across all stages, one derives the gross outputs generated in the production of an iPhone by $\mathbf{(I\text{-}B)^{-1}\ C_z}$, with $\mathbf{I}$ a square matrix in which all the elements of the principal diagonal are ones and all other elements are zeros. This is so because the summation across all rounds ($\mathbf{B\ C_z} + \mathbf{B^2\ C_z} + \mathbf{B^3\ C_z} + ...$) converges to $\mathbf{(I\text{-}B)^{-1}\ C_z}$. Put otherwise, it represents the output in all industries around the world that participate in the GVC of the good.[5]

[5] This holds under empirically mild conditions, see Miller & Blair (2009) for an introduction to input-output analysis.

To find the value added in each country, we additionally need (for each country-industry) the share of value added in gross output represented in matrix **G** with these shares on the main diagonal. In that case the GVC income in the production of z is given by:

(1) $$\mathbf{V = G(I\text{-}B)^{-1}C_z}$$

with vector **V** containing for all country-industries the value added related to $\mathbf{C_z}$. We refer to an element *v(i)* of **V** as the GVC income of country-industry *i* in the value chain of *z*. By construction the summation of GVC income across all country-industries will equal the value of the final good z. We can post-multiply $\mathbf{G(I\text{-}B)^{-1}}$ with any vector final demand levels to find out what value added levels should be attributed to this particular set of final demand levels.

To find the number of jobs in this GVC we need the labour required per value added represented in diagonal matrix **J.** These labour requirements are country- as well as industry-specific. To find all jobs in a GVC, we multiply **J** by the total value added in all stages of production, such that GVC jobs are given by

(2) $$\mathbf{L_z = JV = JG(I\text{-}B)^{-1}C_z.}$$

A typical element of vector L indicates the number of jobs located in country *i* and industry *j* in the production of final good *z*. We sum across industries to get the number of GVC jobs in a country associated with the production of *z*.

2.3 Decomposing growth in GVC jobs

With this information in hand, we can implement an insightful decomposition of the growth in GVC jobs in a country. Let $L_{i,z}$ indicate the number of jobs in country *i* in the GVC of product *z*. Then through simple elaboration we can write

(3) $$L_{i,z} = \left[\frac{C_z}{C_z}\right] * \left[\frac{v_{i,z}}{v_{i,z}}\right] * L_{i,z} = C_z * \left[\frac{v_{i,z}}{C_z}\right] * \left[\frac{L_{i,z}}{v_{i,z}}\right].$$

where $v_{i,z}$ indicate value added in country i in the GVC of final good z. It can be calculated as elements of **V** on the basis of equation (1) post-multiplying with world expenditure on final good z, indicated by C_z. The ratio $\frac{L_{i,z}}{v_{i,z}}$ indicates the labour needed to produce value added in country i for the GVC of product z. $L_{i,z}$ can be calculated as elements of **L** indicated in equation (2). The ratio $\frac{v_{i,z}}{C_z}$ tracks the share of country i in final output of GVC z. This is a measure of GVC competitiveness of country i in this particular chain. This interpretation follows from the accounting identity that the sum of value added across all countries that participate in this chain is by definition equal to world expenditure on the particular good (at basic prices). Put otherwise, $\frac{v_{i,z}}{C_z}$ is the share of country i in the overall income earned in chain z.

Summing across all value chains, $L_i = \sum_z L_{i,z}$, delivers the number of GVC jobs in country i such that

(4) $$L_i = \sum_z \; C_z * \left[\frac{v_{i,z}}{C_z}\right] * \left[\frac{L_{i,z}}{v_{i,z}}\right]$$

We are also interested in a decomposition of the growth in the number of jobs. Let Δ indicating the change during period (0,t), then

(5) $$\Delta \ln L_i = \sum_z \; \bar{w}_{i,z} \, \Delta L_{i,z}$$

with $\bar{w}_{i,z} = \frac{1}{2}\left(\frac{L_{i,z}^t}{\sum_z L_{i,z}^t} + \frac{L_{i,z}^0}{\sum_z L_{i,z}^0}\right)$ the period average share of GVC workers in country i working in GVC z. Taking log derivatives to time on the right-hand side of equation (4) (and ignoring higher-order interactions) we can write growth of GVC jobs in country i as

(6) $$\Delta \ln L_i = \sum_z \; \bar{w}_{i,z} \left(\Delta \ln C_z \; + \; \Delta \ln \left[\frac{v_{i,z}}{C_z}\right] \; + \; \Delta \ln \left[\frac{L_{i,z}}{v_{i,z}}\right]\right).$$

Growth in GVC jobs	Growth of world expenditure	Change in GVC income share	Change in labour requirement

The first term in the decomposition picks up the effect of growth in world expenditure on the final goods completed in the various GVCs. We refer to this as the "GVC demand effect". GVC jobs will be growing faster in a country that is better positioned relative to global demand growth, or put otherwise, a country that has a larger share of its jobs (as reflected in $\overline{w}_{i,z}$) in GVCs for which global demand is growing faster. The second term captures the contribution of a change in a country's income shares in the various GVCs which we will refer to as the "GVC competitiveness effect". A decline in GVC income shares will lead to lower GVC job growth, ceteris paribus. Note that this term measures the contribution of a country relative to the contributions of the other countries in the chain. The sum of GVC income changes within a particular GVC across all countries is zero by construction. The third term is the contribution of changes in labor input requirements which we refer to as the "GVC technology effect".[6] This effect is a combination of technological change within the GVC affecting all stages of production as well as country-specific technology developments (see also Reijnders and de Vries, 2018). Labour-saving technological change will drive down GVC jobs growth for a given output level.

This is the basic decomposition that we will bring to the data in section 4. We will also track the sector of employment such as agriculture, manufacturing or services. To that end let *s* be the sector of employment such that $L_{i,s} = \sum_z L_{i,s,z}$ and $\Delta \ln L_{i,s} = \sum_z \overline{w}_{i,s,z}\, \Delta L_{i,s,z}$, with $\overline{w}_{i,s,z} = \frac{1}{2}\left(\frac{L_{i,s,z}^t}{\sum_z L_{i,s,z}^t} + \frac{L_{i,s,z}^0}{\sum_z L_{i,s,z}^0}\right)$ the period average share of GVC workers in sector *s* in country *i* working in GVC *z*. The decomposition of growth in GVC jobs in sector s is derived by appropriately adding a sector dimension to (6) as follows:

$$(7) \qquad \Delta \ln L_{i,s} = \sum_z \overline{w}_{i,s,z} \left(\Delta \ln C_z \; + \; \Delta \ln\left[\frac{v_{i,z}}{C_z}\right] \; + \; \Delta \ln\left[\frac{L_{i,s,z}}{v_{i,z}}\right]\right).$$

Note that the difference with (6) is in the last term, as it depends on the labour needed *in sector s* to produce value added in country *i* for the GVC of product *z*.

[6] It should be noted that this decomposition is only meaningful when GVC income is measured in constant prices, otherwise one cannot interpret the labor requirement term, which would include price changes. We deflate all GVC income using the US CPI as deflator.

In further analysis, we are also interested in the end market to which a country's GVC income and jobs are linked. $C_z = \sum_k (C_{z,k})$ with $C_{z,k}$ the final demand for good z in end-market k. We can further decompose the GVC demand growth effect as follows:

(8) $$\Delta \ln C_z = \sum_k \bar{w}_{z,k} \left(\Delta \ln C_{z,k} \right),$$

with $\bar{w}_{z,k} = \frac{1}{2}\left(\frac{C_{z,k}^t}{\sum_k C_{z,k}^t} + \frac{C_{z,k}^0}{\sum_k C_{z,k}^0} \right)$ the period average share of end market k in total global demand for final good z. When combined with the decomposition in equation (6), one can link growth in GVC employment to growth in final demand in particular regions (such as EU, US or China). This is not only interesting to do ex-post, but it also provides a useful tool to predict future employment growth in GVCs. For example, one may plug in the expected growth rates of demand from various regions in the world and predict the growth of demand for workers in country i.

It should be noted that the decomposition methodology outlined above is basically an ex-post accounting framework rather than a fully specified economic model (as argued in Timmer et al., 2013). It starts from exogenously given final demand and traces the value added without explicitly modelling the interaction of prices and quantities that are central in a full-fledged Computable General Equilibrium model. While CGE models are richer in the modelling of behavioural relationships, there is the additional need for econometric estimation of various key parameters of production and demand functions. As we do not aim to disentangle price and quantity effects, we can rely on a reduced form model in which only input cost shares are known. We use annual IO-tables such that cost shares in production change over time. Thus the analysis does not rely on Leontief or Cobb- Douglas types of production functions where cost shares are fixed. The changing shares are consistent with a translog production function which provides a second-order approximation to any functional form. In these production models, shifting cost shares summarise the combined effects of changes in relative input prices, in cross-elasticities and input-biased technical change (Timmer and Ye, 2018). This characteristic of the approach makes it particularly well-suited for our ex-post accounting analysis.

3. Data sources

A key ingredient for GVC analysis is a global input-output table that provides information on inter-country and inter-industry flows of goods and services. There is much information for advanced countries and so-called emerging economies (e.g. oecd tiva or wiod) but much less so for poor developing countries. The pioneering work on Trade in value added (TiVa) statistics by the OECD and WTO is now slowly percolating into the international statistical agenda. By nature, this is a slow and arduous process, such that there is high and unmet demand for information, in particular on less developed countries that are not covered by the OECD data.[7] To fill this gap, some users have turned to the EORA database (see e.g. de UNCTAD-EORA Global Value Chain database as used in UNCTAD, 2013) that provides input-output information for a large set of countries. Yet, EORA is not developed for economic analysis, but first and foremost for study of global environmental issues which puts different demands and priorities on the data construction and method. From an economic point of view, the most pressing problem in the data constructed in EORA is the weak link with official economic statistics, in particular the national accounts, compromising over time and across country comparability. Without a clear anchoring in official economic statistics, it is also difficult to link in other economic variables of interest, in particular incomes, employment and jobs. This is of particular importance for the purpose of this study that focuses on the generation of jobs in GVC participation. More specifically, we use time-varying value added to gross output ratios at a high level of industry detail, while ensuring compatibility with national accounts data. We also use a more detailed mapping of intermediate trade flows adding information on end-use from BEC. Arguably each of these procedures is an improvement over the EORA approach and together do justice to a careful treatment of economically important variables and national accounting conventions. Pahl and Timmer (2019) provide additional discussion on the differences in construction philosophy.[8]

We have therefore developed new data for seven low- and middle-income countries according to the methodology of the WIOD such that it can be used in conjunction with the WIOT for global analysis. The WIOD 2016 release covers 43 countries in the world. The newly constructed dataset,

[7] The OECD database is available at oe.cd/tiva, and has recently been updated (December 2018).
[8] The Eora website provides a comparison with the OECD TiVa for a number of key derived indicators which shows that large differences appear for some countries, see https://worldmrio.com/clients/UNCTAD/Results_2018Update/comparison/images/.

adds four African countries (Ethiopia, Kenya, Senegal and South Africa) and three Asian countries (Bangladesh, Malaysia and Vietnam). It includes timeseries of extended national input-output tables and sectoral employment for each country. The choice of countries was determined by the aspiration to have a first overview of the position of some major Sub-Saharan African countries in GVCs, in comparison with the position of some comparable Asian countries. The choice is further based on a balance between the relevance of the countries and the quality and suitability of available official statistics. The construction of the data is discussed extensively in the hope that it provides a platform for further development of GVC statistics for these countries in the future.

3.1 World Input-Output Database

The decomposition of GVC jobs outlined above requires a database that links consumption, production and income flows not only within, but also across countries. We use the World Input-Output Database (WIOD) that was specifically developed for this purpose (Timmer et al., 2015a). The WIOD 2016 release includes annual world input-output tables for the period 2000-2014, distinguishing between 35 industries and 59 product groups. It is publicly and freely available at www.wiod.org. In the world input-output table, the product flows (both for intermediate and for final use) are split into products that are produced domestically or imported. The table also shows in which foreign industry these imported goods and services were produced. The WIOD covers forty economies, including all 27 EU countries (per January 2007) and 13 other major advanced and emerging economies, namely Australia, Brazil, Canada, China, India, Indonesia, Japan, Mexico, Russia, South Korea, Taiwan, Turkey and the United States. Together, these countries accounted for over 85 per cent of world GDP in 2011. An estimate is provided for the Rest of World in order to provide for exhaustive decompositions. A limitation of the WIOD is that many developing countries in Sub-Saharan Africa are not separately distinguished. For the purpose of this study we have added seven new countries as described below.

In the construction of the WIOD, annual supply and use tables were linked over time using the most recent statistics on final demand categories, gross output, and value added by industry from the National Accounts statistics. In principle, the world input-output tables are therefore built according to the conventions laid down by the UN in the system of national accounts (SNA 2008). The national SUTs were subsequently linked to other countries using detailed international bilateral trade data classified by end-use category. This is the so-called B.E.C. category that splits COMTRADE data into that for intermediate use, consumption, or investment. International SUTs were combined to create a symmetric world input-output table of an industry-by-industry type (see Dietzenbacher et al. 2013 for technical details). Two characteristics of the data and method should be noted for a proper interpretation of the results. First, to have international comparability, re-exports are excluded in the WIOTs, assuming no value added in these exports-flows. Second, it should be kept in mind that the results of this analysis are not based on direct observation. Direct information on the value added distribution of a particular GVC is non-existent as firms are unaware of, unable or unwilling to share information on the value distribution in their supply chains. Our data relies on input-output tables that are constructed by national statistical institutes based on patchy information about inter-industry flows of goods and services. As such it must be considered as an indication of broad trends only. For a better understanding of GVC production case studies such as for example in Dedrick et al. (2010) are indispensable.

3.2 New countries built into WIOD

For the purpose of this study we added four African countries, namely Ethiopia, Kenya, Senegal and South Africa and three Asian countries: Bangladesh, Malaysia and Vietnam. We constructed timeseries of extended national input-output tables and sectoral employment for each country. The overall strategy is to first construct a series of national input-output tables (NIOTs) for the period 2000-2014 for each country that can be used in conjunction with the WIOT, that is, that are constructed according to the same concepts and conventions, and using the same classifications. The NIOTs have a single column for exports and a matrix for imports. In a second step, the NIOTs are extended with information on the bilateral trading partners for imports and exports from international trade statistics. In the final step a NIOT is built into the WIOT by splitting off the NIOT from the rest-of-world region as given in the original WIOT. We do this one country at a time. The GVC calculations for a country are then performed with the WIOT that is enlarged with this country.

We need to obtain at least one official input-output table as well as time series of exports, imports, value added, gross output by industry and totals of the final demand categories. The initial input-output tables are obtained from national statistical offices and international organizations, which we describe in more detail in the country-specific notes in the Appendix. The data are not readily available from official sources. The first challenge is in creating series of value added and gross output for detailed industries. Our benchmark series of value added across 10 broad sectors comes from the GGDC 10-Sector Database (10SD as described in Timmer et al., 2015b).[9] Value added data in the 10SD is available up to 2011, and we update it until 2014 by extrapolation with recent releases from UN Official Country Data (UN OCD; UN, 2018b). The 10SD does not provide gross output figures which need to be obtained. We base these on gross output to value added ratios from national accounts (NA) data from the UN OCD. This is consistent with the 10-Sector database because it is also based on NA data published by the statistical offices. Intermediate use by industry is calculated by subtracting value added from gross output. The gross output and value added series thus pin down intermediate use. For Bangladesh and Vietnam no data is available in the 10SD so we use UN OCD data for the entire period.

The 10SD sector provides only data for aggregate manufacturing. For the purpose of this paper, we need to add information on more detailed manufacturing industries. Data on manufacturing industries is typically only available from surveys that cover the formal part of the economy, e.g. only firms that have 10 employees or more. We refer to this as “formal manufacturing”. We split the 10SD value added into a detailed set of formal manufacturing industries and a residual sector.[10] That is, we obtain data for the formal manufacturing sector from several vintages of UNIDO’s Indstat database (2018) available in ISIC Rev.4 and Rev.3. UNIDO’s Indstat (2018) is the only widely available source (across countries and over time) with detailed information on the manufacturing sector. A major advantage of UNIDO’s Indstat is that it provides gross output and employment figures, which are internally consistent with the value added accounts, because the entries generally come from the same establishments sampled within a given ISIC classification.

[9] The value added figures in the 10-Sector Database are based on the latest vintage of national accounts data at the time of construction (and backdated with earlier revisions). It is therefore close to the national account data found in the UN Official Country Data (2018b).

[10] As such, a residual remains which potentially captures informal and small formal firms, but also includes any inconsistencies between the survey data and additional sources that are used in the construction of the national accounts. Note that we do not interpret this sector as the informal sector but as a residual, because it is not based on measurement of the informal sector. For some countries, production in this sector can become negative, indicating a mismatch of the data. We keep this sector in the WIOTs to acknowledge this but we do not analyze it. We set output to equal value added, such that this sector uses no intermediates, and by our definition all its production is domestically consumed.

This is crucial because value-added to output ratios and employment to output ratios are essential in the calculation of value added or employment in exports.

We obtain main aggregates for final demand categories from UN OCD (UN, 2018b). The final demand categories are household consumption (CONS_h), consumption by non-profit organizations serving households (CONS_np), government consumption (CONS_g), gross fixed capital formation (GFCF) and changes in inventories (INVEN). Together with the trade balance these final demand categories sum to GDP from the expenditure side. Information on trade flows is from the UN COMTRADE for goods and services. In the extended NIOT construction process, many data inconsistencies needed to be resolved. For example, we have observed anomalies in the COMTRADE data for several countries, when comparing the aggregate levels derived from COMTRADE to data from the National Accounts (NA). We address these issues in the country specific sources in the Appendix. Broadly speaking these issues range from missing trade data, to having excess trade for certain periods. Whenever this occurs we dive deeper into the trade statistics, by also checking the mirror flows from the country's trading partners, which allows us to spot the sources of these inconsistencies. In a few cases, we use the mirror flows from COMTRADE to replace the disputed data, which is detailed in the country-specific sources.

To analyse the workers involved in GVC production additional data on employment is needed. This requires employment accounts that are consistent with the value added and output series. For example, meaningful labour productivity measures can only be calculated when the data coverage of output and employment input are similar, that is, they refer to the same set of firms. To assure consistency with the value-added and output accounts, we base it on the same sources. For detailed manufacturing industries, we thus also rely on UNIDO's Indstat such that data from the same set of firms is used for all variables. Importantly, we use the same vintages of UNIDO's Indstat (2018) and extrapolate if needed to assure internal consistency with the value added and output accounts. The coverage of the formal manufacturing firms differ per country, depending on the survey. For Bangladesh and Ethiopia, it covers all establishments with 10 or more employees, For Kenya, data pertains to establishments with 5 or more persons engaged. For Senegal, South Africa, Malaysia and Vietnam, the scope of the data is all registered establishments. The data appendix provides more details.

Table 1 Overview of main sources used for adding seven countries to WIOD.

Country	Input-output table	Value added and output	Trade	Employment
Bangladesh (BGD)	2011 (ADB/NSO)	UN OCD; UNIDO Indstat	Comtrade; adjustment for THA-BGD flows	LFS (NSO); UNIDO Indstat
Ethiopia (ETH)	2006 (IFPRI/EDRI)	GGDC 10-Sector Database; UN OCD; UNIDO Indstat	Comtrade; large re-exports in 2013 & 2014	LFS (NSO); UNIDO Indstat
Kenya (KEN)	2003 and 2013 (IFPRI/KIPPRA)	GGDC 10-Sector Database; UN OCD; UNIDO Indstat	Comtrade	LFS & Establishment surveys (NSO); UNIDO Indstat
Malaysia (MYS)	2010 (ADB/NSO)	GGDC 10-Sector Database; UN OCD; UNIDO Indstat	Comtrade	LFS (NSO); UNIDO Indstat
Senegal (SEN)	2005 (UN DESA)	GGDC 10-Sector Database; UN OCD; UNIDO Indstat	Comtrade; large adjustment for re-exports	ESPS-I & ESPS-II (LFS/NSO); UNIDO Indstat
Vietnam (VNM)	2012 (ADB/NSO)	UN OCD; UNIDO Indstat	Comtrade	Population census & LFS (NSO); UNIDO Indstat
South Africa (ZAF)	2013 (NSO)	GGDC 10-Sector Database; UN OCD; UNIDO Indstat	Comtrade; missing commodities before 2011	Population census & LFS (NSO); UNIDO Indstat

Note: NSO refers to national statistical office; IFPRI is International Food Policy Research Institute; ADB is Asian Development Bank; UN DESA is United Nations Department of Economic and Social Affairs; KIPRA is Kenya Institute of Public Research; Ethiopian Development Research Institute; LFS is labor force survey;

For broad sectors, we use the 10-Sector Database as the benchmark source for employment accounts, as we did for value added. These data are typically built up from population censuses at benchmark years and extrapolated using labor force surveys, and aggregated to ISIC Rev.3 as for value added. This assures consistency across variables and across countries as far as possible. A major task for this study was to update and revise the existing employment accounts of the 10-Sector database with additional, more recent information. The original 10SD was constructed in 2013. Whenever possible, we introduce a new (more recent) benchmark year and add new labor force surveys to extrapolate from the benchmark years onwards. These additional sources are highly country-specific, which we therefore describe in the Appendix. Furthermore, Bangladesh and Vietnam are not included in the original 10-Sector Database and we therefore construct new employment accounts for broad sectors of these countries for the purpose of this study. We do so following the same methodology as in the 10-Sector Database. Table 1 provides a summary of the datasources used for each country.

Needless to say that the construction of the data for the seven countries is not straightforward as data sources are relatively scarce and not always compatible. For each country, we first inventoried the available datasources, their quality and comparability before making a choice which ones to use in the construction process. This is discussed extensively in the Data Appendix at the end of the table. We hope that it provides a platform for further development of GVC statistics for these countries in the future.

4. Competitiveness in GVCs of goods: empirical results

Using the new data discussed in the previous section we will present an exploration of the drivers of GVC job growth in four African countries compared to other low- and middle- income countries in the world. We report throughout on a set of eleven countries: two low income countries (Ethiopia, Senegal), five lower-middle income countries (Kenya, Bangladesh, Indonesia, India and Vietnam) and four upper-middle income countries (South Africa, China, Malaysia and Brazil).[11] The period under consideration runs from 2000 to 2014 which are the earliest and latest year for which data is available. We analyse incomes and jobs in the GVCs of all final manufactured goods.[12]

We start with an analysis of the countries' competitiveness in GVCs as measured by their income shares in the various GVCs. GVC income includes value that is added in the last stage of production (that by definition takes place in a manufacturing industry) or in upstream stages of production that may take place in- or outside manufacturing in the country. We calculate the shares using elements of vector V as defined in equation (1) for given final demand for good *z* divided

[11] According to the World Bank country classification as of 2018.

[12] Most goods in the economy undergo some manufacturing before delivered to the final consumer. This is also true for most agricultural and mining products. We thus cover value added generated in these sectors as well. A major exception is production of food for self-consumption. By definition, this will not pass through a manufacturing industry.

by the final demand value ($v_{i,z}/C_z$). Final demand for a product is given in the WIOD data as the sum of household consumption, government consumption and gross fixed capital formation in any country in the world.

Results are given in Table 2. The first two columns report on the shares in 2000 and 2014, and the third column reports on the change in the share over the period 2000 – 2014. The last columns provide the countries' shares in world GDP as a useful comparator. The GVC income share has been growing fast in Kenya and Ethiopia but not in Senegal, and it even declined in South Africa. In contrast, GVC income shares have quadrupled in Vietnam and China. As of 2014, the shares of Ethiopia, Kenya and Senegal in world GVC income are still smaller than their share in world GDP.

Table 2 Competitiveness in GVC of final goods

	GVC income (% share in world)			GDP (% share in world)			GVC income / GDP	
	2000	2014	change	2000	2014	change	2000	2014
Ethiopia	0.01	0.03	2.5	0.03	0.07	2.3	0.3	0.4
Kenya	0.03	0.05	1.7	0.04	0.07	1.8	0.8	0.7
Senegal	0.01	0.01	1.0	0.01	0.02	2.0	1.0	0.5
South Africa	0.53	0.48	0.9	0.39	0.44	1.1	1.4	1.1
Bangladesh	0.19	0.39	2.1	0.15	0.26	1.7	1.3	1.5
China	6.27	24.91	4.0	4.12	15.85	3.8	1.5	1.6
Indonesia	1.00	1.70	1.7	0.60	1.34	2.2	1.7	1.3
India	1.91	3.76	2.0	1.58	3.07	1.9	1.2	1.2
Malaysia	0.56	0.68	1.2	0.32	0.49	1.5	1.8	1.4
Vietnam	0.13	0.52	4.1	0.11	0.26	2.4	1.2	2.0
Brazil	2.27	3.45	1.5	1.97	3.23	1.6	1.2	1.1

Note: Share of country in total for all countries in the world. Based on calculation of GVC income by a country in carrying out activities in the production of final manufacturing goods according to equation (1). Author's calculations based on WIOD, 2016 release, extended with seven countries as described in main text.

What are the characteristics of the most important GVCs for a country? To answer this question we study incomes in GVCs of specific goods rather than their aggregate. In total we distinguish eighteen different final good categories including non-durable goods (such as food, textiles and furniture), durable goods (such as computer and other electronics, machinery and transport equipment) and chemicals and final materials (including pharmaceuticals and refined oil).

Appendix Table 1 provides the full list of products included as well as the ISIC revision 4 coding of the industry in which the good is finalised.

To investigate the specialization of countries in particular product GVCs, we make use of a variant of the well-known Balassa index and define a GVC specialization index as

$$(9) \qquad GVCSI_{i,z} = \frac{v_{i,z} / \sum_z v_{i,z}}{\sum_i v_{i,z} / \sum_{z,i} v_{i,z}}$$

with $v_{i,z}$ the value added of country i in GVC z, derived according to equation (1). A country can be said to be specialized in producing value added in GVC z, when $GVCSI_{i,z} > 1$, that is, when the value added share in this GVC is bigger than the corresponding share in all countries in the world.

We report $GVCSI_{i,z}$ for our set of countries in Table 3: the upper panel reports for 2014, while the lower panel reports for 2000. The product GVC rows are sorted on the basis of economic importance as measured by their global final output in 2014. Ethiopia, Kenya and Senegal stand out as being specialized in delivering value added to food GVCs. This is not only because of value added through activities in food manufacturing, but also through activities higher up in the chain, in particular the cultivation of the food crops in agriculture. More surprising is their specialization in GVCs of chemical products, in particular Senegal. On the other hand, their contribution to GVCs of motor vehicles and machinery is low and comparable to Bangladesh and Vietnam. Vietnam is outstanding by its specialization in GVCs of computer electronics. More advanced countries in East Asia such as China and Malaysia derive most of GVC income in GVCs of electronics and machinery. Like Bangladesh, Ethiopia is specialised in contributing to GVCs of textiles which includes the value added generated in the domestic agricultural production of cotton that is used in textile production. The GVC specialization pattern of South Africa resembles most closely that of Brazil with (relative to other African countries) more specialization in GVCs of motor vehicles, refined petroleum and electrical machinery, and less in food.

Table 3 GVC specialization indices by product GVCs

(a) year 2014

GVC of good	**Ethiopia**	**Kenya**	**Senegal**	**South Africa**	**Bangladesh**	**China**	**Indonesia**	**India**	**Malay-sia**	**Viet-nam**	**Brazil**	**Final output**
FOOD	2.04	2.79	2.56	1.43	0.88	0.87	1.93	1.21	1.03	1.41	1.42	3,076
MOTOR	0.09	0.29	0.08	1.04	0.08	1.00	0.69	0.69	0.64	0.31	0.93	1,951
MACH	0.10	0.08	0.23	0.82	0.04	1.26	0.26	0.48	0.59	0.22	0.65	1,345
COMP	0.08	0.04	0.10	0.29	0.16	1.31	0.60	0.26	1.96	1.60	0.50	1,068
TEX	2.99	0.65	0.34	0.66	6.72	1.72	1.38	2.47	0.62	2.82	1.23	943
OTH TRA	0.07	0.02	0.21	0.37	0.24	1.16	0.22	0.42	0.73	0.92	0.54	677
FURN,OT	1.01	0.07	0.46	0.95	0.09	0.58	0.66	1.54	0.75	1.46	0.92	650
PETRO	0.07	0.06	0.18	2.18	0.01	0.25	1.59	0.71	2.63	0.31	1.12	603
ELEC	0.13	0.06	0.23	0.79	1.00	1.70	0.60	0.75	0.96	0.82	0.72	561
CHEM	1.55	1.05	4.27	1.23	0.25	0.35	0.41	0.59	0.78	0.33	1.45	456
PHARMA	0.15	0.05	0.12	0.17	0.77	0.48	0.87	0.81	0.24	0.09	1.08	368
FAB MET	0.40	3.51	0.18	0.79	0.52	0.90	0.34	0.96	0.95	0.29	0.79	316
RUBBER	4.09	1.09	3.20	0.86	0.32	0.57	1.32	1.98	2.58	0.67	0.92	158
PAPER	0.88	4.01	1.20	1.23	0.21	0.26	0.53	0.93	1.38	0.52	1.24	93
MINERAL	3.05	0.07	1.17	0.91	3.99	0.70	1.29	1.34	0.64	1.76	0.52	81
BAS MET	0.40	2.47	0.23	1.05	17.19	0.84	0.55	4.69	1.18	0.54	1.04	76
WOOD	4.82	0.52	4.70	0.37	0.46	0.73	0.70	3.48	0.57	1.16	0.53	55
PRINT	1.20	2.30	0.96	2.72	0.28	0.23	0.24	3.42	1.63	0.24	0.43	43

(b) year 2000

GVC of good	**Ethiopia**	**Kenya**	**Senegal**	**South Africa**	**Bangladesh**	**China**	**Indonesia**	**India**	**Malay-sia**	**Viet-nam**	**Brazil**	**Final output**
FOOD	2.45	2.55	2.79	1.34	1.14	0.94	1.63	1.20	0.68	2.06	1.31	1,359
MOTOR	0.24	0.04	0.04	1.10	0.09	0.40	0.50	0.77	0.45	0.27	0.91	869
MACH	0.10	0.05	0.17	0.67	0.03	1.24	0.36	0.42	0.54	0.26	0.55	595
COMP	0.06	0.04	0.03	0.21	0.12	1.02	0.63	0.22	2.92	0.35	0.39	713
TEX	2.46	1.66	0.77	0.99	6.15	2.55	1.91	2.96	0.86	2.52	1.67	467
OTH TRA	0.05	0.02	0.11	0.30	0.41	0.82	0.24	0.36	0.54	1.24	0.57	232
FURN,OT	0.83	0.12	0.09	1.02	0.07	1.00	0.81	0.62	1.03	0.59	0.83	401
PETRO	0.06	0.39	0.70	3.29	0.02	0.16	1.79	1.29	2.31	1.08	1.46	195
ELEC	0.11	0.07	0.59	1.10	0.95	1.35	0.84	0.78	0.87	0.68	0.87	271
CHEM	1.20	1.58	3.30	1.17	0.34	0.35	0.55	0.57	0.57	0.39	1.77	214
PHARMA	0.12	0.31	0.18	0.23	1.04	0.77	1.22	0.93	0.26	0.18	1.70	149
FAB MET	0.10	1.70	0.17	0.71	0.64	0.76	0.85	0.71	0.49	0.30	0.62	170
RUBBER	2.71	1.77	2.81	0.94	0.32	1.16	1.87	1.99	1.72	0.41	0.87	82
PAPER	0.66	4.75	1.37	1.11	0.23	0.39	0.93	0.88	1.15	0.36	1.36	55
MINERAL	1.76	0.10	1.19	0.94	2.48	3.11	0.98	1.46	0.76	1.81	0.49	48
BAS MET	0.15	7.38	1.46	1.05	16.08	0.67	0.32	6.59	0.64	0.82	1.10	24
WOOD	2.25	3.78	1.32	0.30	0.46	0.84	0.90	3.76	1.09	1.52	0.51	34
PRINT	0.89	1.51	1.07	2.04	0.84	0.16	0.29	2.25	0.98	0.16	0.35	32

Note: GVC specialization index as defined in (8). Based on calculation of value added by a country in carrying out activities in the production of a particular group of final goods according to equation (1). Final output in billion US$ (current prices), Product groups are sorted on final output value in 2014, from high to low. Author's calculations based on WIOD, 2016 release, extended with seven countries as described in main text.

Following Johnson and Noguera (2012) one can also trace the final destination market of a country's value added in GVCs. For example, how much of Kenyan value added in GVCs is ending up in food consumed in Europe or cars consumed in the US. This is calculated for a particular year with suitable choosing of the final demand vectors in equation (1) incorporating only demand for a particular final good by a particular country, or set of countries. It is important to note that countries can contribute to a GVC of a product that is ultimately absorbed abroad as well as to a product that is consumed domestically. Including the domestic market in an analysis of GVC competitiveness is important as domestic markets for goods are potentially contestable, as are foreign markets.[13] Table 4 provides the results of the decomposition, distinguishing between seven end-markets.

We find that end markets of value added in GVCs vary widely across the four African countries. Kenya stands out for a large dependence on domestic market demand, as 78.2% of the value it adds to GVCs ends up in goods consumed at home. Domestic demand is also important for Senegal, as is demand in the Rest-of-the-World region which includes (other) sub-Saharan Africa and the Middle East.[14] On the other hand, only 47.2% of South African value added in GVCs ends up in domestic demand, almost 20 percent in the Rest-of-the-World region and another 13 percent in Europe. Also Ethiopia has strong demand links with the Rest-of-the-World region and Europe. Unlike for the Asian countries, final demand in the US is relative unimportant for the African countries. GVC value added in Vietnam and Malaysia is particularly linked to final demand in East Asia and China.

In an Appendix table we provide for each of the African countries an overview of the 26 most important markets (cross-classified by product and country of consumption), and the change in importance over the period 2000-2014. For example, in 2000, 29% of the GVC income in Ethiopia

[13] For example, in 2014 South African industry delivered 56 % of the domestic demand for manufactured goods (down from 76% in 2000) and the decline was even stronger in Kenya (from 76 to 43%). The share also declined in Ethiopia (44 to 33 %) and Senegal (62 to 53 %).

[14] Ideally, we would have liked to distinguish sub-Saharan Africa (SSA) as a separate region, but the WIOD does not contain SSA countries (they are all subsumed under the Rest-of-the-World region). We can thus only distinguish the home market for the four newly added African countries. More detailed data is needed to trace GVC income flows between these countries.

was related to production of food that was ultimately consumed in Ethiopia. The last two columns in the table provide information on the share of the country in the global market for that good, $v_{i,z}/\sum_i v_{i,z}$. In 2000, Ethiopia delivered 82% of the value added in the domestic food consumption value, declining to 52% in 2014. A decline in this share can be regarded as a decline in the GVC competitiveness in that particular market, and an increase can be interpreted as an improvement in GVC competitiveness. Ethiopia improved GVC competitiveness in 17 out of the 26 most important markets, Kenya in 15, South Africa in 14, and Senegal only in 10.

Table 4 Final destination of a country's GVC value added, 2014 (% shares)

	Final demand from						
	EU	US	China	East-Asia	Other emerging	Rest of world	Home market
Ethiopia	12.9	4.2	4.7	3.5	2.6	12.7	59.3
Kenya	5.2	3.6	0.6	0.5	1.0	11.0	78.2
Senegal	7.9	1.6	1.2	2.7	2.0	18.0	66.7
South Africa	13.3	6.9	4.2	3.4	5.0	19.9	47.2
Bangladesh	20.4	9.0	0.5	1.3	2.0	2.6	64.1
China	6.8	8.3	-	4.9	4.8	12.7	62.5
Indonesia	5.6	7.4	4.0	5.9	4.0	11.8	61.5
India	4.5	4.1	1.2	1.0	2.0	10.2	76.9
Malaysia	10.7	11.2	9.1	10.2	10.2	20.7	28.0
Vietnam	16.6	19.3	7.4	10.7	6.4	12.7	26.8
Brazil	4.3	3.5	3.0	1.7	2.4	8.2	77.1

Note: Effect of change in final demand for goods in a particular region on GVC income growth in a country. EU are all 28 member countries of the EU as of 2014 plus Switzerland; US includes USA and Canada; East Asia is Japan, Rep. Korea and Taiwan; Other emerging is Brazil, Mexico, Turkey, Russia, India and Indonesia. Each country's home market is included in in the last column such that rows add up to 100, except for rounding.

5. Growth of jobs in GVCs of goods: empirical results

5.1 Sources of GVC job growth

How many jobs in a country are related with carrying out activities in the global production networks of final goods? We trace this by adding information on the job requirements per unit of output as outlined above. The final column in Table 5 provides an overview of the growth in GVC jobs in our set of countries during 2000-14. Fastest growth has been in Bangladesh and Vietnam, followed closely by Ethiopia and India: all recorded more than 0.50 (log points) growth. GVC job growth in Kenya was mediocre and comparable to China and Indonesia. Growth was negative in the cases of Senegal and South Africa. We decompose GVC job growth according to equation (6) into contributions from three proximate "causes": the change in a country's income share in the various GVCs (as analysed in section 4), the change in world expenditure on goods from these GVCs, and changes in labor input requirements in the GVC production. Results of the decomposition are given in Table 5 and further illustrated in Figure 2.[15] Three observations stand out.

First, all countries benefitted highly from an expending demand for goods in the world economy. It added at least 0.50 log points to GVC job growth over the period in each country, even up to 1.21 in China, 1.01 in India, 0.95 in Ethiopia and 0.91 in Vietnam. Second, this boost to employment was severely counteracted by a decline in the labour needed per unit of output in the GVCs. This confirms the hypothesis put forward by Rodrik (2018) that technological change in GVCs is unlikely to be in favour of the use of unskilled labour. Reijnders et al. (2016) provide econometric evidence that technical change in GVCs is indeed biased against workers with high school attainment or below, and in favour of college (or above) educated workers. In related work, Reijnders and de Vries (2018) show that GVCs economize in particular on routine jobs. The negative effect on labour demand is particularly severe in Ethiopia, Senegal, Vietnam and China. In fact, the negative effect of technical change on GVC job demand is even bigger than the positive effect of an expanding global market for China, Senegal, South Africa and Vietnam. Third, a major part of the variation in employment generation across our set of countries is due to differences in the change in competitiveness in carrying out activities in GVCs compared to other countries in world, as measured by their GVC income share in global markets. This reflects the results discussed in the previous section: Kenya, Senegal and South Africa all lost market share, depressing GVC job growth. Also Brazil and Malaysia were barely able to increase job growth through improving their GVC competitiveness. Perhaps surprisingly, demand for GVC jobs increased fastest in Vietnam due to its capturing a larger share of the global GVC income, adding

[15] As noted in section 3, an approximation error arises as higher-order terms are ignored. In practice these are minor as reported in the table.

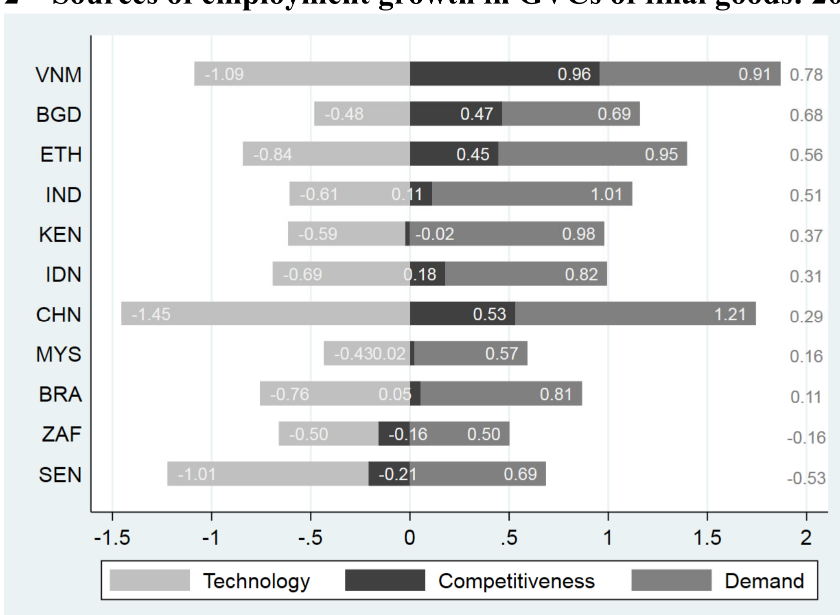
0.96 log points to overall GVC job growth. Also demand for GVC jobs in Bangladesh, China and Ethiopia benefitted highly from increased GVC competitiveness, adding 0.45 log points or more.[16]

Table 5 Sources of GVC job growth in GVCs of final goods: 2000-2014

	Change in Demand (world expenditure)	Change in Competitiveness (GVC income share)	Change in Technology (labor requirements)	Approximation error	Total GVC job growth
Ethiopia	0.95	0.45	-0.84	-0.03	0.53
Kenya	0.98	-0.02	-0.59	0.01	0.38
Senegal	0.69	-0.21	-1.01	-0.05	-0.58
South Africa	0.50	-0.16	-0.50	-0.02	-0.18
Bangladesh	0.69	0.47	-0.48	-0.02	0.66
China	1.21	0.53	-1.45	0.00	0.29
Indonesia	0.82	0.18	-0.69	-0.02	0.28
India	1.01	0.11	-0.61	-0.01	0.50
Malaysia	0.57	0.02	-0.43	0.01	0.17
Vietnam	0.91	0.96	-1.09	-0.16	0.63
Brazil	0.81	0.05	-0.76	-0.01	0.10

Note: decomposition of (log) growth rates of number of workers carrying out activities in the production of final goods based on equation (6). Approximation error arises as only first order terms are taken into account. Total in last column is sum of entries in first four columns.

Figure 2 Sources of employment growth in GVCs of final goods: 2000-2014



Note: data from Table 5. Total effect is given on the right hand side (excluding approximation error).

[16] Note that the effects of changes in GVC income shares on GVC job growth are moderated by the job intensity of production which varies across countries. Thus a similar increase in GVC income in two countries can have different effects on GVC jobs.

5.2 Sectoral distribution of GVC job growth

What is the sectoral distribution of the jobs demanded in GVCs of final goods? We analyse the sector of the economy in which the GVC workers are employed as derived from elements of the **L** vector in equation (2). Table 6 provides for each country the number of GVC workers per sector, distinguishing between the manufacturing, agriculture, other industry (incl. mining) and services sectors. The upper panel provides the levels in 2014 and the lower panel the change over the period 2000-14. It should be noted that we report the number of workers in the formal manufacturing sector for the seven newly added countries to the WIOD (Ethiopia, Kenya, Senegal, South Africa, Bangladesh, Malaysia, Vietnam). As discussed above, we derive employment numbers for manufacturing industries from the surveys collected by UNIDO which pertain only to formally registered firms in a country, often, but not always, with an additional cut-off in terms of firm size (5 or 10 employees).[17] For the countries already included in the WIOD database (China, Indonesia, India, Brazil), the numbers refer to all manufacturing employment.

The African countries have the lowest share of formal manufacturing jobs in their overall GVC jobs as illustrated in Figure 3. The share is 15% or lower, and even in South Africa, the most industrialised country of the four, the share is just above 20%. Levels in Bangladesh, China, Malaysia and Turkey are well above 35% in comparison. This finding reflects the findings of a low share of manufacturing in overall GDP or employment in most African countries as found by Timmer et al. (2015b) and Diao et al. (2017). Yet, as outlined above, GVC jobs can also be generated in more upwards stages of production, that is through backward linkages into domestic sectors in the venerable Hirschmann (1958) tradition. In Ethiopia and Kenya over the period 2000-14 more GVC jobs were generated in the agricultural sector than in any other sector. This does not hold for most other countries in our comparison group. China is an extreme counter example, as the number of GVC jobs in agriculture even declined while jobs in manufacturing boomed. Back in 2000 GVC jobs in agriculture dominated those in manufacturing, but by 2014 this situation has reversed. In Bangladesh, job creation during 2000-14 was also the highest in the manufacturing

[17] Hence it does not cover micro and informal firms in manufacturing that may play a dynamic role as well as suggested by Diao et al. (2018). Using Tanzania's first nationally representative survey of micro-, small-, and medium-sized enterprises (MSMEs) they estimate that non-agricultural MSMEs contributed roughly one percentage point to economy-wide labor productivity growth in Tanzania between 2002 and 2012. A small subset of firms with above average labor productivity accounted for the bulk of this growth.

sector. In Vietnam, GVC jobs in manufacturing increased as much as in agriculture suggestive of strong backward linkages into agricultural materials production. In Indonesia, GVC job creation in agriculture dominated as the Indonesian export mix shifted away from manufactured products towards materials and natural resources. In Brazil, GVC job creation was mostly in the services sector. This phenomenon is relatively novel and less studied as Hirschman and followers mostly emphasize backward linkages into agriculture. The GVC jobs in services may include workers involved in all kinds of activities auxiliary to manufacturing such as communication services, accounting, finance, after-sales services and other business services, as well as cleaning and protective services, and a wide variety of transport, warehousing and trading activities. The loss of GVC jobs in Senegal was mostly due to a decline in jobs in services, and to some extent in agriculture. In South Africa, GVC jobs declined in all sectors, the most in agriculture, but also in manufacturing.

Table 6a Number of workers in GVCs of final goods, by sector of employment (in thousands), 2014

	Manufac-turing[a]	Agri-culture	Other Industry	Services	Total GVC jobs
Ethiopia	215	2,462	32	586	3,295
Kenya	288	1,297	12	395	1,992
Senegal	24	171	17	55	267
South Africa	629	781	181	1,334	2,924
Bangladesh	5,496	5,006	237	3,836	14,574
China	93,182	77,757	8,267	59,565	238,771
Indonesia	9,304	19,065	553	7,960	36,882
India	58,966	69,465	4,168	34,071	166,670
Malaysia	1,152	637	124	1,037	2,949
Vietnam	3,478	9,252	174	2,698	15,602
Brazil	8,670	6,766	344	7,675	23,455

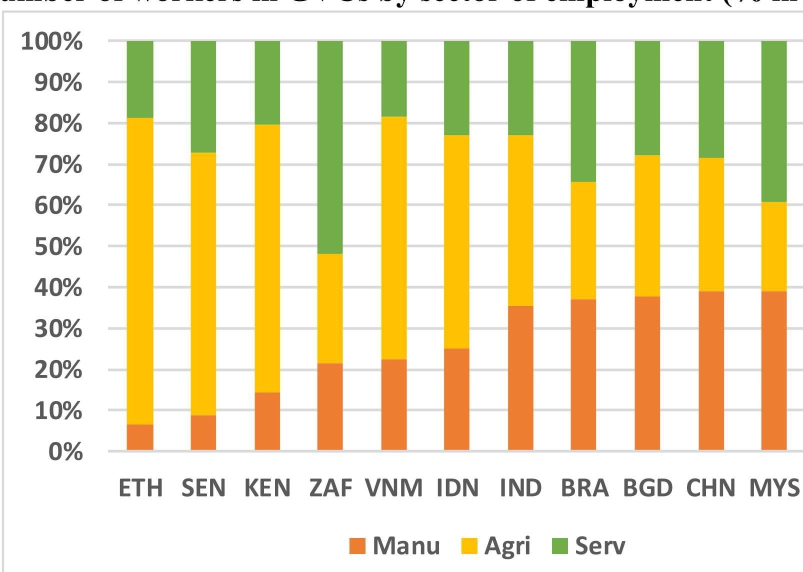
Note: Based on calculation of workers in a country involved in carrying out activities in the production of final goods according to equation (2). Agriculture includes also fishing and forestry. Other industry includes mining, utilities and construction sectors. Services are all other sectors of the economy. Note (a): the coverage of manufacturing differs per country. For Bangladesh and Ethiopia, it covers all establishments with 10 or more employees; for Kenya, data pertains to establishments with 5 or more persons engaged; for Senegal, South Africa, Malaysia and Vietnam, the scope of the data is all registered establishments. Data for China, India, Brazil and Indonesia includes all manufacturing firms (formal and informal).

Table 6b. Number of workers in GVCs of final goods, by sector of employment (in thousands). Change (2014 minus 2000)

	Manufac-turing[a]	Agri-culture	Other Industry	Services	Total GVC jobs
Ethiopia	150	691	27	482	1,350
Kenya	64	471	-8	96	624
Senegal	3	-78	16	-151	-211
South Africa	-184	-318	-45	-37	-584
Bangladesh	3,328	1,843	109	1,754	7,034
China	28,110	-673	2,737	29,121	59,294
Indonesia	2,183	4,590	182	2,141	9,095
India	26,466	19,053	1,807	18,685	66,011
Malaysia	131	26	9	295	461
Vietnam	2,630	2,615	89	1,923	7,257
Brazil	1,395	-1,180	5	1,943	2,164

Note: see Table 6a.

Figure 3. Number of workers in GVCs by sector of employment (% in total), 2014.



Note: see Table 6a. Services includes other industry. Countries are ranked by share of manufacturing.

5.3 Source of GVC job growth in the manufacturing sector.

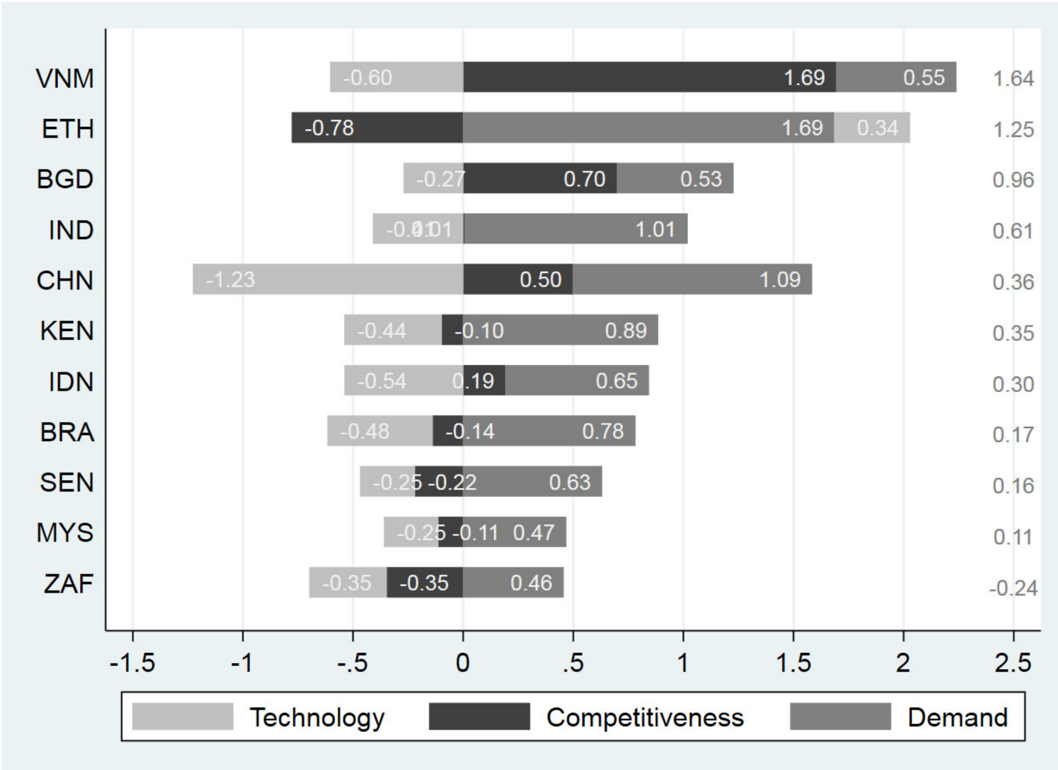
Often, attention is particularly focused on the generation of jobs in the manufacturing sector as these are considered to be more stable, higher paid and having overall better working conditions than jobs in the services sector. Moreover, manufacturing activity is believed to more susceptible to capital and scale-intensification than agriculture and services and as such more conducive for further growth (Rodrik, 2013). We therefore separately analyse GVC job growth in the manufacturing sector, using the decomposition given in equation (7). The results are reported in Table 7 and Figure 4. As before, growth in world demand drove most of the growth in manufacturing GVC jobs over the period 2000-14 adding more than 1.0 log point in China, India and Ethiopia. The African countries are clearly losing out in the competition for manufacturing GVC jobs, as shown by the negative contributions of the GVC income share. In contrast, improved GVC competitiveness boosted job growth in Bangladesh by 0.7 log point and even 1.7 log point in Vietnam. Perhaps surprisingly, changes in labour requirements have much less impact on demand for manufacturing jobs than for jobs in other sectors. Declines in the labour needed per unit of output dampened job growth in the manufacturing sector, but its negative effect was relatively minor (cf. Table 5). In Ethiopia manufacturing labour requirements even went up. This suggests that the manufacturing sector in most countries was already quite advanced in 2000, such that further productivity increases were minor relative to improvements made in the backward linked non-agricultural sectors. Clearly, there are many country-specific characteristics that are potentially driving this widely divergent performance in GVC job growth and more detailed investigation, zooming in on particular GVCs and industries is needed to better comprehend the GVC dynamics.

Table 7 GVC job growth in manufacturing sector, 2000-2014

	Change in				Total
	Demand (world expenditure)	Competitiveness (GVC income share)	Technology (labor requirements)	Approximation error	GVC job growth
Ethiopia	1.69	-0.78	0.34	-0.06	1.20
Kenya	0.89	-0.10	-0.44	-0.09	0.25
Senegal	0.63	-0.22	-0.25	-0.02	0.14
South Africa	0.46	-0.35	-0.35	-0.01	-0.26
Bangladesh	0.53	0.70	-0.27	-0.03	0.93
China	1.09	0.50	-1.23	0.00	0.36
Indonesia	0.65	0.19	-0.54	-0.04	0.27
India	1.01	0.01	-0.41	-0.01	0.60
Malaysia	0.47	-0.11	-0.25	0.01	0.12
Vietnam	0.55	1.69	-0.60	-0.22	1.41
Brazil	0.78	-0.14	-0.48	0.01	0.18

Note: as for Table 5, but only covering jobs in the manufacturing sector using equation (7). The coverage of manufacturing differs per country, see note for Table 6a.

Figure 4. Sources of employment growth in GVCs of final goods in the manufacturing sector.



Note: See Table 7. Total effect is given on the right hand side (excluding the approximation error).

6. Concluding remarks

In this study we analyzed the evolution of GVC jobs in four African countries from an internationally comparative perspective. These are jobs in carrying out an activity in the global production process of a final good. These activities can take place in manufacturing as well as other sectors that are backward linked. We found that in all countries under consideration the demand for GVC jobs was boosted by growth in global expenditure on final goods during the period 2000-14. Labour demand growth was moderated however as the labour requirements per unit of output declined at the same time. This finding aligns with the hypothesis of Rodrik (2018), suggesting a labour-saving bias in technical change in GVCs (see Reijnders et al., 2016, and Reijnders and de Vries 2018 for evidence). Major differences in GVC job growth across countries are due to differential performance in GVC competitiveness, defined by countries' income shares in a given GVC. Ethiopia improved GVC competitiveness, while Kenya, Senegal and South Africa became less competitive relative to the rest of the world. The four African countries stand out in terms of a low share of GVC jobs in the (formal) manufacturing sector, and a relatively high share of GVC jobs in agriculture due to strong backward linkages, especially in the case of production of food. Ethiopia and Bangladesh stand out with a sizeable share in GVC jobs related to production of textiles. In Ethiopia this is in particular in the backward linked cotton agriculture, while more in the manufacturing sector in Bangladesh. Foreign end markets in Bangladesh are mostly in Europe and the US, while Africa and Middle East are important end markets for Ethiopia. Vietnam is specialised in GVCs of computer and electronics equipment, depending in particular East Asian end markets. Obviously, there are many country-specific characteristics that are potentially driving this widely divergent performance in GVC job growth and more detailed investigation, zooming in on particular GVCs and industries, is needed to better comprehend the GVC dynamics.

We constructed new data for a number of low- and medium-income countries in order to perform our GVC analysis. In doing so, we were limited by the availability and quality of the officially published statistics. Complementary evidence would be welcomed on four fronts. First, more data on informal and small-scale enterprises alongside the formal sector firms. Diao et al. (2018) suggest that there is an important subset of small yet highly productive micro firms in what they denote the "inbetween" sector. These are firms that are informal, yet share important characteristics with formal firms such as keeping written accounts in a ledger, and owners saving money in a formal bank account. They suggest that specific targeting financial and other services to these high-potential firms might contribute to future growth.

Second, data on imports and exports at the firm level. It is likely that the production by exporting firms is more intensive in the use of imports than production by firms serving the domestic market, see e.g. Koopman et al. (2012) for the case of China. This information can potentially be captured through a survey, and would give primary evidence on (a part of) the global value chain. This is not the gold standard however, as standard production surveys only reveal direct links in a chain: they cannot reveal end-markets in the case of intermediate export, nor the ultimate source of the imports. Yet, it would be a primary observation and not depend on the synthetic method presented here, whose validity depends on the strong proportionality assumption that technical coefficients are the same for all firms in an industry.

Third, a complete analysis of a GVC would not only involve an analysis of the production stages, as performed in this paper (and by default all papers that rely on IO-statistics). It should also consider the distribution stage from factory to consumer. Wen et al. (2018) provide a value added decomposition of GVCs explicitly accounting for the distribution stage. They showed the increased importance (in terms of income share) of intangible capital (such as brand names) in GVCs. More generally, we would argue that in today's world where production processes are internationally fragmented, analyses of production, trade and income should focus on the type of activities the countries carry out in global production networks, in combination with the type of products exported. Countries specialize in carrying out particular activities such as R&D, marketing or fabrication, dubbed *functional specialization* in trade (Timmer et al., 2018). This calls for information on the activities carried out in production, as for example contained in statistics on the occupations of workers.

Fourth, in this paper we studied GVCs of final manufacturing goods and focused in particular on the creation of GVC jobs in the manufacturing sector. This follows the traditional emphasis on manufacturing as the sector that (historically) drove economic transformation and growth. Yet, there is ample evidence for the servicification of manufacturing activities, as well as suspicion that new technologies such as automation and 3D- printing might be particularly saving on unskilled labour in the manufacturing sector (Rodrik, 2018). At the same time there is a growing number of services and agro-industries that share many characteristics with manufacturing. Newfarmer et al (2018) found some evidence that suggested that a new pattern of structural change is emerging in Africa, based on fast growth in horticulture, ICT-based services, tourism and transport, dubbed industrialization without smokestacks. Study of GVCs in agricultural goods and services should therefore be high on the agenda.[18]

We see this study as a first attempt to collect the necessary data needed for a quantitative GVC analysis of African countries. It offers a macro-economic background, charting patterns and trends that ground more detailed case studies of networks with specific information on technologies and

[18] GVC analysis (also known as Global Commodity Chain analysis) has been developed primarily for industrial commodity chains. In contrast, its predecessor, the French *Filière* approach has its origin in technocratic agricultural research (Raikes et al, 2000).

products, production capabilities as well as location characteristics and full institutional and historical detail (Coe et al., 2008; Coe and Yeung, 2015). Special attention is also needed for the way in which lead firms coordinate cross-border activities in the network (intra- and inter-firm), and how they promote or inhibit the development of local capabilities. Importantly, the lead firms can be firms that are thought of as manufacturing firms, but can also be major multinational retailers (e.g. Gereffi, 1999; Gereffi et al. 2005). The GVC approach pays much attention to the governance structure within chains and the bargaining power of firms involved in GVCs. Typically, goods, services and technology do not flow at arm's length between anonymous market participations, but in coordinated fashion under lead firms that play a major role in the determination of the activities carried out and technologies used. Ultimately, it is a combination of quantitative assessments at the macro-level as in this paper and more qualitative studies of particular value chain cases that will lead to a better understanding of the potential for job growth under GVC participation for low- and middle-income countries.

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Appendix Table 1 Product groups used in this paper

Final goods from industry (ISIC rev.4 code)	Short	Long description
C10t12	FOOD	food products, beverages and tobacco products
C13t15	TEXT	textiles, wearing apparel and leather products
C16	WOOD	wood and of products of wood and cork, except furniture
C17	PAPER	paper and paper products
C18	PRINT	Printing and reproduction of recorded media
C19	PETRO	coke and refined petroleum products
C20	CHEMICALS	chemicals and chemical products
C21	PHARMA	basic pharmaceutical products and pharmaceutical preparations
C22	RUBBER	rubber and plastic products
C23	MINERAL	other non-metallic mineral products
C24	BAS METAL	basic metals
C25	FAB METAL	fabricated metal products, except machinery and equipment
C26	COMPUTER	computer, electronic and optical products
C27	ELECTRICAL	electrical equipment
C28	MACHINERY	machinery and equipment n.e.c.
C29	MOTOR	motor vehicles, trailers and semi-trailers
C30	OTH TRANS	other transport equipment
C31t33	FURNI; OTH.	furniture; other manufacturing; repair and installation

Appendix Table 2 Top-25 destination markets of a country's value added in GVCs of final goods.

(A) Ethiopia

Market		Value added in market as share of all value added by country		Value added by country as share of total market (%)	
Consumer	**Product**	**2000**	**2014**	**2000**	**2014**
ETH	C10t12	29.2	21.4	82.487	51.803
ETH	C13t15	13.6	18.1	53.667	43.430
ROW	C10t12	6.5	9.6	0.025	0.057
DEU	C10t12	7.8	3.6	0.059	0.080
ETH	C20	4.0	5.3	37.014	20.573
ETH	C31t33	4.3	4.3	45.211	31.207
ETH	C22	3.5	4.9	59.691	39.112
JPN	C10t12	3.2	2.2	0.008	0.029
USA	C10t12	1.5	2.0	0.003	0.012
ETH	C23	1.4	1.9	69.703	63.949
FRA	C10t12	1.5	1.3	0.014	0.035
ITA	C10t12	1.8	0.9	0.017	0.034
CHN	C10t12	0.1	2.5	0.001	0.012
ETH	C29	2.4	0.0	10.771	0.002
ETH	C16	0.6	1.7	44.961	52.850
ROW	C13t15	1.1	1.1	0.009	0.018
USA	C13t15	1.2	0.7	0.005	0.013
GBR	C10t12	0.7	0.9	0.007	0.040
NLD	C10t12	0.6	0.6	0.024	0.064
ITA	C13t15	0.7	0.2	0.012	0.018
ETH	C17	0.4	0.5	51.806	42.675
BEL	C10t12	0.6	0.3	0.032	0.059
ETH	C18	0.4	0.4	78.251	60.028
DEU	C13t15	0.3	0.4	0.007	0.038
ESP	C10t12	0.4	0.4	0.007	0.020
ETH	C25	0.0	0.7	0.001	25.980

(B) Kenya

Market		Value added in market as share of all value added by country		Value added by country as share of total market (%)	
Consumer	Product	2000	2014	2000	2014
KEN	C10t12	46.4	57.0	66.399	66.508
KEN	C25	4.6	8.5	47.279	45.346
KEN	C13t15	10.7	0.2	64.871	3.114
ROW	C10t12	4.4	6.3	0.048	0.073
KEN	C17	4.3	2.9	77.948	56.057
KEN	C20	4.5	2.1	44.629	8.655
KEN	C24	3.0	1.4	56.382	12.741
KEN	C29	0.0	3.6	0.001	13.439
USA	C13t15	0.3	2.7	0.004	0.103
KEN	C22	2.0	1.0	57.438	17.051
ROW	C13t15	1.5	1.2	0.034	0.035
ROW	C20	1.0	1.6	0.099	0.201
DEU	C10t12	1.8	0.7	0.040	0.031
KEN	C16	1.8	0.1	87.829	25.925
KEN	C18	0.8	0.8	65.398	62.872
GBR	C10t12	0.8	0.7	0.022	0.055
NLD	C10t12	0.8	0.6	0.089	0.130
FRA	C10t12	0.7	0.7	0.018	0.035
ITA	C10t12	0.6	0.3	0.017	0.019
KEN	C19	0.9	0.0	22.885	0.006
ROW	C29	0.2	0.6	0.005	0.013
USA	C10t12	0.5	0.4	0.002	0.004
ROW	C21	0.7	0.0	0.068	0.001
BEL	C10t12	0.5	0.2	0.077	0.085
ROW	C22	0.4	0.3	0.047	0.060
ESP	C10t12	0.3	0.3	0.014	0.029

(C) Senegal

Market		Value added in market as share of all value added by country		Value added by country as share of total market (%)	
Consumer	Product	2000	2014	2000	2014
SEN	C10t12	43.3	41.9	60.127	40.974
SEN	C20	10.8	14.0	51.962	54.197
ROW	C10t12	2.5	14.0	0.011	0.038
SEN	C22	3.3	3.6	63.485	55.070
ITA	C10t12	5.4	1.0	0.058	0.018
SEN	C13t15	4.5	0.9	48.055	11.474
FRA	C10t12	4.7	0.6	0.050	0.007
ESP	C10t12	3.8	1.3	0.078	0.030
SEN	C16	0.7	2.0	21.996	50.749
SEN	C27	2.4	0.2	35.304	2.701
SEN	C17	1.2	0.8	69.967	47.460
KOR	C10t12	0.1	1.9	0.002	0.056
ROW	C20	0.7	1.3	0.026	0.038
SEN	C28	0.9	0.9	6.016	6.339
SEN	C23	0.9	0.7	68.741	63.234
CHN	C10t12	0.9	0.4	0.008	0.001
SEN	C19	1.2	0.0	29.820	0.004
SEN	C30	0.3	0.7	24.564	28.228
JPN	C10t12	0.6	0.3	0.002	0.002
SEN	C31t33	0.0	0.9	0.001	21.580
ROW	C28	0.5	0.3	0.006	0.003
SEN	C18	0.5	0.3	75.959	75.902
ROW	C13t15	0.3	0.5	0.003	0.004
IND	C19	0.5	0.1	0.041	0.004
USA	C31t33	0.1	0.5	0.000	0.004
IND	C13t15	0.4	0.2	0.016	0.003

(D) South Africa

Market		Value added in market as share of all value added by country		Value added by country as share of total market (%)	
Consumer	Product	2000	2014	2000	2014
ZAF	C10t12	24.9	25.6	80.223	67.553
ZAF	C19	5.5	6.2	74.343	49.729
ZAF	C29	8.9	2.6	55.418	18.189
ZAF	C13t15	5.4	2.2	64.353	25.228
ROW	C10t12	2.1	5.2	0.440	0.591
ZAF	C31t33	4.2	3.0	60.823	42.604
ROW	C29	1.4	4.4	0.547	0.861
ZAF	C20	3.0	2.3	65.525	46.987
ZAF	C27	3.2	1.0	55.920	18.039
ROW	C19	2.8	1.2	8.743	1.081
ROW	C28	1.0	2.4	0.559	0.880
USA	C29	1.2	2.2	0.107	0.268
ZAF	C28	1.4	1.4	27.859	18.502
DEU	C29	1.4	1.3	0.519	0.571
ROW	C13t15	0.5	1.4	0.210	0.401
ZAF	C18	1.0	0.8	87.587	82.247
DEU	C28	0.8	1.0	0.454	0.750
ROW	C20	0.5	1.2	0.857	1.441
USA	C28	0.8	0.8	0.141	0.199
ROW	C27	0.4	1.1	0.440	0.553
ZAF	C17	0.8	0.7	76.307	65.967
ZAF	C22	0.8	0.5	60.300	37.078
JPN	C29	0.5	0.8	0.171	0.744
GBR	C29	0.6	0.6	0.481	0.573
USA	C26	0.7	0.4	0.076	0.089
CHN	C28	0.2	0.8	0.114	0.117

DATA APPENDIX   Method and sources for seven new countries added to the World Input-Output Database 2016 release

Contents

I. Introduction

This appendix outlines the approach and country-specific sources for adding seven countries to the World Input-Output Database, Release 2016 (WIOD; Timmer et al., 2015b). Table 1 lists the seven newly added countries. It includes three countries from South-East Asia and four countries from Sub-Saharan Africa. Table 2 lists the industries of the WIOD which is the target level of detail for the new countries as well. The table also includes the mapping to ISIC Rev.3 to which we will refer to later. In section II, we outline the general approach for inclusion of these countries and discuss the main data sources and construction of the data series. In section III, we discuss country-specific sources and provide consistency checks on the constructed data.

Table 1 List of countries

ISO3 Letter code	Country name
BGD	Bangladesh
MYS	Malaysia
VNM	Vietnam
ETH	Ethiopia
KEN	Kenya
SEN	Senegal
ZAF	South Africa

Table 2 List of industries in ISIC Rev.4 and mapping to ISIC Rev.3.1

Rev 4	Description	Rev 3.1
A	Agriculture, forestry and fishing	AtB
B	Mining and quarrying	C
C10-C12	Manufacture of food products, beverages and tobacco products	D15-D16
C13-C15	Manufacture of textiles, wearing apparel and leather products	D17-D19
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	D20
C17	Manufacture of paper and paper products	D21
C18	Printing and reproduction of recorded media	D222
C19	Manufacture of coke and refined petroleum products	D23
C20	Manufacture of chemicals and chemical products	D24 excl D2423
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	D2423
C22	Manufacture of rubber and plastic products	D25
C23	Manufacture of other non-metallic mineral products	D26
C24	Manufacture of basic metals	D27
C25	Manufacture of fabricated metal products, except machinery and equipment	D28

C26	Manufacture of computer, electronic and optical products	D30, D32, D33
C27	Manufacture of electrical equipment	D31
C28	Manufacture of machinery and equipment n.e.c.	D29
C29	Manufacture of motor vehicles, trailers and semi-trailers	D34
C30	Manufacture of other transport equipment	D35
C31-C33	Manufacture of furniture; other manufacturing; repair and installation of machinery and equipment	D36
DtE	[Electricity, gas, steam and air conditioning supply]; [Water supply; …]	E + D37
F	Construction	F
GnI	[Wholesale and Retail Trade]; [Accommodation and food services activities]	GtH
HnJ61	[Transportation and storage]; [Telecommunications]	I
JtN	[Information and communication]; [Financial and insurance activities]; [Real estate activities]; [Professional, scientific and technical activities]; [Administrative and support service activities]	JtK + D22 excl. D222
OtQ	[Public administration …]; [Education]; [Human healt activities]	LtN
RtT	[Residential care and Social work activities]; [Arts, entertainment and recreation]; [Other services activities]; [Activities of households …]	OtP
U	[Activities of extraterritorial organizations and bodies]; [Residual manufacturing output]	

II. General procedure

The 2016 release of the WIOD contains so-called World Input-Output Tables (WIOTs) which cover flows between 43 countries in 56 industries. In addition it contains a so-called 'Rest of the world' (ROW) block. This is an estimate of the overall input-output structure of all the countries that are individually covered in the WIOD (representing about 15 % of world GDP). We add new countries to the WIOTs by splitting off newly constructed National Input-Output Tables (NIOTs) for a country from the 'Rest of the world' (ROW) block in the original WIOT.[19] In doing so, we preserve the numbers for the countries that were originally in the WIOTs, adding new information on their trade with the newly added countries. Each new country is separately added to the existing WIOT.

This estimation procedure firstly requires time series of national input-output tables for each country (see section II.A). We extend the standard IO table by adding information on the bilateral trade partners of a country's import and export flows. This ensures that the national IO table can be used in conjunction with the overall structure of the WIOT (see section II.B). Lastly, we also construct employment accounts for these countries consistent with the value added and output accounts for our analyses (see section II.C).

[19] The alternative would be to reconstruct the whole WIOT by including the countries in the International Supply and Use tables (SUTs). The disadvantage of this approach would be that the estimates for the countries that are already in the WIOD would be affected in the process.

II.A. Estimation of national input-output tables (NIOTs)

We aim to analyse developments over time and need therefore time series of national input-output tables. These are typically not available from the national statistical offices as the required data is very information-rich. Input-output tables require a consolidated account for the use and supply of detailed products throughout the economy. Even advanced countries tend to publish these tables only at regular benchmark years (every five years) and typically do not aim to harmonise the tables over time. For our new set of countries, we first obtained at least one official input-output table for each country within the relevant time period (2000-2014). We construct the time series of the NIOTs by use of the economic structure of this table and annual country data on value added, gross output, imports, exports, consumption, and gross capital formation from national account statistics. This ensures that comparisons over time can be made. Given the generally data-poor environment of the newly to be added countries, we reduced the industry dimension and cover only 9 broad sectors in addition to 18 detailed manufacturing industries, as shown in table 2. This will be sufficient for the main analysis of this study which focuses on global value chains of goods. We describe the general estimation approach in II.A.1, and discuss the data sources in section II.B.1.

II.A.1 Approach

We estimate the time series of the NIOTs using country and year-specific data, as illustrated in figure 1. The figure is a simplified and aggregated version of an input-output table. As shown, we have annual country data for the indicated components for each industry (see table 2), final demand category, and trade flow.

Once we have constructed the annual country data, we estimate the NIOTs using the economic structure of the official input-output table as the first estimate for the interior matrices.[20] The official tables are obtained from multiple sources as described in the country-specific notes. In order to estimate balanced NIOTs that adhere to the annual country data, we use a GRAS-procedure, as outlined in Lenzen et al. (2007). GRAS is an iterative process that adjusts the values in the rows and columns of the matrix such that the row and column totals converge to externally supplied target values. The row totals are the total output that is used and consumed domestically from each industry (i.e., output minus exports plus imports). The column totals are the total value of intermediates used by the industry (i.e., output minus value added), and the totals for the final demand categories, all in basic prices. Annual data on the international trade values by industry are available from statistical sources (see section II.B). Therefore, they do not need to be estimated using GRAS.

[20] If we have more than one benchmark table, the initial economic structure for GRAS will be based on a weighted average of the two closest benchmark years.

Figure 1 Simplified national input-output table

	Agriculture	Mining	Manufacturing	Services	Demand	Exports	Imports	Output
Agriculture	Interior matrix: estimated based on official table structure					Data	Data	Data
Mining								
Manufacturing								
Services								
Totals	Data				Data			
Value added	Data							
Output	Data							

Note: 'Data' indicates that we obtain annual country data for this component. All 'Imports' entries are negative. Demand is final demand.
Source: Authors' illustration.

II.A.2 Data sources and construction of external data

We need to obtain at least one official input-output table, time series of exports, imports, value added, and gross output by industry, as well as totals of the final demand categories. The initial input-output tables are obtained from national statistical offices and international organizations, which we describe in more detail in the country-specific notes.

Value added, gross output and intermediate use

For this set of countries, the time series on output and intermediate use are not readily available from official sources. The first challenge is in creating series of value added and gross output for detailed industries. Our benchmark series of value added across 10 broad sectors comes from the GGDC 10-Sector Database (10SD; (Timmer et al., 2015a).[21] As the WIOTs are in ISIC Rev.4, we map the sectors in the 10SD to Rev.4 as is indicated in table 2. Value added data in the 10SD is available up to 2011, and we update it until 2014 by extrapolation with recent releases from UN Official Country Data (UN OCD; UN, 2018b). For Bangladesh and Vietnam no data is available in the 10SD so we use UN OCD data for the entire period.

The 10SD does not provide gross output figures which need to be obtained. We base these on gross output to value added ratios from national accounts (NA) data from the UN OCD. That is, we multiply the value added series with gross output to value added ratios for broad sectors. This is consistent with the 10-Sector database because it is also based on NA data published by the statistical offices. Intermediate use by industry is calculated by subtracting value added from gross output. The gross output and value added series thus pin down intermediate use.

[21] The value added figures in the 10-Sector Database are based on the latest vintage of national accounts data at the time of construction (and backdated with earlier revisions). It is therefore close to the national account data found in the UN Official Country Data (2018b).

Detailed manufacturing industries

The 10SD sector provides only data for aggregate manufacturing. For the purpose of this paper, we need to add information on more detailed manufacturing industries. Data on manufacturing industries is typically only available from surveys that cover the formal part of the economy, e.g. only firms that have say 10 employees or more. We refer to this as "formal manufacturing". We split the 10SD value added into a detailed set of formal manufacturing industries and a residual sector. That is, we obtain data for the formal manufacturing sector from several vintages of UNIDO's Indstat database (2018) available in ISIC Rev.4 and Rev.3. To generate the series of value added in the formal manufacturing industries, we use the ISIC Rev.4 release as the initial series to match the industry classification in the WIOTs whenever possible. As this series is not available for the whole time series, we backdate it with the growth rates of UNIDO's releases in ISIC Rev.3 after mapping to Rev.4 as indicated in table 2.[22] UNIDO's Indstat (2018) is the only widely available source (across countries and over time) with detailed information on the manufacturing sector. As these data are based on industrial censuses and business registers, it only captures formally registered firms and it typically uses a threshold of 10 or more formally employed workers (e.g., to limit the size of the business register). Therefore, our set of detailed manufacturing industries refers to formal manufacturing firms. We sum across all manufacturing industries and subtract this from the aggregate manufacturing data from the 10SD. As such, a residual remains which potentially captures informal and small formal firms, but also includes any inconsistencies between the survey data and additional sources that are used in the construction of the national accounts.[23] A major advantage of UNIDO's Indstat is that it provides gross output and employment figures, which are internally consistent with the value added accounts, because the entries generally come from the same establishments sampled within a given ISIC classification. This is crucial because value-added to output ratios and employment to output ratios are essential in the calculation of value added or employment in exports (see main text).

Other main aggregates

We obtain main aggregates for final demand categories from UN OCD (UN, 2018b). The final demand categories are household consumption (CONS_h), consumption by non-profit organizations serving households (CONS_np), government consumption (CONS_g), gross fixed capital formation (GFCF) and changes in inventories (INVEN). Together with the trade balance these final demand categories sum to GDP from the expenditure side. In the ROW block of the current WIOTs there is no information on Taxes Less Subsidies on Products (TXSP) and all values in the WIOTs are in basic prices. Therefore in the country NIOTs, GDP from the income side is

[22] For several countries, we start with UNIDO's release in Rev.3 as Rev.4 data are not available (see country notes below).

[23] Note that we do not interpret this sector as the informal sector but as a residual, because it is not based on measurement of the informal sector. For some countries, production in this sector can become negative, indicating a mismatch of the data. We keep this sector in the WIOTs to acknowledge this but we do not analyze it. It is included in sector U. We set output to equal value added, such that this sector uses no intermediates, and by our definition all its production is domestically consumed.

determined by 10SD value added. In order to balance GDP from the expenditure side with GDP from the income side, the final demand categories for capital and consumption goods are adjusted in the expenditure data. Since the trade totals used for the NIOTs are taken from external sources (see II.B), the GDP adjustment to final demand has three components: adjustment for TXSP; adjustment for discrepancies in the trade balance between UN OCD and COMTRADE (UN COMTRADE, 2018); statistical discrepancy between 10SD value added and implied UN OCD value added. The adjusted final demand categories are used as column totals in GRAS (see figure 1).[24] Lastly, we need to obtain exports and imports by (supplying) industry to estimate the NIOTs. The next section describes the construction of the trade data, and how these are used to integrate the NIOTs into the WIOTs.

II.B. Trade data & integration into WIOD

For the integration of each of the new countries' NIOTs into the World Input Output Database (WIOD) we apply a common procedure that accomplishes three distinct tasks. We take the time series of the NIOTs for each country, estimated as explained in the previous section, shown in figure 2A. First we separate the *import matrix* – which distinguishes the imported products from domestically produced products for each using industry and final demand category (figure 2B). We determine the country of origin, expanding the import matrix (figure 2C). Second, we expand the *export matrix*, which shows the exports by supplying *and* using industry or final demand category by trading partner (figure 2D). Last, we integrate the expanded NIOT (from figure 2D) into the original 2016 WIOD (figure 2E) to obtain a new set of WIOTs expanded with the new countries (figure 2F). As previously noted, the new countries are separated out from the original Rest-of-World (ROW) region, meaning the flows to and from the ROW will be reduced in the expanded WIOTs.

For this procedure we rely on three sources of data: the new countries' NIOTs, the 2016 release WIOTs, and trade flows from the UN COMTRADE for goods and services. The assembling of the COMTRADE data is discussed in the next section. Following this brief discussion of the trade source, each step in the integration of the new countries in the WIOTs is discussed in a separate section. We conclude with a limited discussion of the data problems we encountered when working with the trade data and how we solved them. More detailed country information is provided in the country-specific sources and methods.

[24] Note that we exclude changes in inventories from the GRAS procedure. In principle, GRAS can cope with negatives but the results were unbalanced. Therefore, we instead distribute the total of changes in inventories across industries using the information from the official tables and supply it externally to the time series of the NIOTs, as we do for the trade values.

Figure 2; Schematic procedure of the extension of the 2016 WIOTs

Figure 2A; Simplified NIOT for country NEW, 3 USE categories

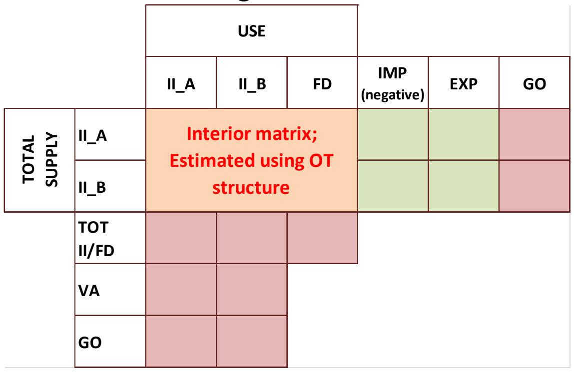


Figure 2B; NIOT with IMP matrix by USE category

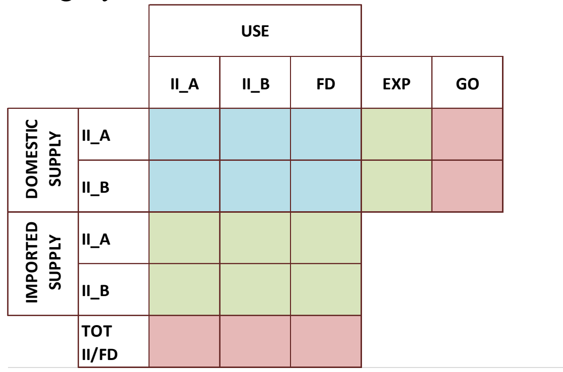


Figure 2C; NIOT with bilateral IMP matrix

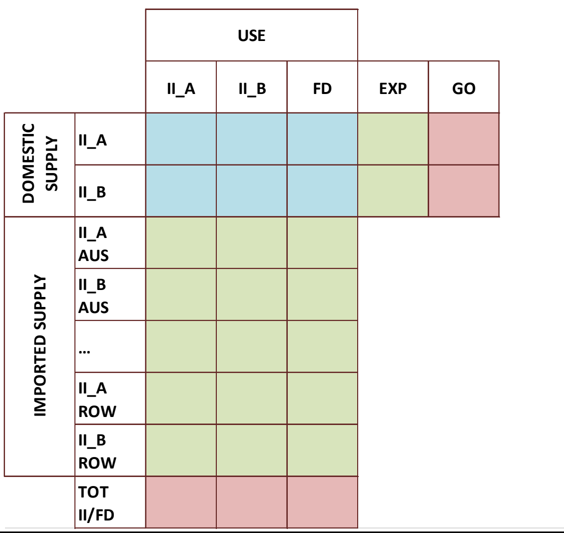


Figure 2D; NIOT with bilateral IMP/EXP matrices; SUPPLY/USE categories consolidated

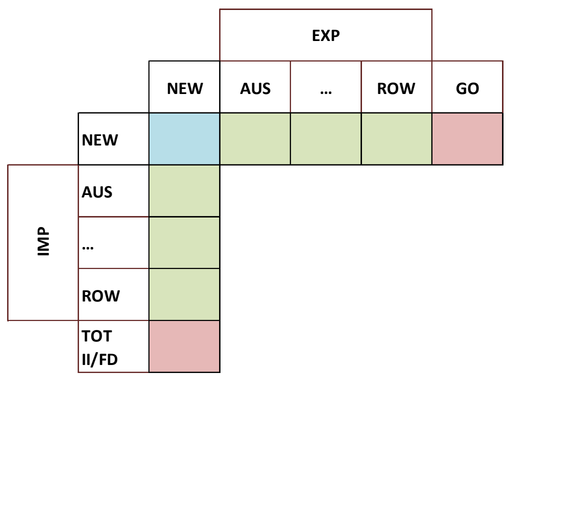
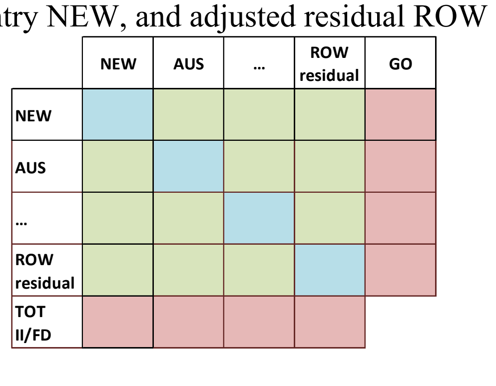


Figure 2E; WIOTs 2016

Figure 2F; 2016 WIOT expanded with country NEW, and adjusted residual ROW



II.B.1 UN COMTRADE

We use the UN COMTRADE database since it is the most comprehensive data source available on detailed commodity trade statistics. It provides the values of trade for each commodity, as well as country of origin and destination. For each year in our sample we downloaded the raw commodity-trade data in the HS-classification as reported by the UN.[25] We then map the trade data in each year to the ISIC Revision 4 industry classification (ISIC4), closely matching the industry detail in the 2016 WIOD.[26] We also map the individual commodities to a Broad Economic Classification (BEC),[27] which tells us what proportion of imports and exports are used as intermediate inputs, FD, and GCF, i.e. the end-use shares.

We take these aggregated levels of trade from the COMTRADE data and use this in our estimation of the NIOTs. Generally the values of trade derived in this way should match the values given in the national accounts, although some definitional issues and reporting conventions may lead to discrepancies. We discuss the cases where the levels of trade differ substantially from the national accounts in the country-specific sources.

Additionally COMTRADE also provides statistics on services trade. However, this information lacks the same level of detail as available for the trade in commodities – data on the trading partner or end use category is not provided. The volume of services trade tends to be relatively small for the countries we are adding, typically less than 10 percent of GDP. Therefore, we assume that the trading partner for services trade is always the ROW and the end-use category is always final consumption.[28] We download the services trade data from COMTRADE for 10 broad EBOPS categories which are mapped to ISIC4 industries.

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[25] https://comtrade.un.org/

[26] Mapping the data to HS3 is not straightforward, since the mapping tables contain many-to-many product relations between HS classifications. This problem is most problematic for earlier classifications (i.e. HS0-HS2) and can lead to visible breaks in the levels of trade and/or trading partner shares. Instead we use a custom one-to-many concordance for each country to map all commodity trade data to HS3.We base this mapping on country specific Export/Import shares taken from years where raw data is listed in HS3. Having mapped the commodity trade statistics to HS3 and subsequently to CPA08 and ISIC Rev. 4, we can aggregate the trade data up to the final industry level in table 2. Sources: UN Harmonized Commodity Description and Coding Systems, HS0 (1992) HS1 (1996), HS2 (2002), HS3 (2007), HS4 (2012) - https://unstats.un.org/unsd/trade/classifications/correspondence-tables.asp ; Statistical Classification of Products by Activity in the European Economic Community, 2008 (CPA08) - http://ec.europa.eu/eurostat/ramon/relations/index.cfm?TargetUrl=LST_REL.

[27] Mapping tables for HS to BEC: https://unstats.un.org/unsd/trade/classifications/correspondence-tables.asp

[28] Note that due to redistributions of the services trade values (see the discussion in section II.B.4), the results can deviate from this assumption. This occurs in cases where trade values exceed the reported total consumption in the NIOTs or the ROW block. The only sizeable redistribution occurs for Ethiopia in the transport and trade sector (HnJ61), for all years.

COMTRADE also provides information on re-exports and re-imports, which need to be excluded from the trade data in order to avoid double counting of trade in the WIOTs.[29] Particularly Re-exports can be large for transit countries; e.g. 50 percent of commodity exports for Senegal in 2006. Re-Imports are generally small (less than 1 percent). As discussed in the country-specific source, typically these values are available for a limited number of years. In these cases, the ratio of Re-Exports to Exports is interpolated for missing years at the default commodity level (HS3).[30]
Since re-exports affect both imports and exports of a country, we calculate the net trade flows by deducting re-exports from both exports and imports. When calculating the net flows of ISIC4 industry imports and exports from the COMTRADE data, inconsistencies can still arise with the data on domestic output from an industry When gross output turns out to be smaller than the net flow of exports for the industry, domestically produced output is insufficient to provide the reported net flow of exports, which suggests that some of the remaining exports must be sourced from imports. Therefore, in those cases, we set net exports equal to gross output and reduce net import by the same amount. That is, we also obtain re-exports in these cases.

II.B.2 Imports

The interior matrix of the NIOTs, structured as outlined in figure 1 and figure 2A, reports products consumed for intermediate use (II), final demand (FD), and gross capital formation (GCF), that are produced both domestically and abroad. We estimate the import matrix to separate imported products from domestically produced products for each individual column, i.e. use category. The Import column in the NIOTs show how much of the total of II, FD, and GCF is sourced from imports for each row. In order to split the total row-value of imports by II, FD and GCF, we use end-use shares derived from COMTRADE. For the commodity trade statistics in HS3 we use a mapping table to classify each commodity by end-use, based on the Broad Economic Classification (BEC). Aggregated to the ISIC4 industry level this gives the end-use shares of II, FD, and GCF in total imports for each supplying industry. Within the three end-use categories, we split imports further by taking the shares from the NIOTs, thus assuming that imported and domestically produced products are consumed in the same proportion. This gives us the import matrices indicated by the green 'imported supply' squares, as well as the domestic use block, indicated by the blue squares in figure 2B.

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[29] COMTRADE defines these terms as follows: "Re-exports are exports of foreign goods in the same state as previously imported; they are to be included in the country exports", whereas "Re-imports are goods imported in the same state as previously exported. They are included in the country imports. The exported good might be defective, the importer might have defaulted on payments or cancelled the order." https://unstats.un.org/unsd/tradekb/Knowledgebase/Reexports-and-Reimports

[30] In case there is no commodity match, we apply the ratio of the aggregate ISIC4 industry to which the commodity belongs. The implicit assumption is that Re-exports/imports are concentrated in specific products, or if unmatched, specific industries. Note that this procedure could result in a bias when moving away from the reference year, as the trade composition changes. Alternative interpolation methods show that the results tend to be quite robust, however.

Having obtained the import matrices the next step is to split the import values by bilateral trading partner. For each combination of end-use category and trading partner, we aggregate the commodity import values up to the ISIC4 industry level. This gives us the bilateral import shares for each supplying industry by end-use category. The values for re-exports are excluded from this aggregation since we are interested in the trade structure of the net flows. We then split the import matrix by trading partner by applying the bilateral trade shares uniformly within the end-use categories. Thus we end up with the expanded bilateral import matrix in Figure 2C.

II.B.3 Exports

Exported products are supplied by the domestic industries in the NIOTs. Since the NIOTs only provide the aggregate (net) value of exports by supplying industry, we need to obtain information on where exported products end up being consumed and how they are used. The procedure for estimating the export-matrix is similar to that of splitting the imports, but works in reverse and partially relies on information that is already available from the WIOTs. This is because the imports of WIOD-countries are already known in the WIOTs and should remain unaltered. Therefore, we start by determining the bilateral trade shares of total exports for each industry, based on the COMTRADE commodity trade statistics. Subsequently we determine the end-use shares for each trading partner, based on the BEC information from COMTRADE. The within end-use category shares are taken from the bilateral trading partners' distribution of imports from the ROW. Applying these shares to the industry-export totals from the NIOTs gives us the expanded bilateral export-matrices, indicated by the green squares on the first row in figure 2D.

II.B.4 Integration into WIOTs

The rows and columns of the fully expanded NIOT are added to the WIOT as indicated in figure 2F. The values of the NIOT are deducted from the pre-existing ROW-block in the WIOT in order to preserve the row and column totals.

The procedure as outlined above relies on three different kinds of data: data from the NIOT, data from the WIOT, and trade data from COMTRADE. It is inevitable that sometimes these sources are inconsistent which can cause tables that are unbalanced or contain negative values for trade. Therefore, we have to impose constraints on the data and/or apply re-balancing procedures whenever these inconsistencies arise. Fortunately, these discrepancies are typically small in value and this rebalancing does not affect the main structures of production, trade and use.

For each industry and end-use category, the sum of imports can never be greater than total use. Applying the COMTRADE end-use shares can result in values of trade that are larger than total use for any end-use category. In these cases, we redistribute trade over the end-use categories.
At the most detailed level, estimated trade values for the newly added countries can also turn out to be larger than the pre-existing trade values in the ROW-block. Since deducting these values would result in negative values in the residual ROW trade block, we apply a top-down

redistribution technique to redistribute trade between end-use categories, industries and trading partners.[31] Overall, we aim to stay as close as possible to the original trade shares in both COMTRADE and the industry shares in the NIOTs.

Table 3 shows the correlations between the initial export and import levels versus the redistributed levels for goods.[32] The adjustments to exports were minor, the linear correlation always exceeds 0.98 and the rank-order correlation approach unity for all countries. Redistribution of imports required more effort, primarily because import values could not exceed the values in the ROW-block (same as for exports) nor exceed the total use in the original NIOTs. Regardless, correlations never drop below 0.90, showing that our assumed structure of trade closely mirrors the flows from COMTRADE.

Table 3 correlations, initial vs redistributed exports and imports of goods

Country	Export Pearson	Export Spearman	Import Pearson	Import Spearman
Bangladesh	1.00	1.00	0.97	0.98
Ethiopia	1.00	1.00	0.93	0.98
Kenya	1.00	1.00	0.92	0.98
Malaysia	0.98	1.00	0.95	0.98
Senegal	1.00	1.00	0.99	0.99
Vietnam	0.98	1.00	0.92	0.97
South Africa	0.99	1.00	0.95	0.99

II.B.5 Data issues

Apart from the data inconsistencies already mentioned, we have observed anomalies in the COMTRADE data for several countries, when comparing the aggregate levels derived from COMTRADE to data from the National Accounts (NA). We address these issues in the country specific sources. Broadly speaking these issues range from missing trade data, to having excess trade for certain periods. Whenever this occurs we dive deeper into the trade statistics, by also checking the mirror flows from the country's trading partners, which allows us to spot the sources

[31] The order is dependent on the trade flow; for imports we first adjust the end-use shares, then the industry shares, and then the trading partner shares. For exports the order is first trading partner shares, then the end-use share and last the industry share. This top-down procedure requires the least adjustments to the trade shares.

[32] Note that we excluded services from this comparison. COMTRADE does not have information on the country of origin/destination or end-use category for imports and exports of services, making a direct comparison between the initial and our redistributed levels impossible.

of these inconsistencies. In a few cases, we use the mirror flows from COMTRADE to replace the disputed data, which is detailed in the country-specific sources (section IV).

Trade data is sometimes missing from COMTRADE for certain years. In these cases we interpolate the data at the HS commodity level. The interpolations are normalized to match the growth of the aggregate trade flows from the UN OCD. For some exports/imports there is no commodity class defined, in which case these values are redistributed at the commodity level, based on the product shares by trading partner. In cases where no trading partner is defined, the trading partner for the commodity is assumed to be ROW.

III. Employment accounts

We also construct employment accounts for the calculation of the employment content in production. This requires employment accounts that are consistent with the value added and output series. For example, meaningful labour productivity measures can only be calculated when the data coverage of output and employment input are similar, that is, they refer to the same set of firms.

To assure consistency with the value-added and output accounts, we base it on the same sources. For detailed manufacturing industries, we thus also rely on UNIDO's Indstat such that data from the same set of formal firms is used for all variables. Importantly, we use the same vintages of UNIDO's Indstat (2018) and extrapolate using the same vintages to assure internal consistency with the value added and output accounts. Aiming for data from the same industrial censuses and surveys such that the same establishments are covered assures highest possible internal consistency.

For broad sectors, we use the 10-Sector Database as the benchmark source for employment accounts, as we did for value added. These data are typically built up from population censuses at benchmark years and extrapolated using labor force surveys, and aggregated to ISIC Rev.3 as for value added. This assures consistency across variables and across countries as far as possible. A major task for this study was to update and revise the existing employment accounts of the 10-Sector database with additional, more recent information. The original 10SD was constructed in 2013. Whenever possible, we introduce a new (more recent) benchmark year and add new labor force surveys to extrapolate from the benchmark years onwards. These additional sources are highly country-specific, which we therefore describe in more detail below.[33]

Furthermore, Bangladesh and Vietnam are not included in the original 10-Sector Database and we therefore construct new employment accounts for broad sectors of these countries for the purpose of this study. We do so following the same methodology as in the 10-Sector Database, as we describe in detail below.

[33] We also deviate to some extent on a productivity-trend assumption in extrapolating, as compared to the GGDC 10SD.

IV. Country-specific sources and approaches

Table 4 provides a general overview of the datasources used for each country.

Table 4 Overview of main sources

Country	Input-output table	Value added and output	Trade	Employment
BGD	2011 (ADB/NSO)	UN OCD; UNIDO Indstat	Comtrade; adjustment for THA-BGD flows	LFS (NSO); UNIDO Indstat
ETH	2006 (IFPRI/EDRI)	GGDC 10-Sector Database; UN OCD; UNIDO Indstat	Comtrade; large re-exports in 2013 & 2014	LFS (NSO); UNIDO Indstat
KEN	2003 and 2013 (IFPRI/KIPPRA)	GGDC 10-Sector Database; UN OCD; UNIDO Indstat	Comtrade	LFS & Establishment surveys (NSO); UNIDO Indstat
MYS	2010 (ADB/NSO)	GGDC 10-Sector Database; UN OCD; UNIDO Indstat	Comtrade	LFS (NSO); UNIDO Indstat
SEN	2005 (UN DESA)	GGDC 10-Sector Database; UN OCD; UNIDO Indstat	Comtrade; large adjustment for re-exports	ESPS-I & ESPS-II (LFS/NSO); UNIDO Indstat
VNM	2012 (ADB/NSO)	UN OCD; UNIDO Indstat	Comtrade	Population census & LFS (NSO); UNIDO Indstat
ZAF	2013 (NSO)	GGDC 10-Sector Database; UN OCD; UNIDO Indstat	Comtrade; missing commodities before 2011	Population census & LFS (NSO); UNIDO Indstat

Note: NSO refers to national statistical office; IFPRI is International Food Policy Research Institute; ADB is Asian Development Bank; UN DESA is United Nations Department of Economic and Social Affairs; KIPRA is Kenya Institute of Public Research; Ethiopian Development Research Institute; LFS is labor force survey;

IV.A. Bangladesh

NIOT

For Bangladesh, we obtain one official set of supply and use tables for the year 2011 (ADB, 2018b). The tables provide information on 74 commodities and 51 sectors, and on all relevant consumption and capital formation categories. Importantly, they also provide information on trade and transport margins and on taxes and subsidies on products. This allows us to estimate the use table in basic prices (as opposed to keeping it in purchasers' prices). We calculate the margins rate and the tax rate by products and assume the same rate across all use categories. Subsequently, we estimate the industry x industry input-output table using 'Model D' (Eurostat, 2008), applying the 'fixed product sales assumption'. This is also the standard procedure in the WIOD in constructing input-output tables from supply and use tables. We thus obtain the 51x51 table, which we map to our industries, as shown in appendix A1.

Time series of value added and output

Bangladesh is not included in the 10SD, and we therefore construct the entire time series of VA and GO. We obtain value added by broad sectors in ISIC Rev.3 from UN OCD, which we map to ISIC Rev.4 as indicated in table 2. We obtain GO for broad sectors also from UN OCD.

For manufacturing VA and GO, we obtain data from UNIDO's Indstat. Across the different releases, UNIDO provides data for 1998, 2006 and 2011. However, the value added and employment accounts in year 2006 are not consistent. Several industries do not cover the same activities across the two variables. The most extreme example is sector C19 ('Coke and refined petroleum'), which is indicated to only cover refined petroleum in employment (records 22 employees). However, in VA, it does cover everything but processing of nuclear fuel, leading to very high VA per worker. We therefore drop the year 2006, and (linearly) interpolate between 1998 and 2011 for VA and GO in UNIDO's Indstat. The data in ISIC Rev.4 is only available in 2011, so we backdate the data with this trend between 1998 and 2011, obtained from the data in ISIC Rev.3.

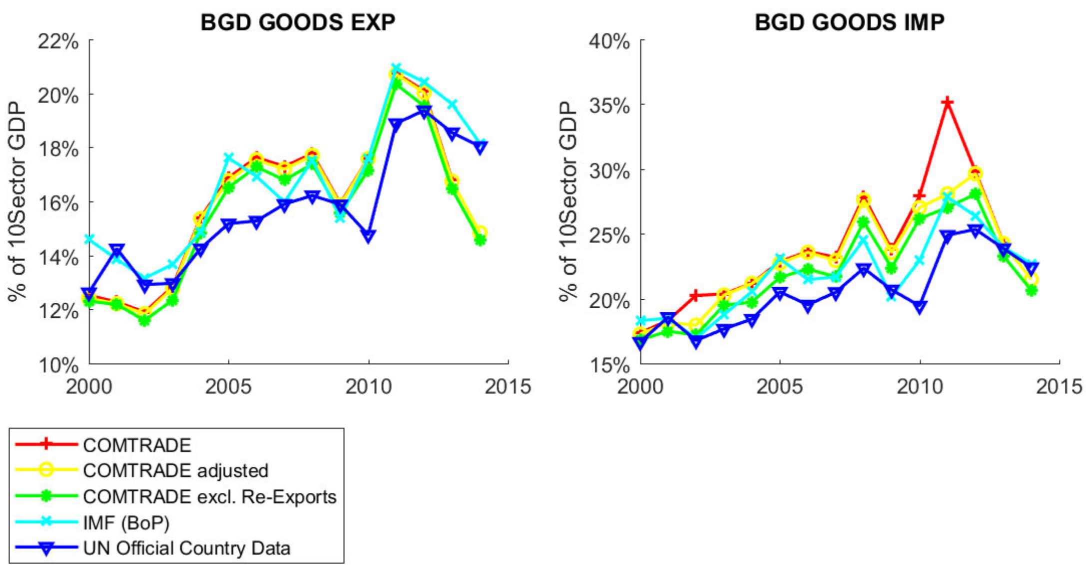
The reported UNIDO data are obtained from the 'Survey of Manufacturing Industries', published by the Bangladesh Bureau of Statistics in 2012. It covers all establishments with 10 or more employees, sampled in a survey. VA and GO are both valued at factor values. The data for 1998 is originally published in the 'Bangladesh Census of Manufacturing Industries', published by the Bangladesh Bureau of Statistics. UNIDO does not provide metadata on the firm size threshold of this publication.VA and GO are also valued at factor values.

Trade data

There is no commodity trade data for 2014 in COMTRADE, and these values have thus been extrapolated. Re-imports are available for 2003, 2004, 2007-2009.

Figure 3 shows the trade flows relative to GDP of Bangladesh in comparison to other sources. It shows the ratio obtained from the raw COMTRADE data, the adjusted COMTRADE data in case we were able to trace anomalies, and the adjusted COMTRADE data excluding re-exports (following the procedure described in section II.B). For comparison, we show data from the IMF Balance of Payments statistics (IMF, 2018) and from UN OCD national account data. Overall, COMTRADE is well in line with the trade flows reported by the IMF and the UN OCD in the case of Bangladesh. However, we observe a considerable spike for imports in 2011, which is not reported in the other sources. We can trace the cause of this discrepancy in COMTRADE to patterns of trade for imports from Thailand. The total trade flow jumps from 0.7 billion USD in 2009, to 9.5 billion USD in 2011. Yet, the mirror flows, i.e., the exports of Thailand to Bangladesh, show a much smoother trend for the entire period. We therefore replace the import flows from Thailand to Bangladesh with the reported exports statistics of Thailand for the entire period. This results in the adjusted COMTRADE flows (as shown in figure 3), which do not show the spike in 2011 and which are overall closer to the alternative sources. Since there is no goods trade data at all for 2014 reported for Bangladesh, we extrapolate using the standard procedure discussed in section II.B (and also do not use any information on Thailand's exports to Bangladesh). Note that we also obtain a small amount of re-exports for the case of Bangladesh even though COMTRADE does not report those because gross exports are sometimes larger than gross output (see section II.B.1).

Figure 3 Trade flows of Bangladesh



Source: Authors' illustration.

Employment

Bangladesh is not included in the 10SD, and we therefore also built up employment accounts for the whole time period. Bangladesh has two population census round in the relevant time period, but these are subject to considerable mismeasurement. The census in 2001 records only a population of 124 million (later adjusted to 128 million) and persons engaged as about 35 million, with another 30 million in household work (not assigned to any economic sector). Yet, the PWT (Feenstra et al., 2015) estimates for the same year a population of 134 million and persons engaged as 41 million. A similar problem seems to exist in the 2011 census, reporting a population of 144 million and persons engaged as 43 million, while the PWT reports 153 million and 53 million respectively (which is in line with other sources).[34] Moreover, Bangladesh's labor force surveys (published by the NSO and ADB) suggest the number of persons engaged to be much closer to the PWT and other sources than to the census rounds. For example, the total number of persons engaged according to the LFS in 2013 is 58.1 million and 57.8 million in the PWT; it is 39.0 million in the LFS in 2000, and also 39.0 million in the PWT. We therefore decide not to include the census rounds as benchmark levels when constructing the employment accounts. Instead, we rely on LFS for 2000, 2003, 2006, 2010 and 2013 obtained from the ADB Facts and Figures (ADB, 2018a). These provide employment by 9 to 12 broad sectors. Sector OtQ and RtT, however, are reported as one sector and we therefore split it with the nearest split for these sectors from the LFS that we additionally obtained from the NSO for 2003 and 2006. We interpolate between these five benchmark years with the average productivity trend normalized to the economy-wide productivity trend as calculated from the PWT.

For detailed manufacturing, we rely on UNIDO's Indstat. Similarly to the VA and GO series, we use ISIC Rev.4 data for 2011 and backdate using the ISIC Rev.3 series based on (linear) interpolation between 1998 and 2011. Similar to the VA and GO data, the data in 2011 come from the 'Survey of Manufacturing Industries' covering establishments with 10 or more employees. For 1998, no information is given on the firm size threshold. In 1998, the number of employees includes workers paid through labor contractors.

III.B. Ethiopia

NIOT

We construct one benchmark input-output tables from a social accounting matrix (SAM) of the year 2005. The 2005 SAM is obtained from the Ethiopian Development Research Institute (EDRI, 2009), constructed in collaboration with the Institute of Development Studies at the University of Sussex and contributors from IFPRI. The SAM has detail on 48 activities and 69 commodities, on all relevant consumption and capital formation categories, and importantly on taxes and subsidies, and trade and transport margins. The latter allows us to obtain the use table in basic prices. We calculate the margins rate and the tax rate by products and assume the same rate across all use categories. Subsequently, we estimate the industry x industry input-output table using 'Model D' (Eurostat, 2008), applying the 'fixed product sales assumption'. We obtain an input-output table of 48 x 48 industries. As this provides a more aggregate sectoral classification than in our external data for some manufacturing industries, we need to split some industries. We do so proportionally

[34] The World Bank reports a population of 134 million in 2001, and a population of 154 million in 2011.

by gross output shares within the more aggregate categories, which we have obtained from the external data. EDRI (2009) provides a mapping to ISIC Rev.3.1, which we map to our ISIC Rev.4 as indicated in table 2. Appendix table A2 shows this mapping.

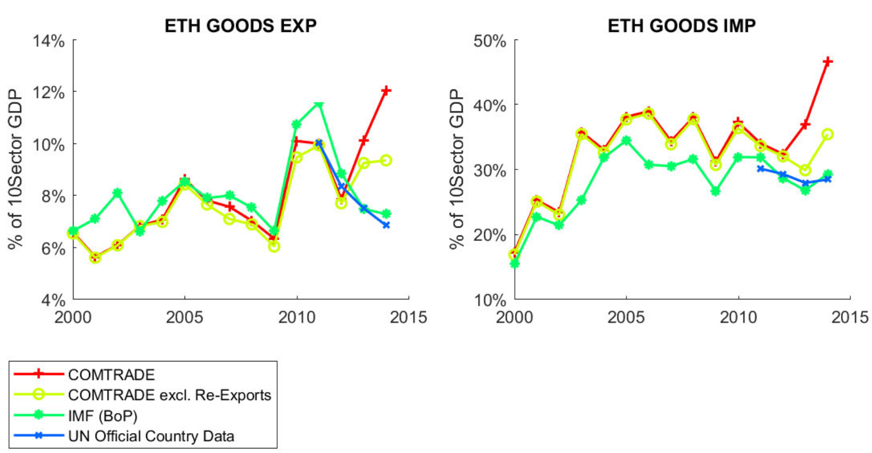
Time series of value added and output

Ethiopia is part of the GGDC 10SD, so we use these VA data as the benchmark series for broad sectors from 2000 to 2011. We obtain the VA series for 2012 to 2014 by extrapolation using the trend in UN OCD. As there is no information on GO in the national account data available from UN OCD or UN EMA, we construct the series of GO for broad sectors using the GO-VA ratios from the benchmark input-output table. For detailed manufacturing industries, we obtain series of VA and GO from UNIDO's Indstat in ISIC Rev.3 for the whole time period. The series in ISIC Rev.4 is not available for Ethiopia. The UNIDO data are originally provided in the 'Statistical Abstract', and the 'Annual Survey of Manufacturing Industries', which are both published by the Central Statistical Agency of Ethiopia. For the whole period, the data cover establishments with 10 or more employees. VA and GO are both valued at producer's prices.

Trade data

For Ethiopia the trade data in COMTRADE is complete for 2000-2014. Re-exports are available for 2004-2006, 2008-2010, 2012, and 2014. Re-imports are available for 2009-2014.
Figure 4 shows the comparison of the COMTRADE data with the UN OCD and the IMF. The COMTRADE data is overall on the low side in terms of exports and on the high side in terms of imports, leading to a lower trade balance. Reassuringly, the trend is generally well in line, except for 2013 and 2014. After adjusting for re-exports, we find that they are negligible for most of the period but this brings the COMTRADE statistics much closer to the alternative data sources in 2013 and 2014. Re-exports are most considerable in industry C19 (oil and refined petroleum).

Figure 4 Trade flows of Ethiopia



Employment

Ethiopia is included in the 10SD until 2011. The latest benchmark year in the 10SD is 2007, and is based on the population census for 2007. As the census did not provide information on employment shares by broad sectors, the employment shares had been taken from the 2005 labor force survey in Ethiopia. As the level in the 2005 LFS is close to the level in 2007 and close to the resulting estimate of the 2005 total in the 10SD, we choose to deviate from the 10SD and to use the 2005 LFS as a benchmark level and take the employment levels as reported in the 2005 LFS. As the 10SD applies interpolation methods between benchmark years, this adjustment of the benchmark year implies that also our employment estimates for broad sectors deviate from the 10SD for the years 2000 to 2005. However, given the small differences in the shares and the total level of employment, these differences are small. Ethiopia had another round of the LFS in 2013, which we use as a second benchmark (Central Statistical Agency of Ethiopia, 2014). The total level of employment in the 2013 LFS is well in line with alternative estimates: it is 43.6 million in the PWT, and 42.4 million in the LFS. We interpolate between 2005 and 2013 with the labor productivity trend by broad sectors normalized to the aggregate productivity trend as calculated from the PWT. We further extrapolate the data from 2013 to 2014 using the productivity trend between 2003 and 2013 by broad sector but normalized to the aggregate productivity trend in the PWT.

For manufacturing industries, we obtain the employment data from UNIDO's Indstat. For Ethiopia, employment data is available in ISIC Rev.3, which we readily use (similar to its VA and GO data). The series records employees. For 2000, UNIDO indicates that employees are expressed in full-time equivalents. Part-time workers are converted to full-time equivalents on the basis of the number of months worked. As for VA and GO, the original publication is provided by the Central Statistical Agency of Ethiopia and pertains to establishments with 10 or more employees.

III.C. Kenya

NIOT

We construct two benchmark input-output tables from a SAM of the year 2003 and a SAM of the year 2013. The 2003 SAM was constructed by Kiringai et al. (2006) and was a joint project of the Kenya Institute for Public Policy Research and Analysis (KIPPRA) and the International Food Policy Research Institute (IFPRI). The 2013 SAM was constructed by Randriamamonjy and Thurlow (2016), also under the leadership of IFPRI.

The 2003 SAM provides information on 50 commodities, 50 sectors and industries, and all relevant consumption categories. It also provides information on taxes and on trade margins. The table also distinguishes between household's consumption of (household's own) economic activities and marketed consumption of commodities. All of these household activities take place in agriculture, except one in manufacturing of food and beverages. As we are not interested in distinguishing between marketed and non-marketed production, we aggregate them.

Based thereupon, we build the use and the supply table for obtaining the input-output table. We use the information on taxes and margins to calculate a use table in basic prices. Subsequently, we estimate the industry x industry input-output table based on 'Model D' (see Eurostat, 2008), applying the 'fixed product sales assumption'. This provides an input-output table with 50 sectors and industries. We map these to ISIC Rev.4 based on the mapping provided in table A3. As this provides a more aggregate sectoral classification than in our external data, we need to split some sectors. We do so proportionally by gross output shares within the more aggregate categories, which we have obtained from the external data.

For 2013, we follow the same strategy. The SAM has detail of 56 commodities and 54 activities. It also provides information on taxes and trade margins, and of all relevant consumption categories. We calculate the use table in basic prices, and use 'Model D' to calculate the industry x industry input-output table, and map it to our industry classification (table A4). Randriamamonjy and Thurlow (2016) provide a mapping of the sectors to ISIC Rev.4, which we can thus readily use. We also have to split several sectors by use of output shares.

For Kenya, we have to make an additional adjustment. For industry HnJ61, OtQ, and RtT, there is no use data in the 2003 table (that is, these industries do not use intermediates in the benchmark table). Yet, from the external data, we see that these industries do use intermediates for multiple years. To obtain potential intermediate use for these industries, we calculate the ratio of intermediate use over GO from the 2013 table, multiplied by the 2003 GO. For JtNexJ61, the 2003 table shows no supply to intermediate use but only to final demand. To allow for potential intermediate use, we also use the 2013 ratio of intermediate use to gross output to obtain potential intermediate supply. Moreover, in the benchmark tables, C26 and C30 are grouped in C26tC30. Since GO is zero for these industries, splitting the industry rows and columns using GO shares would result in zeros. However, since there are imports of C26 and C30 in the external input data, we split these rows and columns using import shares.

Time series of value added and output

Kenya is part of the GGDC 10-Sector Database, which we thus use as the benchmark VA series. It is available until 2011. For the years 2012 to 2014, we extrapolate the GGDC series using the trend of the series in UN OCD. We obtain GO for broad sectors using the GO-VA ratios from the UN OCD applied to the obtained VA series. For detailed manufacturing, we use UNIDO's Indstat which provides series of GO and VA. However, UNIDO's Indstat includes an SNA break from 2008 to 2009. We take the ISIC Rev.3 2-digit series for 2000-2008. For this period, aggregate manufacturing exactly matches total manufacturing from the SNA93 UN OCD. In 2009, UNIDO's Indstat ISIC Rev.4 series report differing values than UN OCD, suggesting a break in SNA. We therefore estimate the 2009 value added by manufacturing industries using the 2008 shares applied to the SNA93 UN OCD total. We extrapolate the series until 2014 using UNIDO's Indstat ISIC Rev.4 series for 2010 to 2014.

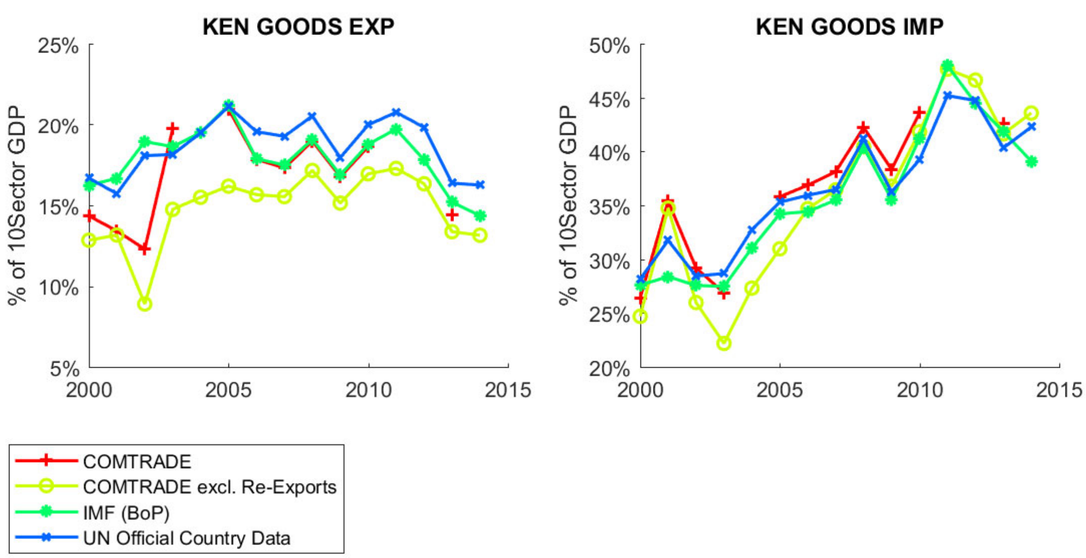
The UNIDO ISIC Rev.3 data is retrieved from the Kenya National Bureau of Statistics and pertains to establishments with 5 or more employees. The data is obtained through sample surveys for VA and GO, both recorded in basic prices. The ISIC Rev.4 series is retrieved from the 'Statistical Abstract' and the 'Economic Survey Report', both are also sample surveys published by the Kenya National Bureau of Statistics. The data pertains to establishments with 5 or more persons engaged. VA and GO are both reported at basic prices.

Trade data

For Kenya, import data is missing for 2004, 2011, 2012, and 2014. For exports commodity trade data is missing for 2011, 2012, and 2014. No services trade is available prior to 2005. Re-exports are available for the years 2008 and 2013. Re-imports are available for 2013. For 2004 there is no bilateral trade data for imports at the country level, only trade totals by commodity are available. Therefore we have interpolated the values for 2004 imports.

Figure 5, which compares Kenya's trade flows to alternative sources, shows that exports and imports tend to be close to the IMF data, and generally in line with UN OCD. At the start of the period from 2000 to 2002, however, the reported exports in COMTRADE are considerably lower and the imports considerably higher. This implies a relatively low trade balance for this period in the COMTRADE data. Yet, the COMTRADE data did not provide clear clues on these discrepancies not allowing for meaningful adjustments. Our adjustments for re-exports range between two and five percent of GDP throughout the period.

Figure 5 Trade flows of Kenya



Source: Authors' illustration.

Employment

Kenya is available in the 10SD. The latest benchmark employment levels come from 2006, and are based on an LFS. The data between 2006 and 2011 is extrapolated using information on multiple surveys. The most recent years are extrapolated with Kenya's establishment survey, which importantly however only covers formal establishments. We continue this extrapolation using the same survey as has been done in the 10SD for the years 2012 to 2014 (Kenya National Bureau of Statistics, 2015).

For detailed manufacturing industries, we use UNIDO's Indstat. However for persons engaged, data are only available from 2009 onwards, in both ISIC Rev.3 and ISIC Rev. 4. For 2000-2008 only the series for employees are available in ISIC Rev.3 (2-digits). Since the VA data was taken from the level of the ISIC Rev.3 data (SNA93), we also use ISIC Rev.3 data for employment. As sectors C21 and C22 are only reported as aggregates, we split this sector using the shares from the ISIC Rev.4 data. Moreover, since there is no overlapping year between 2008 and 2009 in UNIDO (as the classification changes from employees to persons engaged), we use 2008/2009 growth rate of VA to obtain the number of persons engaged in 2008 (i.e. labour productivity growth is zero between 2008 and 2009). The 2000-2007 series are back-casted using the growth of the ISIC Rev.3 series for employees.

The UNIDO ISIC Rev.4 series is obtained through the 'Statistical Abstract' and the 'Economic Survey Report', both published by the Kenya National Bureau of Statistics. The scope refers to all establishments with 5 or more persons engaged, and the number of persons engaged does not include active business partners. In the ISIC Rev.3 series, there is no information on the concept of persons engaged. The data is also retrieved from the Kenya National Bureau of Statistics, and is based on complete enumerations for obtaining the number of persons engaged.

III.D. Malaysia

NIOT

We obtain one set of supply and use tables for 2010 (ADB, 2018b). The tables provide information for 86 sectors and industries and 68 products. From the supply table, we extract information of trade and transport margins and taxes and subsidies, which we use to calculate the use table in basic prices. We use 'Model D' to obtain the industry x industry table with 86 industries and sectors. The industries are classified to the Malaysian Classification of Products by Activity (MCPA) 2009. This classification provides a close match to ISIC Rev.4 (the ISIC code is part of the MCPA code), such that we can readily map to our industry classification (appendix table A5).

Time series of value added and output

Malaysia is part of the GGDC 10SD, which we use as the benchmark series for the period 2000 to 2011. We use the trend in UN OCD to extrapolate the series until 2014. UN OCD and UN EMA do not provide any information on output for broad sectors for Malaysia, and we therefore use information from the benchmark IO table on the GO-VA ratios to obtain GO by broad sectors. We obtain benchmark GO-VA ratios for broad sectors for 2005 and 2010 and interpolate linearly in-between.

For detailed manufacturing industries, we make use of UNIDO's Indstat. It is available in ISIC Rev.4 for the years 2009, 2010, 2012, and 2014 for both VA and GO. The series in ISIC Rev.3 is available for the whole time period. We use ISIC Rev.4 as the benchmark series and interpolate between 2010 and 2012, and between 2012 and 2014 with the trend from ISIC Rev.3. We backdate for years before 2009 with the trend from the series in ISIC Rev.3.

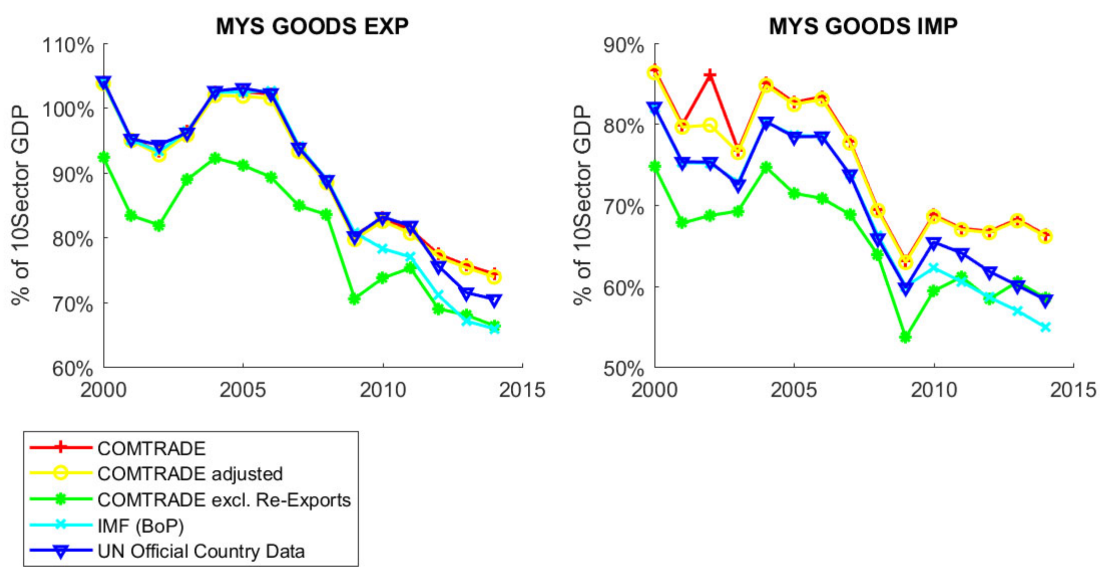
The ISIC Rev.4 series is obtained from the 'Survey of Manufacturing Industries' published by the Department of Statistics of Malaysia in 2014. The scope of the data is all registered establishments, which are fully enumerated in 2010 and biannually sampled. VA and GO are reported at basic prices. The ISIC Rev.3 data also pertains to all registered establishments. For the years before 2009, the data is provided by the Department of Statistics, which completely enumerates all establishments with at least 30 employees and samples the remaining establishments. VA and GO are also reported in basic prices.

Trade data

For Malaysia the trade data in COMTRADE is complete for 2000-2014. Re-imports are available for 2000, 2004, 2005, 2007, 2010-2014.

Figure 6 shows Malaysia's trade flows in comparison to the IMF and UN OCD data. Overall, exports tend to be well in line across the three sources, but imports in COMTRADE tend to be on the high side. This implies a relatively lower trade balance in the COMTRADE data, but the general trend is well in line. In 2002, we find a considerable jump in the COMTRADE imports data, which we trace to implausibly large values from 'Areas, not elsewhere specified'. To adjust for this, we replace this item with import levels for the year 2002. This shifts the import level in 2002 downwards, which is much more in line with the trend in the alternative sources.

Figure 6 Trade flows of Malaysia



Source: Authors' illustration.

Employment

Malaysia is covered in the 10SD and the latest benchmark levels come from the NSO's LFS for the year 2010 and 2011. The data for previous years is backdated with data from LFS for the years 2000 to 2010. We use the data from the 10SD but update the series for the years 2012 to 2014. We obtain the recent LFS from the NSO for the years 2011 to 2014 and extrapolate the series based thereupon for broad sectors (Department of Statistics Malaysia, 2018).

For detailed manufacturing industries, UNIDO's Indstat is available in ISIC Rev.4 for 2009, 2010, 2012, and 2014. The series in ISIC Rev.3 is available for the whole time series. As for VA and GO, we use the levels of the ISIC Rev.4 series and backdate and extrapolate using the Rev.3 series. Similar to the VA and GO data, the ISIC Rev.4 series is obtained from the Department of Statistics, and covers employees of all establishments. The ISIC Rev.3 series also pertains to all establishments and records employees.

III.E. Senegal

NIOT

We construct the initial input-output table from a SAM of the year 2005, obtained from Diagne et al. (2011). Its construction was implemented by the Development Policy and Analysis Division of the United Nations Department of Economic and Social Affairs (DPAD/UN-DESA), in collaboration with the United Nations Development Programme in Senegal.

This SAM provides detail on 49 activities, 53 commodities, all relevant consumption categories, and direct and indirect taxes and subsidies. Based thereupon, we build the supply and use table, which we calculate in basic prices. The SAM does not provide any information on trade and transport margins. Subsequently, we estimate the industry x industry input-output table based on 'Model D' (see Eurostat, 2008), applying the 'fixed product sales assumption'.

This provides an input-output table with 49 sectors and industries. We map these to ISIC Rev.4 based on the mapping provided in table A6. As this provides a more aggregate sectoral classification than of our external data, we need to split some sectors. We do so proportionally by the gross output shares within the more aggregate categories, which we have obtained from the external data.

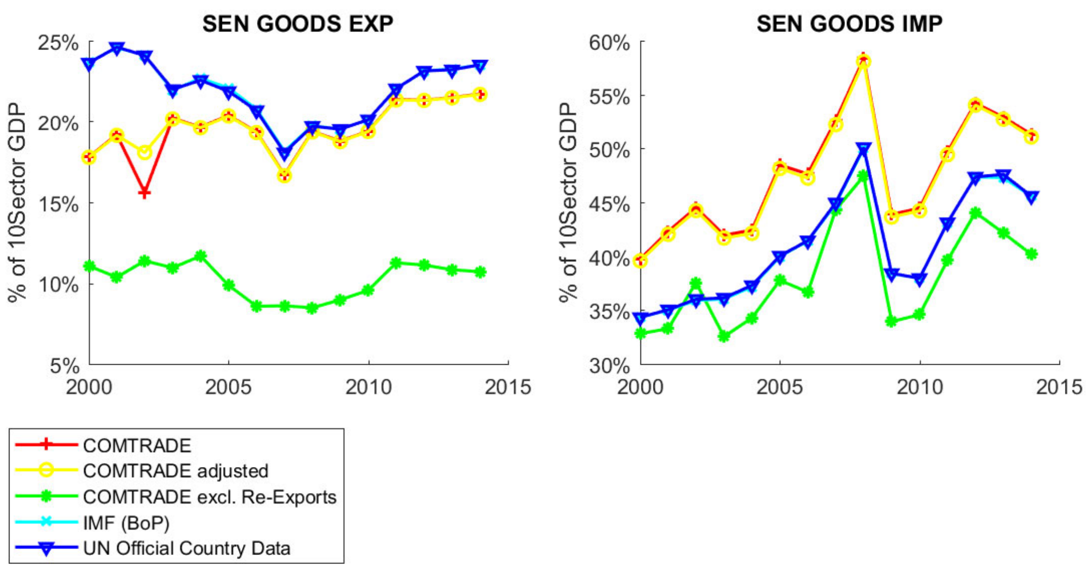
Time series of value added and output

Senegal is included in the 10SD. We use it as the benchmark series of VA from 2000 to 2011. We extrapolate from 2012 to 2014 based on the trend in UN OCD. We obtain GO by use of the GO-VA ratios also obtained from UN OCD, applied to the series of VA. For detailed manufacturing industries, UNIDO's Indstat is only available in ISIC Rev.3 for employees and we therefore also only use the series in ISIC Rev.3 for VA and GO for the whole time period. The original data is provided by the Direction de la Prevision et de la Statistique and the Agence National de la Statistique et de la Demographie, and is retrieved from annual reports on financial and accounting activities, and annual surveys and administrative source. It pertains to all (formal) establishments and VA and GO are valued at producer's prices.

Trade data

For Senegal the trade data in COMTRADE is complete for 2000-2014. Re-exports are available for 2006. Figure 7 shows Senegal's trade flows across the three sources. Overall, the levels show clear discrepancies across COMTRADE, IMF and UN OCD. Clearly, it is not possible to trace the source of the large level difference. Yet, we find a considerable drop in Senegal's exports for 2002. Exploring the COMTRADE data reveals that exports of commodities 30379 and 30613, frozen fish and shrimps show sizable exports in all years, except for 2002. These products account for more than 10 percent of total goods trade, and are also heavily re-exported. To solve this issues we copied the detailed commodity export values from 2001 to 2002. Figure 7 shows the effect of this adjustment for total exports, repairing this break.
Despite the sizeable discrepancy to the alternative sources, COMTRADE has the major advantage to allow for an adjustment for re-exports. Figure 7 shows that this adjustment considerably affects the level of total exports and imports. Re-exports constitute of more than 40 percent of total exports for Senegal at the start of the series, growing to over 50 percent of total exports in 2014. Importantly, we want to omit those re-exports in the analysis as no value is added to these..

Figure 7 Trade flows of Senegal



Source: Authors' illustration.

Employment

Senegal is included in the 10SD. Senegal has several rounds of population censuses but they generally provide little detail on employment by economic activity. Therefore, the 10SD based the latest benchmark year of 2005 on the Enquete de Suivi de la Pauvreté au Sénégal (ESPS) obtained from the NSO. We obtain the second round of the ESPS for 2011 to update the employment accounts in recent years (ANSD, 2013). The ESPS provides data on 18 broad sectors, which can mostly be readily mapped to our classification. One services sector ('Autres branches marchands') however consists of services activities that could be mapped to multiple services sectors. As has been done in the 10SD, we split this sector by shares obtained from the population census in 1988. However, this sector only makes up of 0.04 percent of total employment in 2011, and therefore will not affect our results. We interpolate between the ESPS of 2005 and of 2011 using the labor productivity trend by broad sectors normalized to the aggregate labor productivity trend in the PWT. For the years 2012 to 2014, we extrapolate using the labor productivity trend by broad sectors between 2001 and 2011, normalized to the aggregate labor productivity trend in the PWT.

For detailed manufacturing industries, UNIDO's Indstat is only available in ISIC Rev.3 but for the whole period. Similar to the series of VA and GO, the series pertains to employees of all establishments and is obtained through reports of financial and accounting activities and administrative sources, published by the Agence National de la Statistique et de la Demographie.

III.F. South Africa

NIOT

We obtain an industry x industry input-output table for the year 2013 from the NSO (Statistics South Africa, 2018). The table provides information for 50 industries. These industries are classified in Standard Industrial Classification of all Economic Activities 5th edition (SIC). We map these to SIC7, which provides a close match ISIC Rev.4 up to 3-digits, which thus allows for a close mapping to our classification (shown in appendix table A7).

Time series of value added and output

South Africa is part of the GGDC 10SD, which we thus use as the benchmark series of VA until 2011. We extrapolate the VA series until 2014 using UN OCD. We obtain the GO-VA ratios from UN OCD and obtain the GO series for broad sectors. UNIDO's Indstat is only available in ISIC Rev.3 2-digits. These series of VA and GO are available for the whole period but only provide aggregate numbers for ISIC Rev.4 sectors C21 and C22. We split C21tC22 using export shares. The UNIDO data is retrieved from the 'Quarterly Employment Statistics' published by Statistics South Africa. For VA and GO, the data pertains to all privately owned establishments, based on sample surveys. VA and GO are reported in basic prices. After 2011, the data is retrieved from 'Manufacturing Production and Sales', which is a survey on the manufacturing sector, also published by Statistics South Africa. The UNIDO metadata does not report the scope of this survey however.

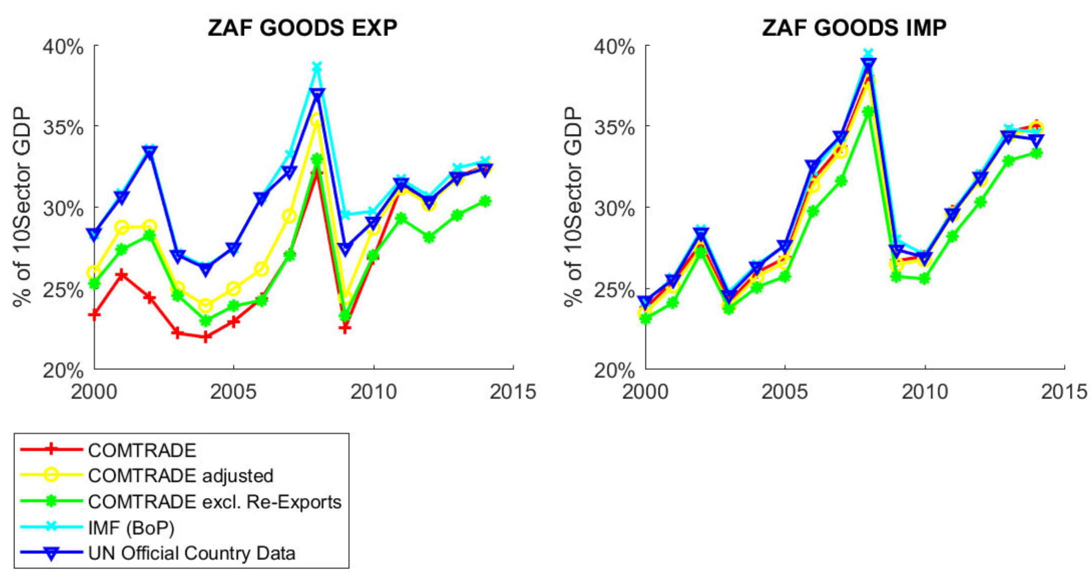
Trade data

For South Africa the trade data in COMTRADE is complete for 2000-2014. Re-imports are available for 2002, 2003, 2006, 2008, and 2010-2014.

Figure 8 shows the comparison of the trade flows to the IMF and UN OCD. It shows that all sources line up very well for 2011 to 2014. Before 2011, the COMTRADE export flows show a considerably lower level. Closely inspecting the COMTRADE data, we find that no exports are recorded in the following commodity codes before 2011: 710811, 710812, and 710813. These are products of gold which are mapped to basic metals (C24). This is a substantial part of South Africa's exports, and omitting these commodities would yield a drop in the trade balance by as much as 10% of GDP (in 2011). These commodities are thus likely to partly explain the discrepancy.

Therefore we have downloaded the mirror flows from South Africa's trading partners that import these commodities, and added these values to South African exports. For the period 2011-2014 South Africa does report exports for these commodities, but appears to be exporting to very few non-WIOD countries (countries not included in the WIOD database). The mirror flows for this period show a very different structure in the partners of trade for these exports, with a much larger share going to WIOD countries. Therefore we apply the trade structure from the mirror flows to the reported export totals. This has the added advantage that there is no break in the partner distribution over the whole period. Adding back the gold products to the exports of South Africa raises total exports by 2.5 percent of GDP on average for 2000-2011. It thus helps to diminish the discrepancy but COMTRADE exports are still lower than in UN OCD and IMF.

Figure 8 Trade flows of South Africa



Source: Authors' illustration.

Employment

South Africa is included in the 10SD. The latest benchmark levels come from (averaged) quarterly LFS for the years 2008 to 2011. Years before 2008 are backdated using LFS. We update the series from 2012 to 2014 by extrapolation using recent quarterly LFS and thus the same source as in the 10SD (Statistics South Africa, 2018).

As for VA and GO, UNIDO's Indstat is only available in ISIC Rev.3, 2-digits. This series records employees, and is available for the whole period. However, ISIC Rev.4 sectors C20 and C21 are aggregated into one sector. As for VA and GO, we split these sectors using export shares. Similar to VA and GO, this series is retrieved from Statistics South Africa. Yet, importantly, the employment accounts pertain to all establishments and not only privately-owned units, as for VA and GO for all years before 2011. After 2011, the UNIDO metadata does not report the scope of the variables anymore.

III.G. Vietnam

NIOT

We obtain a set of benchmark supply and use tables for 2012 with 164 industries and sectors and 164 commodities (ADB, 2018b). Using the information on trade and transport margins and on taxes and subsidies, we obtain the use table in basic prices. Based thereupon, we obtain the 164 x 164 industry x industry input-output table using 'Model D'. We map these 164 sectors and industries to our classification, as shown in table A8 in the appendix.

Time series of value added and output

Vietnam is not part of the GGDC 10SD. We therefore built up the series of VA from national account data. We use UN OCD for VA, which is readily available until 2012. For 2013 and 2014, we extrapolate the series from UN OCD using UN EMA. UN OCD and UN EMA do not provide any information on GO. We therefore use the GO-VA ratios from the benchmark table in 2011 to obtain GO for broad sectors.

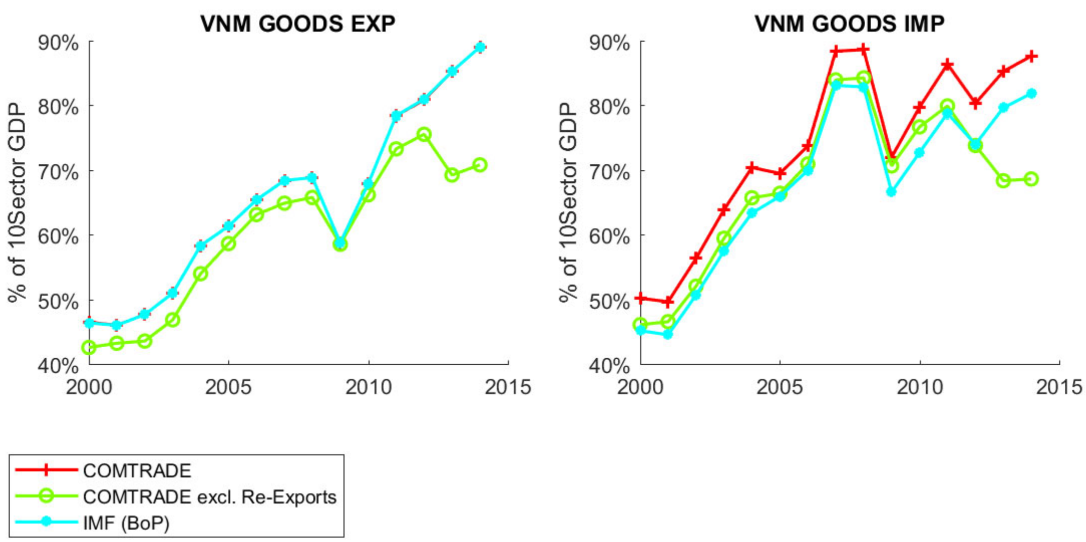
For detailed manufacturing industries, VA is available from UNIDO's Indstat in ISIC Rev.4 from 2006 to 2012, and ISIC Rev.3 in 2-digits is available for the whole period. We use ISIC Rev.4 as the benchmark series and extrapolate using the trend in ISIC Rev.3. For GO, the ISIC Rev.4 series is available for 2005 to 2012, and ISIC Rev.3 is available for the whole time period. We thus also extrapolate the ISIC Rev.4 series using the ISIC Rev.3 series. The UNIDO ISIC Rev.4 series is retrieved from the 'Statistical Yearbook of Viet Nam', published by the General Statistics Office of Viet Nam. It pertains to all registered enterprises. VA and GO are reported at producer's prices. Also the ISIC Rev.3 series pertains to all registered enterprises and is obtained through the statistical yearbook. Yet, in 2000, the data only pertain to all enterprises with 5 or more employees.

Trade data

For Vietnam the trade data in COMTRADE is complete for 2000-2014. No re-export/imports are available from COMTRADE.

Figure 9 shows the COMTRADE flows for goods trade compared to the IMF data (UN OCD does not report goods trade flows of Vietnam). These sources almost fully overlap. However, residual re-exports (i.e. re-exports not given in COMTRADE) reduce the levels of goods trade by about 4 percent of GDP. A marked increase in re-exports can be observed from 2010 onwards. This is due to a steep increase in the exports of C13tC15 (Manufacture of textiles, wearing apparel and leather products) from 19 billion US dollars in 2010 to 38 billion in 2014. The same is happening for C26 (Manufacture of computer, electronic and optical products) with exports growing from 6 billion US dollars in 2010 to 39 billion in 2014. Gross output is growing at about half the rate of exports, which results in exports having to be sourced from imports.

Figure 9 Trade flows of Vietnam



Source: Authors' illustration.

Employment

Vietnam is not included in the 10SD, and we therefore also built up the employment series for the whole period. Vietnam had a population census in 1999 and in 2009. Both reported total levels of employment are well in line with alternative estimates. In 2009 for example, the PWT reports 47.4 million persons engaged and the census reports 47.7 million. We can map the reported sectors readily to our classification in table 2. Moreover, we obtain LFS data from NSO for the years 2005, and 2007 to 2014 (General Statistics Office of Vietnam, 2018). In the census year 2009, the LFS is well in line with the census data (also 47.7 million). Hence, we use the census 1999 and the census 2009 as benchmark levels. We extrapolate from 2009 to 2014 using the NSO LFS. We further backdate the 2009 census using the NSO LFS until 2005 (we linearly interpolate in 2006). Between 1999 and 2005, we interpolate using the labor productivity trend by broad sectors normalized to the economy-wide trend as calculated from the PWT.

For detailed manufacturing industries, UNIDO's Indstat is available in ISIC Rev.4 from 2006 onwards. For earlier years, ISIC Rev.3 is available. As for VA and GO, we use ISIC Rev.4 and backdate using the Rev.3 series. The employment figures are originally published in the 'Statistical Yearbook of Viet Nam', published by the General Statistics Office of Viet Nam. The number of workers pertains to employees including home workers. The ISIC Rev.3 series does not explicitly indicate whether home workers are included. As for VA and GO, this series is also retrieved from the statistical yearbook, but pertains to establishments with 5 or more employees in 2000.

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