# Germs, Globalization, and Trade Spillovers: How could COVID-19 affect African Economies and AfCFTA

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***Research in progress—Draft version, please do not quote.***

*"Africans are leaving their fields, but not flowing into factories"—(p. 62) in The Economist April 19th, 2017.*

## Abstract

*Drawing on selective stylized facts, the paper evaluates the growth-effects for African countries and the disruptive potentials resulting from the COVD-19 pandemic, as African countries are involved in intra-regional integration processes. As AfCFTA involving 55 countries (ratified by 22 countries) is an ambitious project for industrialization for achieving SDG targets of inclusive development via trade facilitation, and regional integration, the paper argues that given the Covid-19 setback full potential depends on trade-led spillover benefits and structural factors. Our objective is to show that: given the low labor-productivity growth in the African nations—without reinventing the wheel by estimating the impact of preferential access trade agreement--the ricochet effect of the trade-induced productivity benefits via intermediates in the presence of COVID-19-led trade disruptions is crucial. The study highlights the role of trade-growth-structural factors for providing basis to simulate scenarios of technology-imports contents in a global non-linear CGE model, viz., Global Trade Analysis Project (GTAP) with 27 sectors and 51 regions. The paper shows: (i) role of trade-mediated productivity benefits for facilitating regional supply chain, (ii) factors underlying absorption of such benefits for economic transformation; (iii) how trade and technology could boost trade not just trade-liberalization per se; (iv) given the region's weaker production basis, in the presence of Covid-19, how the risks posed by trade plus non-trade external shocks to African intra-regional integration matter. Findings also indicate that technological benefits due to trade liberalization under FTA may be hindered by non-trade factors like epidemic or pandemic resulting in skill deficiencies, and translating into productivity slowdown. The paper empirically shows that for realizing the enormous potential of AfCFTA as driver of industrialization deep policy reforms in the areas of technology, absorptive capacity, institutions, and infra- and info-structure for digitization are necessary for long-term development. Also, the result proves that: for effectiveness of AfCFTA to deliver benefits to poor countries via allocative efficiency and welfare, apart from improving the 'behind-the-border' factors, trade with not only emerging economies like China, but also with industrialized nations is important. Also, the research shows the necessity of formulating policies to develop targeted sectors for reaping substantial benefits via AfCFTA. Thus, AfCFTA is not a panacea for industrial development.*

***JEL Codes: O24, I15, R13, D58***

[1] Corresponding author: dasgouranga@gmail.com The first author acknowledges extremely helpful discussions wiith Professors Alan Powell, Peter Dixon, Imed Drine, S. Paul, Sohom D, M. Horridge, David Tarr, S. Marjit, and Mia Mikic.

## 1. Background Motivation

*African* Continental *Free Trade Agreement* (AfCFTA) entered into force in 2019. This will affect international trade flows, patterns, directions, and composition in African countries. The African Continental Free Trade Area (AfCFTA) represents a major opportunity for countries to boost growth, reduce poverty, and broaden economic inclusion. If implemented fully, the trade pact could boost regional income by 7% or $450 billion, speed up wage growth for women, and lift 30 million people out of extreme poverty by 2035 (World Bank, 2020). The AfCFTA covers an area worth over US$3 trillion in GDP and eliminates tariffs on 90 percent of goods traded across the continent. Over 1.3 billion (across 55 countries) African consumers will be impacted by the agreement. *However, the report (World Bank 2020) highlights that: "Governments will need to design policies to increase the readiness of their workforces to take advantage of new opportunities."* Likely success of AfCFTA depends on expanding non-commodity trade flows, especially manufactured ones. Production of the latter in Africa has increasingly been dependent on imported technology from China (via trade in intermediates, or, parts and components—Das and Han 2013, WDR (World Bank 2020)[2]).

Although intra-African trade has increased in recent years to 15%, Asia, mainly China, and Europe are still the main trade partners of the continent. China has been a major broker in the AfCTFA deal, using its diplomatic, political, and trade clout to harness an agreement that includes 52 out of 55 African countries. Yet, critics of AfCFTA argue that cheap and low-quality Chinese goods will fill up the market, thereby destroying existing, local manufacturing businesses. Proponents of the relations have said that this argument is baseless. Arguably, China has been pushing low-end manufacturing out of China and into lower-cost Southeast Asian markets, such as Vietnam, the Philippines, and Indonesia. Yet, these destinations too are slowly becoming more expensive with Vietnam now being close to capacity in terms of manufacturing facilities available in Hanoi and Ho Chi Minh City. Consequently, low-cost manufacturing over the next decade is likely to start heading to Africa, where China still needs to source cheap and reliably raw materials (Chris Devonshire-Ellis, 2019).

It has not gone unnoticed that most of intra-African trade infrastructure are being designed, financed and built by China. Its recent global agenda, the Belt and Road Initiative (BRI) is very much part of this. AfCFTA and the Belt and Road Initiative will not only consolidate the already-flourishing relationship between Africa and China, but will also help push for more investments in infrastructure connectivity, trade facilities, and industrial promotion. Furthermore, China has already been making efforts to develop free trade development zones in Africa with the agenda of boosting Africa's manufacturing development and trade performance (Maswana and Davies (2014). In this connection, Hence, China also has double tax treaties with a number of African nations: Algeria, Botswana, Egypt, Ethiopia, Mauritius, Nigeria, Uganda, Seychelles, South Africa, Sudan, Tunisia, Zambia, and Zimbabwe. AfCTFA along with the Chinese-built infrastructure, boost Africa's manufacturing capacity, and Africa has and will continue to have a large labor force, although organizing and management skills are still very much required. Clearly, the structuring and timing of the AfCTFA agreement has all the hallmarks of Chinese organizational skills (Chris Devonshire-Ellis, 2019). Yet, to the best of our knowledge empirical studies on the economic potential of the AfCTFA has not taken into account this China effect. This is one of the particular focus points of the present study.

Another focus point of the study looks at the COVID-19 interactions with AfCTFA via the China-related supply chains. *The report by World Bank (2020) says: "COVID-19 has caused major disruptions to trade across the continent, including in critical goods such as medical*

[2] China has become the main supplier of intermediate inputs for manufacturing companies abroad. As of today, about 20 percent of global trade in manufacturing intermediate products originates in China (up from 4 percent in 2002). Chinese manufacturing is essential to many global value chains, especially those related to precision instruments, machinery, automotive and communication equipment (UNCTAD 2020a).

*supplies and food"* [3] On top of the effects envisaged due to trade restrictions plaguing global trade, the recent *pandemic of COVID-19 causing disruptions* in the global economy is bound *to reinforce the impacts of trade diversion* on not only trade partners of China, but via ripple effects also on others, including Africa. This has caused many economists to drastically reduce their economic-growth forecasts for African countries. Clearly, the ongoing COVID-19 pandemic could undermine intraregional trade as well as international trade performance in Africa, via disruptions in trade-mediated spillover effects. COVID19 highlights how fast the global supply chains can be disrupted. Needless to say, African authorities have responded to the external shocks associated with the pandemic by, for example, cutting general spending, introducing balance of payments safeguards and restricting imports. This has allowed the government to contain the fiscal deficit, but is, in turn, resulting in a fall in imports of parts and components, which represents the main source of their technology and productivity enhancement.

This implies for most countries the ***urgency to re-establish local production*** for some of the products on which dependence on China is higher. The challenge here has to do with ***the weakness in African countries' technology basis; which is being further undermined since the COVID19 outbreak***. Trade preferences (via different intra and inter regional schemes) could stimulate productive activities and help leveraging learning effect through technological diffusion and upgrading.

In the present investigation, we follow two kinds of impact assessments: (i) we evaluate the growth-effects of trading with China for African countries ***before exploring the disruptive potentials resulting from the COVD-19 pandemic***, as African countries are involved in intra-regional integration processes. (ii) The paper proposes some fresh evidences on the risks posed by Pandemic-induced *trade shocks (decline in trade due to social distancing and lack of demand as well as supply) plus non-trade external shocks* to African intra-regional integration, given the ***region's weaker production basis***. Such **dual nature of external shocks** could impede technology transmission, pose barriers to learning effects, absorption of benefits, and further aggravate growth momentum (Das 2012&2015, Das and Drine 2020). Emergence of G20 replacing G7 clearly is a pointer to the direction that high-growth emerging economies are major forces shaping the world growth scenarios. For laggard economies in Africa, some have missed the digital fastlane due to lack of human capital and readiness in absorption, skill mismatching, and infrastructural hurdles. With the emergence of Robotics and Automation adoption following digitization-led transformation, windows of opportunity for rapid structural transformation resurfaces for industrialization via manufacturing. Emergence of fourth industrial revolution (4IR) opens up vistas of new entrepreneurship to which human capital should respond in Africa and other Low and middle-income economies. As they still depend on technology developed elsewhere, the adoption rate determines their efficacies in harnessing the convergence of new technologies. Thus, despite growth spillovers and rapid technical progress, we find unequal geographical dispersion of benefits resulting in phenomenon of successful catch-up or, growth failure.

Going forward for successful implementation of the AfCFTA, the recovery is likely to require some structural changes dictated by *pro-active government policies (via stimulus package) to enable technology absorption, structural diversification, and thus enhancing productivity. Thus, it is worthwhile to explore 'ex ante' the possible consequences to gauge their potentials simultaneously*. The primary interest is to see whether this could be a *'turning point'* of economic performances and what needs to be done so that the recent improvements could be sustained and *translated into inclusive growth, and long-run rise in living standards.*

The objective of the research is to show how African nations suffering from premature deindustrialization, technological gap and low labor-productivity growth could benefit from overcoming the relative backwardness via productivity spillover through trade and FDI. Economic Partnership Agreements (EPA)'s reciprocal preferential access or AGOA between SSA nations and industrialized countries as well as role of China is evaluated as the latter is the

[3] https://www.worldbank.org/en/topic/trade/publication/the-african-continental-free-trade-area

most important source and destination of African trade flows. The aim is to *review/survey* the extant literature, highlight the issues and present, in terms of current strands of research, the evidences and explanations. This will form the background motivation and inform the issue and context of analysis and help us to think about a framework. Using an 27 sectors-51 regions Global Computable (Applied) General Equilibrium (CGE or AGE interchangeably) Comparative-Static model, we intend to provide (in an *ex ante* fashion) an understanding (a mechanism) of how all these country-specific factors create a climate conducive for potential trade-led development as is expounded in case of AfCFTA-driven growth. This will enable to formulate and identify/implement better policies for developing a supportive environment for innovation diffusion and adoption like National Innovation System or Regional Innovation System in a nation.

The present paper has been organized as follows. Section 2 reviews theoretical considerations, and present some stylized facts which will be used as the basis of simulation. Section 3 focuses on econometrics method and data while Section 4 offers a CGE analysis of productivity escalation spillover—labor-productivity, intermediate-input augmenting technical change—and adverse impact of pandemic on employment, output, prices, and welfare incorporating the mechanism involving underlying factors, presents and discusses empirical results. Section 5 offers an applied theoretical framework for further extension of the work on the basis of Sections 3 and 4. Lastly, Section 6 concludes.

## 2. Literature and Stylized Facts:

### 2.1 A Bird's Eye View of Trade, Productivity Nexus in the Context of AfCFTA

Role of globalization via trade and FDI in propagating productivity benefits is not new. Considerable amount of endogenous growth literature has paid attention to this aspect of trade-mediated technology diffusion and its perceived benefits to the recipients (Eaton and Kortum, Coe, Helpman and Hoffmaister 2007, Das 2015, Das 2012, etc.). Bengoa et al. (2020) offers a systematic review of the vast literature in this area.

Trade, per se, is insufficient driver of economic growth. As has been argued elsewhere, trade creates opportunities by widening the scope; technology flow is one such process of functioning to enhance the potential capabilities. According to Stiglitz (2003), "globalization can be a very powerful force for developing countries, enabling the technology gap and the knowledge gap that separates the developed from the less developed countries to be overcome." Nevertheless, he continues, "if that promises to be achieved, I do think that there will have to be fundamental reforms in the institutions and in the policies governing globalization in the world today." In particular, it has been emphasized that the success stories of East Asian miracle and the other newly industrializing nations owe much to the concerted efforts by the government directed towards 'closing the technology gap'. In this context, by emphasizing the role of better-designed institutions and intellectual infrastructure, Stiglitz (2003) argues, "[one] needs to have a coterie of individuals who are able to absorb knowledge, translate that knowledge, and adapt the knowledge." Accrual of benefits from trade and technology depends on a whole host of factors like human capital, structural congruence, socio-institutional features like governance, corruption, domestic circumstances (Das 2012, 2015, 2020; Asongu and Andres. 2020, Fosu 2009, Fosu et al. 2017 ).

In particular, government policies in a country could shape the region-specific investment climate by proper choice of policy instruments influencing info-structure, infrastructure, property rights, governance features, functioning of labor markets, and other pertinent socio-institutional features.[4] All these factors promote foundations for better

[4] World Bank's World Development Report (2005) evaluates the role of better investment climate from the perspectives of firms as well as society. On the basis of Investment Climate Surveys conducted at the firm level for

investment opportunities and diffusion of new ideas and import of sophisticated equipment -'the engine for growth and poverty reduction' (World Bank, World Development Report, 2005, p. 19) and thus, help reducing the productivity differences across nations by providing incentives for developing, adapting, organizing and adopting better business practices. In this context, the role of information and communication technology (ICT) as general-purpose technology can no way be overstated.

A North-South dividing line in linear fashion is not pertinent now. A **Four-Speed World** Classification a la Wolfesohn (2007) in the World Bank study—affluent, converging, Struggling, and poor—has been made esp. to facilitate categorization of heterogeneities of the South. Over the years the core converging economies have pulled away from the 'struggling and poor' ones, but scope of growth spillovers remain as they have also become more internationally linked or integrated. Classification of four-speed world and fundamental differences in their performances are reflected in the TFP with the least developed ones registering extremely low rates of TFP growth of 0.5 to 0.6% per year as opposed to the converging counterparts with higher average rate of 3%. TFP growth is accompanied by changes in ***structural composition*** of the economy as observed in case of China and India, shift of production factors or resources out of agriculture into manufacturing and services. Shifting wealth to the large converging economies has ***multi-dimensional impact on development outcome and the manifestation*** depending upon how the others are able to take the opportunities and challenges unfolded onto them by these shift or change of economic centre of gravity.

More specifically, this shift is obvious in that the traditional export destination of Africa, which is Europe, represents now 35.4% of its exports (32% to the EU-28) while Asia and Oceania has 38% of Africa exports and 10% to the Americas in 2018. In terms of individual countries, China leads the list as the top destination of African countries' exports (16.8%), following by India (9.6%), USA (7.3%), Spain (7.1%), France (6.9%), etc.

**Table 1: Africa's Top 15 major export destinations, in % of total regional exports**

| | | |
|---|---|---|
| 1 | China | 16.8 |
| 2 | India | 9.6 |
| 3 | United States of America | 7.3 |
| 4 | Spain | 7.1 |
| 5 | France | 6.9 |
| 6 | Italy | 5.6 |
| 7 | Germany | 4.4 |
| 8 | Netherlands | 4.4 |
| 9 | United Arab Emirates | 4.1 |
| 10 | United Kingdom | 4.0 |
| 11 | Switzerland, Liechtenstein | 2.7 |
| 12 | Belgium | 2.3 |
| 13 | Japan | 1.8 |
| 14 | Turkey | 1.7 |
| 15 | Brazil | 1.6 |

26,000 firms in 53 developing nations, and the recent Investment Climate and World Bank's 'Doing Business Project' (2020) benchmarking different indicators for regulatory regime for 190 countries, the report looks at variations in investment climates across the world and their perceived influence on growth and poverty across nations. https://www.worldbank.org/en/topic/investment-climate#results

Source: Computed from raw UNCTAD Database, 2020

Similarly, in terms of import origins, Africa's top trading countries are roughly same as those among its top export destinations. Again, China top the list with 17.1% of Africa's imports in 2018, following by France (5.1%), USA (5%), Germany (4.7%), India (4.6%), Italy (4%) and so on.

**Table 2: Africa's Top 15 major import origins, in % of total regional imports**

| | | |
|---|---|---|
| 1 | China | 17.1 |
| 2 | France | 5.1 |
| 3 | United States of America | 5.0 |
| 4 | Germany | 4.7 |
| 5 | India | 4.6 |
| 6 | Italy | 4.0 |
| 7 | United Arab Emirates | 3.0 |
| 8 | Spain | 3.0 |
| 9 | Saudi Arabia | 3.0 |
| 10 | Netherlands | 2.5 |
| 11 | Belgium | 2.5 |
| 12 | Turkey | 2.3 |
| 13 | Russian Federation | 2.2 |
| 14 | United Kingdom | 2.1 |
| 15 | Japan | 1.7 |

Source: Computed from raw UNCTAD Database, 2020

With proliferation of trade agreements and regional integration, the scope of positive benefits for diversifying production and structural transformation is enormous. In this context, the role of ***Tripartite Free Trade Area (TFTA)*** agreement involving 26 African countries in the COMESA-SADC-EAC is significant as it envisioned the great transformation in long-run via Accelerated Industrial Development of Africa (***AIDA***) Programme, Programme for Infrastructure Development in Africa (***PDIA***), and Comprehensive Africa Agriculture Development Programme (***CAADP***). ***African Continental Free Trade Area (AfCFTA)*** is a much broader and bigger program initiated four years later in 2019 and has overarching ambitious objective of diversifying into manufacturing sophistication away from minerals and primary commodity exports (and job creation), employment generation, and growth via such industrialization drive. With establishment of the African Continental Free Trade Area (AfCFTA), where 27 countries have already signed and ratified the AfCFTA agreement in 2019, Africa is poised to grow by increasing trade among the countries and regional blocks. The AfCFTA is expected to accelerate intra-African trade and boost Africa's trading position in the global market[5]. Market size differences and geography generate differences in the toughness of competition across markets (Mayer, et al., 2014). Moreover, under economic reforms and trade liberalization the prospect of Southern African Development Community (SADC) in the region as a regional integration platform for the member states calls for the analysis of a development strategy for technical and industrial cooperation between these countries with South Africa establishing herself as a hemispheric hub.

As the Southern engines have shown resilience and done better than the North to weather the external trade and finance shocks, the scope of South-South cooperation can no way be undermined. In particular, the emergence of 'Southern Engines for Global Growth 'has changed

[5] African Union, 2019

the global development scenarios, no longer based on typical North-South cooperation and polarization, rather driving a shift in the balance of power from North to South. These countries established themselves as 'new' locus of technological dynamism in their respective geographical territories or regions as well as globally. This calls for investigating the role of South-South development co-operation or integration in a predominantly (and historically well-established) North-South trade flows. "Shifting wealth" from emerging economies like India and China has been due to not only global re-distribution of manufacturing capacity or industrial activity, but also by the pro-active government policy to enable technology absorption and acquisition in the hosts. Others lagged due to lack of effective government policy to provide an enabling environment. This has created an intra-South "new cleavage." As Fosu and Mold (2008) mentions, for laggards like African economies, the scope for gains via multilateral liberalization is limited unless other policy of mutual beneficial action like technology acquisition is pursued. OECD (2010, Ch7, p.153) points out *two potential channels* of cooperation for mutual benefits of the Southern economies: (1) eliminating trade barriers of any sort and (2) technology transfer between the Souths via 'cross-border clusters of specialization and cooperation along the global value chain.' In this context, importance of Chinese economy at this juncture is crucial as it's a rising economy with expansion of global value chain as well as its role as 'Factory Asia'. China is Africa's largest trading partner and if Chinese-made products are hit with US tariffs, there could be a knock-on effect. Tariffs, protectionist measures and retaliation redirect trade flows, out of China and USA, to other destinations.

Although African economies are weakly integrated into China's export supply chains, China-Africa's bilateral trade has been increasing since the early 2000s, the growth rate of China's trade with Africa is now the highest in the world. The import growth rate was also the highest in the world, 15 percentage points higher than China's import growth rate of foreign trade in the same period (China's Ministry of Commerce, 2019). Particularly, according to statistics from the General Administration of Customs of China (2019), China's total import and export volume with Africa was US$204.19 billion, a year-on-year increase of 19.7%, exceeding the overall growth rate of China's foreign trade in the same period by 7.1 percentage points.

However, while African countries are embarking in free trade agreement, the pandemic-induced crisis due to COVID-19 has caused severe global recession with diverse impacts across regions. Since the Global Financial Crisis (GFC) in 2009/10, this is the severest one—totally different in nature with exogenous type unlike 1929-30 or GFC where only financial and economic forces worked havoc—with health and wealth or lives versus livelihood trade-offs. With both Aggregate Supply (AS) and Aggregate Demand (AD) shock, the impacts are multi-pronged and multi-dimensional. Not only that, Covid-19 hit the global economy when already the rise of protectionist policies were thwarting global trade with disruptive trade practices between China and the US and their ripple effects across the trade partners. A considerable amount of literature covers the issue of trade war and its multiple economic effects. First and foremost, protectionist measures and retaliation raise the costs of trade for the participants involved in the trade conflict. This lead to lower export and import volumes on either side. The negative impact on trade volumes is partly mitigated by export substitution effects, as the negative impact is partly offset by redirecting trade to other destinations. In contrast to the mitigating export substitution effects, the negative impact of the trade war could be *aggravated by integrated value chains*. Over the past decades, multinational firms have increasingly been exploiting international comparative advantages by relocating parts of their production processes abroad. The downside of this is that multinationals have become more vulnerable to import tariffs on intermediate products or commodities from abroad. For instance, the US tariff package on Chinese imports of USD 50bn implemented in August 2018 applies primarily to intermediate products and capital goods (Bown, Jung and Lu, 2018). Consequently, only about 40% of the tariffs in this USD 50bn package are borne for by Chinese firms while the remaining 60% of the tariffs are absorbed by foreign firms that are active in China (see Lovely and Liang, 2018). Consequently, companies will face either a deterioration of competitiveness due to higher retail prices (and higher export prices and a lower global market share) or an absorption of the higher costs, which will hurt their profitability.

*Ultimately, the slowdown in business of these multinational firms should affect their demand of parts and components; and therefore demand of primary commodities in upstream chains. Herein lies the link with African countries suppliers of such commodities.*

Over the last decades, many Western companies have moved parts of their production facilities to China (*relocation of production*). This was mainly related to a comparative labor cost advantage, which meant that on balance it was cheaper to produce in China than, for example, in their own country. As a result of the increased tensions between China and the US, more companies are considering a relocation (Rapoza, 2018). Such a move could benefit other developing countries, especially those integrated in china's value chains. *Need not to say, African economies are not especially integrated in China's global value chains and mostly export raw, unfinished goods, to China.* Despite their weaker integration in China-led value chains, indirect effect from slowing growth in the two superpowers' economies will create unwelcome challenges for Africa in terms of lower demand for raw materials such as iron ore, coal, and platinum, which could seriously distress African economies that depend on exporting these commodities.

In the medium term, exporters in Africa could take the opportunity and benefit as supply chains adjust to the new environment. The imposition of tariffs on certain goods could provide a competitive advantage for some exporters, allowing them to command a greater market share in segments such as agricultural products like soybeans or animal feed that were previously imported from the US to China and now targeted by tariffs, for example. This could in turn translate in increased Chinese investment in these African exporters' agricultural sectors. Another small window of opportunity comes from the oil market. West Africa produces similar quality crude as the US, and China could replace US crude imports with West Africa's. By utilizing AGOA[6] mechanisms to fill the partial vacuum that may be created as a result of slowing exports from China to the United States, African countries could take advantage of the U.S.-China trade war in areas where they have the ability to produce competing goods. In addition, Chinese investors themselves may look for "alternative destinations" for their own investments, in order to circumvent tariffs on goods originating from China. That, of course, depends on the quality of the investment environment that African countries can provide. To turn them into fruition, some other associated factors are necessary and that gets reflected in the differences in country performances as they differ in the endowment or accumulation of such factors. Some countries lag in harbouring the benefits of such spillover and hence, wide development differentials persist among the recipients differing in constellation of factors that enable them to reap the benefits. Thus, there are gaps between 'actual' and 'potential' capabilities to utilize the benefits. In case of low income African countries, esp. the Sub-Saharan Africa, who invest a lot less in education, for them, the emigration (brain drain not brain circulation) is a kind of hindrance. Although emigrants send remittances, inadequacies of infrastructure in broad sense and weak governance (the pernicious syndrome effects) act as anti-growth and remittances fall. In other words, lack of investment in education, etc. coupled with the entire socio-institutional constraints obstacle the technological catch-up. Emigrants will not send the best part of what they could unless domestic human capital and other factors are adequate, and good policy and politics exist. Thus, remittances supporting education sector or releasing finance for development could foster human capital provided institutions are 'right'. Emigration also hinders ability to innovate. Weak institutions leading to malfunctioning cause more emigration, brain drain, and fewer remittances, furthering deleterious effect on ability to innovate and invest in human capital. That hinders TFP and social capital formation and also hobbles quality immigration (returning of those who emigrated), and renders achievement of growth and development a hard objective.

Although some of the sub-Saharan African countries are registering growth, in a post-economic crisis world of uncertainty sound macroeconomic policies and enabling environment

[6] AGOA is a "unilateral scheme of preferences dating back to 2000, and has served as the bedrock of trade relations between the U.S. and sub-Saharan Africa. It grants eligible African countries duty-free access to the US markets for thousands of products." The law is currently extended to 2025.

via facilitating state apparatus could be necessary to overcome development traps such as lack of human capital, inadequate infrastructure, slack institutions, civil strife, resource extraction, instability, to name a few syndromes of anti-development (see Das 2015, Das and Drine 2020). The puzzle is: whether these arrest economic growth in Africa and what fundamental policy changes confront them? This will be viewed from a North-South, and then exploring the South-South potentials. Freeman (2013) has referred to the knowledge creation, globalization of knowledge and resultant productivity as 'one-ring' influencing skilled immigration, technology transfer, and within-country, between-country inequalities. Trade-led technological linkage is one such, primarily due to the evolution of ICT as a prime mover of technological change (as general purpose technology affecting other technologies). Emergence of ICT is like a paradigm shift in technology like in the case of Steam engine or Electricity paving the path for Industrial Revolution. In case of ICT, as has been stressed in the literature, 'the *use* of IT, not necessarily its production, is what matters for economic development.' Martinez-Zarzoso and Chelala (2020) has shown—first of its type—for a panel of 176 countries over 1995-2015 that for any trade agreements to have positive impacts on exports of goods it shold consider technology 'provisions' and the impact differs depending on source-specific technology content of goods imported, as well as on technological cooperation, and levels of development among trade partners (i.e., heterogeneous effects).

Literature in the context of Africa has shown mixed experiences in their findings. Malikane and Chitambara (2017) has shown for 45 African nations in a GMM analysis for 1980-2012 that although positive, the effect of trade and FDI on 'convergence' of technology gap or relative backwardness via technology is weak due to lack of institutions facilitating diffusion. Amendolagine et al. (2013) has shown in the context of the 19 SSA countries that for 'backward linkages' to work successfully between foreign subsidiaries and local firms, pre-conditions such as 'local' factors like good institutions, legal system, infrastructure, and technology adoption are necessary. *According to Morrissey 2012, " … FDI in Sub-Saharan Africa has not in general been associated with significant linkages or spillovers". "… China has become a major investor in SSA but its FDI delivers few linkages and almost no spillovers.* This is also attributed to low absorptive capacity of the domestic economies and sectoral composition (primary sector bias instead of manufacturing for industrialization), and negative effect due to institution (corruption) and infrastructural bottlenecks. Also, World Bank (2014) discusses such factors for local spillovers despite trade-dependence. Diallo et al (2018) has shown for a panel of 37 SSA countries that the Chinese FDI has a weak positive effects for these countries due to syndromes such as lack of productive capacity, low level of competitiveness, and good governance impeding structural transformation.

## 2.2 Covid-19 and its Repercussions

Pandemics are expected to have a severe negative impact on economic activities, at least in the short run. According to Jonas(2013), the impact ranges from: i) avoidance reaction due to social distancing measures (e.g., individuals might forgo consumption and purchases of certain goods and services), ii) small direct costs (e.g., hospitalization and medical costs), iii) larger indirect costs (loss of labor, production), and iv) offsetting and cascading effects (disruption of services, travel and others). A number of studies tried to anticipate the economic loss from a pandemic. Barro et al. (2020) estimate that, holding everything else constant, the 2.1 percent death rate during the Spanish Influenza pandemic in 1918-1920 would translate to roughly 150 million deaths worldwide (compared to the World's population of 7.5 billion in 2020) during COVID-19 pandemic. The authors also find that, on average, the 2.1 percent death rate corresponds to 6 percent decline in GDP and 8 percent fall in private consumption

Understanding COVID-19 in Africa requires an understanding of its diverse impacts. The number of infections per million population in early December 2020 ranged from as low as 8 (Tanzania) to as high as 19,673 (Cape Verde), a difference of 2,500-fold. South Africa, with

the largest number of COVID-19 cases on the continent, is reporting more than 13,000 cases per million population. Chad and Niger have fewer than 110 cases per million population, while just to the north, Libya and Tunisia report more than 8,000 cases per million population. How countries are affected economically are in part related to how they are affected epidemiologically. However, the economic vulnerability of African countries cannot be projected solely based on the number of reported COVID-19 infections. Some extremely poor African countries, such as Burkina Faso, have not seen a large number of COVID-19 cases, but are nonetheless facing dire economic consequences as a result of COVID-19. Other African countries, such as Tanzania, have tried to avoid the impact of COVID-19 by simply not reporting on cases, a "solution" which is not likely to be sustainable. (Steven Forsythe and Suneeta Sharma, 2010).

With pandemic-induced crisis the much-avowed objective of AfCFTA and AGOA will experience setback depending on African economies' trade exposure to China and other economies. Trade preferences (via different intra and inter regional schemes) could stimulate productive activities and leveraging technological learning effect through technological diffusion and upgrading. Question is: what could be the different schemes or formats of preferential trade arrangements to leverage the effect from the technologically advanced developing countries vis-à-vis China and other emerging economies, and what other associated factors are necessary for reaping the benefits of AfCFTA. Thus, it is worthwhile to explore 'ex ante' the possible consequences to gauge their potentials simultaneously.

## 2.3 Stylized Facts on Trade Exposure and Selective indicators:

Globalization has the ricochet effect via current spate of global integration and geographical de-concentration of production, via both extensive and intensive growth in trade in products and services alike, known as '***fragmentation***' of integrated production systems into more specialized and distinguishable parts and components (P&C) or intermediates (Arndt and Kierzkowski 2003). This has given rise to Global Value-chain (GVC) via Global Production Network (GPN) across regions, and often, thanks to proliferation of FTAs, has led to emergence of regional production networks (RPN). As per the ***World Bank's World Development Report (2020),*** GVC comprises over 50% of global trade despite plateauing since 2008. According to WTO (2013) in Asia intermediate goods account for over 50% of exports and 60% of import, and the image of "Factory Asia" is well-known for East and South-East Asia's predominant role in supply chain (Das and Han 2013). GVC is measured by percentage of **Foreign Value-added (FVA)** embodied in a country's gross exports, as well as a **GVC index** capturing **backward (FVA content of exports) and forward (domestic value-added content of partners' exports)** indicators for supply-chain linkages (OECD December 2018). The latter is **Trade in Value-added (TiVA) index** (OECD 2018). As effects of GVCs are heterogeneous across regions and sectors, it is necessary to look into the factors that could have differential impacts on structural changes in those economies. This necessarily depends on hosts of factors, such as, infrastructure, institutions, assimilation of technology, dissemination embedded in the traded intermediates, skill-intensity for absorptive capacity, industrial competitiveness, and government's overarching policy favoring the trade and business climate.

Assessing the growth effects of the above outcomes is of an utmost importance for African policymakers. Recently released data indicate bilateral China-Africa is increasing. China's total import and export volume with Africa was US$204.19 billion, a year-on-year increase of 19.7%, exceeding the overall growth rate of foreign trade in the same period by 7.1 percentage points. *Among these, China's exports to Africa were US$104.91 billion, up 10.8% and China's imports from Africa were US$99.28 billion, up 30.8%; the surplus was US$5.63 billion, down 70.0% year on year (General Administration of Customs of China, 2019).* China imported more crude oil from Angola and other countries in an apparent effort to compensate for declining imports of natural gas from the U.S. amid the two powers' mutual hiking of tariffs, as well as

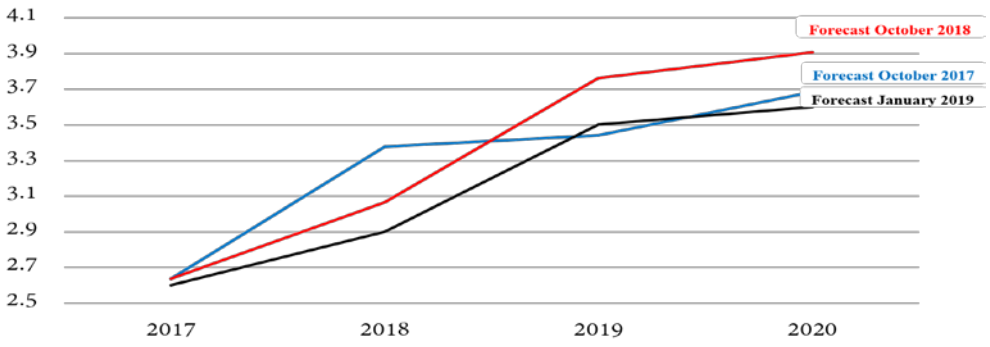
Washington's move to impose sanctions on Iranian crude oil. However, first we take a look at the IMF's revisions in growth forecasts for African countries under the assumption that the lower than previously expected rates of economic growth rates result from a direct and indirect effects linked to the US China Trade War (UCTW). We used the difference from Oct. 2017 WEO Projections for the 2018-2020 GDP growth for Africa to estimate the impact on economic growth. It is assumed that the lower than previously expected rates of economic growth rates result from a direct and indirect effects linked to the US-China trade war.

**Table 3. Overview of the *World Economic Outlook* Projections**
(Percent change, unless noted otherwise)

| Year over Year | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | Difference from Oct 2018 WEO Projections 1/ | |
| | | Estimates | Projections | | | | |
| | 2017 | 2018 | 2019 | 2020 | | 2019 | 2020 |
| **Emerging and Developing Asia** | 6.5 | 6.5 | 6.3 | 6.4 | | 0.0 | 0.0 |
| **China** | 6.9 | 6.6 | 6.2 | 6.2 | | 0.0 | 0.0 |
| **Sub-Saharan Africa** | 2.9 | 2.9 | 3.5 | 3.6 | | –0.3 | –0.3 |
| **Nigeria** | 0.8 | 1.9 | 2.0 | 2.2 | | –0.3 | –0.3 |
| **South Africa** | 1.3 | 0.8 | 1.4 | 1.7 | | 0.0 | 0.0 |

Source: Raw data sourced from the IMF's January 2019 World Economic Outlook

**Figure 1: Africa's Real GDP Growth Forecast, 2017-2020**

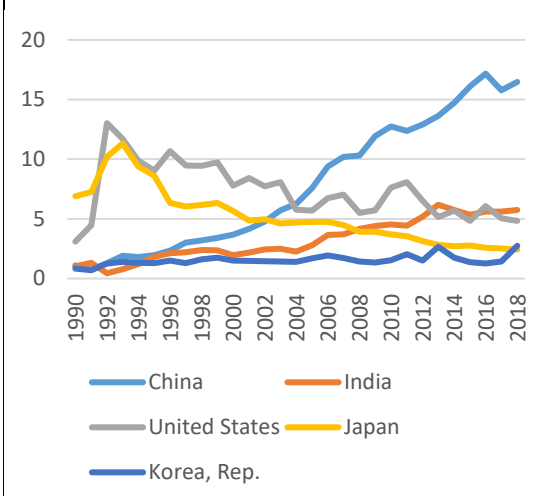



Source: Raw data sourced from the IMF's January 2019 World Economic Outlook

For both 2019 and 2020, the projection is 0.3 percentage point lower than last October 2018's projection. Detailed growth projections from the IMF's latest Outlook forecast growth losses (In percentage point) in 2019 for Botswana (-0.21), South Africa (-0.18), Sudan (-5.48), Tanzania (-0.19) while countries expected to gain include Angola (1.66), Nigeria (0.66), Ethiopia (0.42), and Uganda (0.37), among others. While this approach may offer some useful broad view, however, it does not provide a useful indication on the long-term effects, which is also a concern of policymakers. Only a more robust empirical assessment can get to the bottom of such a concern.

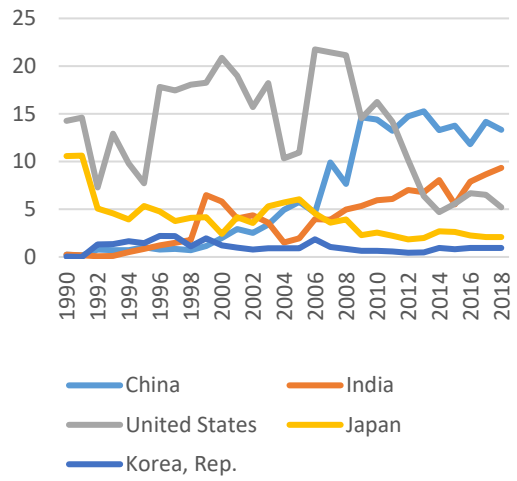
Trade between China and Sub-Saharan Africa has significantly increased over the decade. The share of import from China to Sub-Saharan Africa has increased significantly from 3.7 percent in 2000 to 16.5 percent in 2018, while the share of import from the US and Japan has declined from 7.8 percent and 5.7 percent to 4.8 percent and 2.4 percent respectively during the same period (Figure 2). The share of export to China from Sub-Saharan Africa has increased significantly from 2 percent in 2000 to 13.3 percent in 2018, while the share of import from the US has significantly declined, especially after the financial crisis, from 21.1 percent in 2008 to 5.2 percent in 2018 (Figure 3).

Figure 2: Import Partner Share in Sub-Saharan Africa Trade (%)




Source: World Trade Integrated Solution

Figure 3: Export Partner Share in Sub-Saharan Africa Trade (%)




Source: World Trade Integrated Solution

The import and export intensity index in 2018 show that Sub-Saharan African countries have stronger ties with India and China as compared with the global average (Tables 1, 2, and 4).

**Table 4: SSA's Import and Export Intensity Index in 2018**

| Country | Import Intensity Index | Export Intensity Index |
|---|---|---|
| China | 1.13 | 1.47 |
| India | 3.79 | 4.62 |
| United States | 0.58 | 0.42 |
| Japan | 0.57 | 0.66 |
| Korea, Rep. | 0.86 | 0.41 |

Source: World Trade Integrated Solution

The import product share of capital foods from China to Sub-Saharan Africa accounted for 44.4 percent in 2018. The export product share of intermediate goods from Sub-Saharan Africa to China was only 11.2 percent, while raw materials accounted for 85 percent (Table 2).

**Table 5: Sub-Saharan Africa Product exports and imports from China in 2018**

| Product Group | Export (US$ Thousand) | Import (US$ Thousand) | Export Product Share (%) | Import Product Share (%) |
|---|---|---|---|---|
| Capital goods | 78,553 | 19,976,286 | 0.2 | 44.4 |
| Consumer goods | 1,335,373 | 12,984,284 | 3.6 | 28.9 |

| | | | | |
|---|---|---|---|---|
| Intermediate goods | 4,195,159 | 10,902,616 | 11.2 | 24.2 |
| Raw materials | 31,947,249 | 615,551 | 85.0 | 1.4 |
| All Products | 37,570,068 | 45,009,981 | 100.0 | 100.0 |

Source: World Trade Integrated Solution

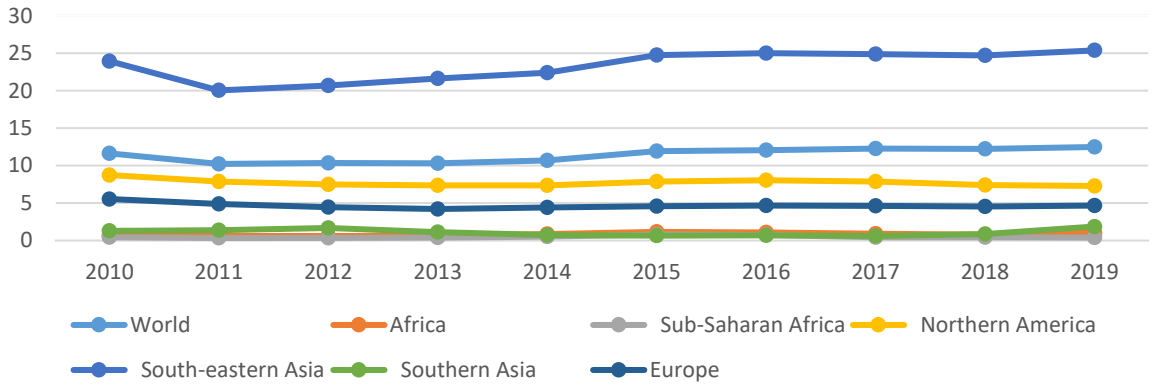
**Table 6: Sub-Saharan Africa Product exports and imports from China in 2018 (Detail Product Group)**

| Product Group | Export (US$ Thousand) | Import (US$ Thousand) | Export Product Share (%) | Import Product Share (%) |
|---|---|---|---|---|
| Animal | 131,514 | 329,506 | 0.4 | 0.7 |
| **Chemicals** | **128,311** | **3,829,565** | **0.3** | **8.5** |
| Food Products | 322,676 | 546,250 | 0.9 | 1.2 |
| Footwear | 2,370 | 1,110,761 | 0.0 | 2.5 |
| Fuels | 24,701,686 | 528,319 | 65.8 | 1.2 |
| Hides and Skins | 77,215 | 324,358 | 0.2 | 0.7 |
| **Mach and Elec** | **122,603** | **18,127,845** | **0.3** | **40.3** |
| **Metals** | **3,295,678** | **5,368,604** | **8.8** | **11.9** |
| Minerals | 7,115,050 | 118,701 | 18.9 | 0.3 |
| Miscellaneous | 15,946 | 3,099,891 | 0.0 | 6.9 |
| Plastic or Rubber | 126,917 | 2,751,247 | 0.3 | 6.1 |
| Stone and Glass | 232,316 | 1,018,196 | 0.6 | 2.3 |
| **Textiles and Clothing** | **377,963** | **3,451,483** | **1.0** | **7.7** |
| **Transportation** | **28,390** | **3,118,704** | **0.1** | **6.9** |
| Vegetable | 505,572 | 454,071 | 1.4 | 1.0 |
| Wood | 385,862 | 832,480 | 1.0 | 1.9 |
| All Products | 37,570,068 | 45,009,981 | 100.0 | 100.0 |

Source: World Trade Integrated Solution

The share of ICT goods as percentage of total export remains low around one percent in Africa. Especially, in Sub-Saharan Africa, the share remained low at 0.44 percent in 2010 and 0.42 in 2019 (Figure 4). But imports of such goods are higher. Same for Chemicals, Transportation, Textiles and Clothing, and Metals (see Table 6 above).

## Figure 3: Share of ICT goods as percentage of total export, annual




Source: UNCTAD.[7]

**Table 7: Composition of Africa' exports to and imports from China, 2001- 2018**

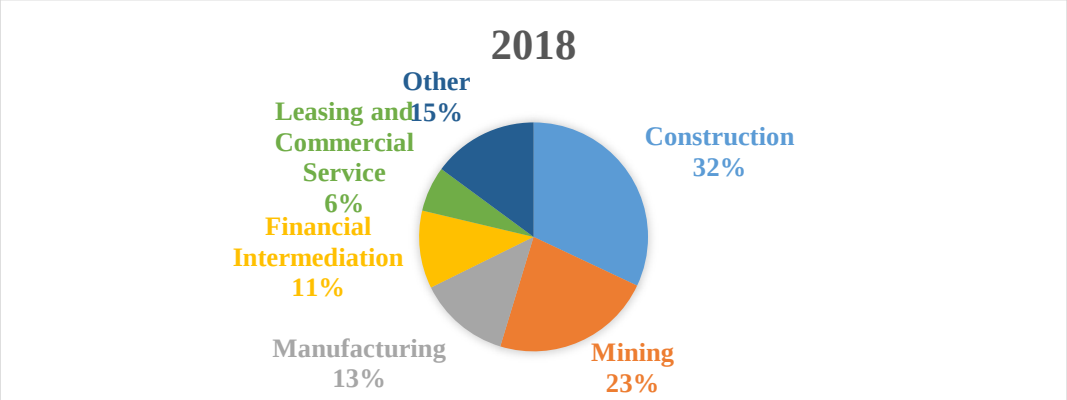
| Africa's Top 5 Imported Products from China | | | | | | |
|---|---|---|---|---|---|---|
| 2HS | Product | US$bn | % of Total | CAGR 2001-2018 | Imports from China as % of Total African Imports | |
| | | | | | 2001 | 2018 |
| 85 | Electrical machinery | 17.5 | 19 | 22 | 7 | 39 |
| 84 | Machinery | 15.0 | 16 | 22 | 4 | 25 |
| 87 | Vehicles | 4.9 | 5 | 23 | 2 | 12 |
| 73 | Articles of iron or steel | 4.4 | 5 | 21 | 6 | 31 |
| 39 | Plastics and articles thereof | 3.5 | 4 | 23 | 3 | 16 |
| | Other | 46.1 | 50 | - | - | - |
| | **All products** | **91.4** | **100** | **19** | **4** | **16** |

| Africa's Top 5 Exported Products to China | | | | | | |
|---|---|---|---|---|---|---|
| 2HS | Product | US$bn | % of Total | CAGR 2001-2018 | Exports to China as % of Total African Exports | |
| | | | | | 2001 | 2018 |
| 27 | Mineral fuels and oils | 46.1 | 64 | 18 | 5 | 22 |
| 26 | Ores, slag and ash | 12.0 | 17 | 26 | 11 | 52 |
| 74 | Copper and articles thereof | 3.7 | 5 | 33 | 3 | 22 |
| 81 | Other base metals; articles thereof | 3.5 | 5 | 39 | 5 | 84 |
| 44 | Wood and articles of wood | 1.6 | 2 | 12 | 14 | 40 |
| | Other | 5.4 | 7 | - | - | - |
| | **All products** | **72.3** | **100** | **19** | **3** | **15** |

**Source: Cathkin Analyses, Trade Map**

The following ***Figure 4*** shows that the bulk of China's investment or lending to Africa is directed towards China's strategic objectives, namely securing access to resources (23%), using China's excess capacity in construction and transportation (32%) and manufacturing and financial services (roughly 13% each). Chinese investments in Africa are increasingly diverse in terms of investment locations and sector. While resource-rich African countries still attract more Chinese investments, there have been some diversification taking place in recent years. One of the sectors with increasingly visible Chinese presence is the telecommunications sector. Chinese *telecommunications companies (such as Huawei ZTE)* have made significant inroads into the telecom sector in Africa.

[7] https://www.theafricareport.com/17380/chinas-growing-reach-in-africa-are-we-seeing-a-fair-trade/
And https://unctad.org/press-material/facts-figures-0




The level of logistics performance and quality of trade- and transport-related infrastructure remain low in Africa. The overall average score of Logistics Performance Index in Africa was 2.3 in 2007 and 2.4 in 2018, which was lowest among other regions in the world.

**Table 7a: Logistics Performance Index: Overall score (1=low to 5=high)**

| | 2007 | 2010 | 2012 | 2014 | 2016 | 2018 |
|---|---|---|---|---|---|---|
| Africa | 2.3 | 2.4 | 2.5 | 2.5 | 2.5 | 2.4 |
| East Asia and Pacific | 3.0 | 3.1 | 3.1 | 3.2 | 3.2 | 3.2 |
| Europe and Central Asia | 3.1 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 |
| Latin America and the Caribbean | 2.6 | 2.7 | 2.7 | 2.8 | 2.7 | 2.7 |
| Middle East and North Africa | 2.7 | 2.9 | 2.8 | 2.8 | 2.9 | 2.8 |
| South Asia | 2.3 | 2.5 | 2.6 | 2.6 | 2.6 | 2.5 |
| China | 3.2 | 3.5 | 3.6 | 3.7 | 3.8 | 3.8 |
| USA/Canada | 3.9 | 3.9 | 3.9 | 3.9 | 4.0 | 3.8 |
| Total | 2.7 | 2.9 | 2.9 | 2.9 | 2.9 | 2.9 |

Some progress has made in enhancing human capital over the decades, but it remains low in the world. The Human Development Index in Africa was 2.3 in 2007 and 2.4 in 2018, which was lowest among other regions.

**Table 7b: Human Development Index trends, 1990-2019**

| | 1990 | 2000 | 2010 | 2014 | 2015 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|
| Africa | 0.41 | 0.44 | 0.50 | 0.53 | 0.53 | 0.54 | 0.55 | 0.55 |
| East Asia and Pacific | 0.61 | 0.65 | 0.71 | 0.73 | 0.74 | 0.74 | 0.74 | 0.74 |
| Europe and Central Asia | 0.74 | 0.77 | 0.82 | 0.84 | 0.84 | 0.85 | 0.85 | 0.85 |
| Latin America and the Caribbean | 0.61 | 0.67 | 0.72 | 0.74 | 0.74 | 0.74 | 0.75 | 0.75 |
| Middle East and North Africa | 0.64 | 0.68 | 0.73 | 0.73 | 0.73 | 0.74 | 0.74 | 0.74 |
| South Asia | 0.42 | 0.51 | 0.58 | 0.61 | 0.62 | 0.63 | 0.64 | 0.64 |
| China | 0.50 | 0.59 | 0.70 | 0.73 | 0.74 | 0.75 | 0.76 | 0.76 |
| USA/Canada | 0.86 | 0.88 | 0.91 | 0.92 | 0.92 | 0.93 | 0.93 | 0.93 |
| Total | 0.60 | 0.63 | 0.69 | 0.71 | 0.71 | 0.72 | 0.72 | 0.72 |

*Notes: A composite index measuring average achievement in three basic dimensions of human development—a long and healthy life, knowledge and a decent standard of living.*

On Product Aspect: Growth through ***cheaper imports of capital goods (CGDS)— by the low-income countries— produced by India and China and other Southern Engines*** offer scope of potential GFT from South-South trade. As these Southern Engines diversify and move up the value-added chain, they produce more capital goods at low prices. Cheaper CGDS imports by the low-income countries enable them to ***have better intermediates with embedded technological contents***. (See UNCTAD 2007 for Data on such imports and OECD PGD 2010, p. 77 on this aspect). According to ***ICT trade—Evolving patterns*** Chapter 3 of UN ITC Report, "industrial

products dominate this trade with 73 percent exports market share and exports value nearly tripled in the period 1995-2005. The most traded ***industrial sectors include electrical machinery and equipment (including electronics),*** where exports value more than tripled in the reference period and the respective market share rose from 18 percent to 22 percent." **Technology Aspects**—R&D expenditure as % of GDP, Digitization Index, and IMF report (attached) has some **EDAI/DAI (Digital adoption index).** The share of GDP on research and development expenditure is significantly low in African countries. The average share was only 0.47 percent in 2007. The share in low-income countries are around 0.1 to 0.3 percent (Table 7c).

**Table 7c: Research and development expenditure (% of GDP)**

| Country/Region | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| East Asia & Pacific | 2.38 | 2.38 | 2.27 | 2.42 | 2.35 | 2.51 | 2.30 | 2.50 | 2.36 | 2.38 | 2.36 | 2.51 |
| Europe & Central Asia | 1.66 | 1.72 | 1.81 | 1.78 | 1.78 | 1.84 | 1.80 | 1.84 | 1.92 | 1.88 | 1.97 | 1.98 |
| Latin America & Caribbean | 0.63 | 0.67 | 0.70 | 0.74 | 0.71 | 0.69 | 0.72 | 0.74 | 0.75 | 0.72 | 0.71 | .. |
| Middle East & North Africa | .. | .. | .. | 0.92 | .. | 0.93 | .. | .. | .. | .. | .. | .. |
| South Asia | 0.79 | 0.83 | 0.79 | 0.76 | 0.71 | 0.74 | 0.64 | 0.68 | 0.62 | 0.67 | 0.62 | 0.65 |
| Sub-Saharan Africa | 0.47 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| Ethiopia | 0.17 | .. | .. | 0.24 | .. | .. | 0.60 | .. | .. | .. | 0.27 | .. |
| Egypt, Arab Rep. | 0.26 | 0.27 | 0.43 | 0.43 | 0.53 | 0.51 | 0.64 | 0.64 | 0.72 | 0.71 | 0.68 | 0.72 |
| Madagascar | 0.14 | 0.13 | 0.15 | 0.11 | 0.11 | .. | .. | 0.02 | .. | 0.02 | 0.01 | .. |
| South Africa | 0.88 | 0.89 | 0.84 | 0.74 | 0.73 | 0.73 | 0.72 | 0.77 | 0.80 | 0.82 | 0.83 | .. |
| Tunisia | 0.67 | 0.64 | 0.71 | 0.69 | 0.71 | 0.68 | 0.67 | 0.65 | 0.63 | 0.60 | .. | 0.60 |
| China | 1.37 | 1.45 | 1.66 | 1.71 | 1.78 | 1.91 | 2.00 | 2.03 | 2.07 | 2.12 | 2.15 | 2.19 |
| United States | 2.63 | 2.77 | 2.81 | 2.74 | 2.77 | 2.68 | 2.71 | 2.72 | 2.72 | 2.76 | 2.82 | 2.84 |

Source: World Development Indicators

## 3. Trade-Growth Nexus and Underlying Constraints: Survey of Empirics

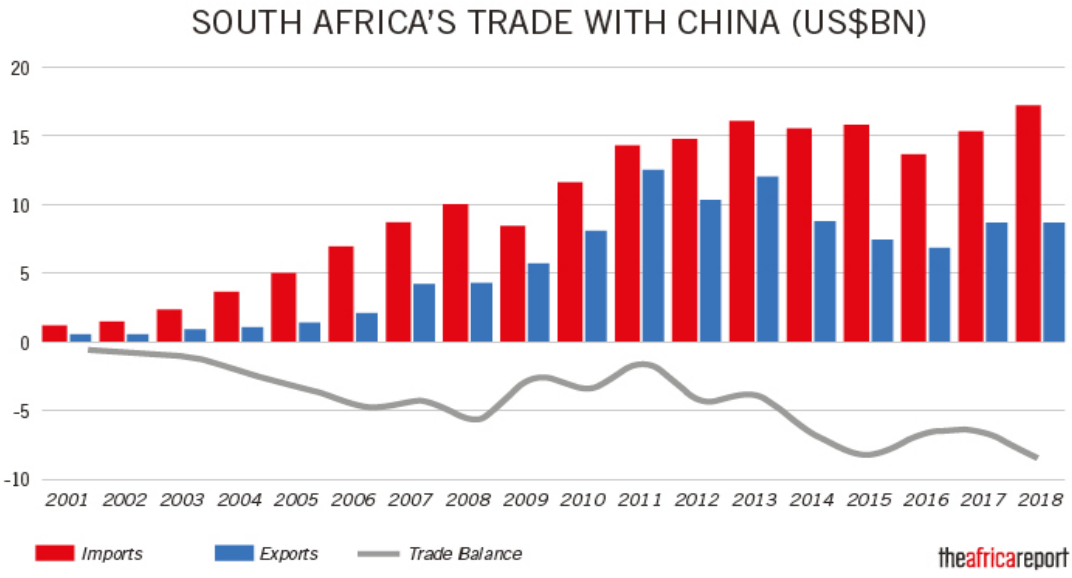
If history is any guide, African trade has, on average, stagnated and in some cases even regressed for decades (Ansu et al., 2016), despite a big reduction in tariffs, global logistic charges, and other factors affecting the cost of trading internationally. One of the potential explanations for this stagnation is that intra-national trade costs remain substantially high in many countries in Africa. Atkin and Donaldson (2015) have shown that while the low availability and quality of roads is a well-recognized factor, inefficient logistics, low vehicle quality, and policies restricting competition also have significant effects (Donaldson et al., 2017).

Trade logistics have become an increasingly large obstacle to African trade performance because of a profound change in the nature of international trade that has taken place in the last quarter century: the explosion of "trade in tasks." In some manufacturing activities, a production process can be decomposed into a series of steps or tasks. As transport and coordination costs have fallen in many parts of the world, it has become efficient to produce different steps in the process in different countries. Task-based production has expanded dramatically in the past 25 years. From 1986- 1990, imported intermediates constituted 12 percent of total global manufacturing output and 26 percent of total intermediate inputs. By 1996-2000, these figures had risen to 18 percent and 44 percent respectively. Globally, the import intensity of export production rose from about 67 percent in 1986-1990 to 78 percent in 1996-2000. (Krafft and Page, 2010).

Trade in tasks also amplifies the importance of trade logistics. In task-based production, high shares of intermediates in final output magnify the effect of changes in logistics costs on value added and profit margins. Countries at the final stages in the production chain of a task-traded good are unlikely to be competitive if their trade costs on imported intermediates are high, and countries hoping to enter upstream in a global value chain cannot afford to have high trade costs for their exports. Beyond these direct costs, the predictability and reliability of supply chains are increasingly important in a world of just-in-time production sharing. (Krafft and Page, 2010).

The World Bank's 2012 report (Dinh et al., 2012) on Light Manufacturing in Africa identified poor trade logistics performance as a constraint that especially penalized African exporters that relied on imported inputs very often making them uncompetitive. The report highlighted research that demonstrated how this added roughly a 10 percent production cost penalty in Ethiopia, Tanzania and Zambia across the five subsectors of light manufacturing where opportunities were identified as greatest in Africa. The report outlined how in Africa poor trade logistics increase production costs (often wiping out the labor cost advantage), and lead to long and unreliable delivery times, making local firms unattractive suppliers to lead firms in global value chains, particularly for light manufacturing.

As the disappointing outcomes of its growth effects of trading with China shows, conditional on the level of the logistics index and China's FDI to Africa, economic growth tends to be greater in countries with higher index of trade intensity in manufactured exports to China. Another noticeable finding is that while being constrained in their manufactured trade expansion with China by low-logistics quality, surprisingly, the very same low-quality infrastructures remain somehow adequate for primary commodity exports to China (Maswana, 2020).




GVC is nowadays mostly led by logistical consideration more than the traditionally considered factors such as distance. Naturally the volume of goods traded between two countries is largely influenced by the availability and the quality of logistics services, among other things.

Mendoza (2010) observes that the relationship between trade openness and economic growth is conditional on factors such as logistics infrastructure, Chang et al. (2005) documented that the impact of increased openness on economic growth will be greater if the process is supported by higher investment in logistics infrastructure. Hence, the quality and efficiency of logistics services can matter for international trade as a weak logistics infrastructure and operational processes can be a major reducing factor in trade integration (Devlin & Yee, 2005).

Following Hinloopen and van Marrewijk (2001, 2006), Maswana (2020) confirms some

early studies (e.g., Maswana, 2014) in that in their dealing with China, African countries' trade has undergone no structural change from unskilled-labor-intensive production to human-capital-intensive production or technology-driven industrial production. The share of African primary commodity products exported to China during that period increased from 16% to 23%. Another significant factor in the overall trade growth in this category is a rapid increase in trade in oil and copper. Asongu and Andres (2020) finds that—by employing World Bank's Knowledge Economy Index—Sub-Saharan Africa and MENA countries are catching-up with others despite having still relative backwardness. Also, Manacorda and Tesei (2020) finds that digital and ICT ("liberation technology") enhance coordination via information for African continent for institutional efficacy like political mobilization in case of economic downturns-led social disruptions, for example, grievances. Chang et al. (2005) documented that the impact of increased openness on economic growth will be greater if the process is supported by higher investment in human capital, deeper markets, and the availability of infrastructure. Moreover, in their growth-effects of their bilateral trade with China, four groups of African countries have been identified, namely, (1) those with low trade intensity and trade concentration (which includes Kenya, Namibia, Egypt, Mozambique, and Cote d'Ivoire), (2) those with low trade intensity and high trade concentration (which includes Rwanda, Guinea, Malawi, Algeria, Zambia, Botswana, and Chad), (3) those with high trade intensity and low trade concentration (which includes Mauritius, South Africa, Niger, DRC, Tanzania, Mauritania, and Togo), and (4) those with high trade intensity and high trade concentration (which includes Angola, Congo, Sudan, CAR, Benin, and others). Overall, each of these groups have specific effects on economic growth resulting from their trade with China.

More important, it has been found that the interaction of Chinese FDI with the institutional quality variable has a significant positive effect on the GDP per capita growth of African countries, indicating the conditional effect of the China–Africa economic relationship on the economic growth of African countries. Likewise, it has been found that Chinese FDI and China–Africa trade alone have no significant positive effect on economic growth in African countries, while a better institutional environment encourages a growth-enhancing effect of Chinese FDI and China–Africa trade to African countries (Miao et al., 2020).

## 4. Theoretical Premise and Conjectures: A CGE-Based Impact Assessment

The commission on growth and development, appointed for by the World Bank and led by Robert Solow and Micahel Spence along with expert commissioners from developing economies, submitted the Spence Commission Report (May, 2008) on the 'growth strategies for sustained growth and development'. Drawing on the idiosyncratic regional growth experiences and historical trajectories of development episodes, the report highlights, *inter alia*, the importance of pursuing context- and case-specific policies such as those related to trade and industry development, environment, education, knowledge creation, technological improvement, inequality, etc.; in particular, it emphasizes the preponderant role of engagement in the global economy as well as extending the knowledge frontier via investment in human capital, institutional quality, R&D and learning. Many less developed or developing countries (LDCs) have pursued liberal trade and technology policies and have depended for their growth and development on foreign technologies originating in the industrialized, developed countries (DCs) of the world. Considering a panel of 101 developing and industrial economies, Arora and Vamvakidis (2004, 2005a) has shown that the United States (US) being a major 'global engine' and among the 10 most important trading partners, economic integration with the developing South has led to substantial growth spillover. It has been argued that fostering local capabilities, skills, institutional infrastructure are essential for 'rooting' deep the globally mobile technology and moving up the value chain ladder. Those who fail remain 'outsiders' to the process of technological dynamism whereas the 'insiders', developing 'capability' base by investing in human and social capital, evolve as leaders.

Given the above background, in this section we offer analytical foundation of our work. With the rise to prominence of endogenous growth theory, role of international trade and foreign direct investment (henceforth, FDI) in transmission of technological benefits via traded intermediate inputs and consequential rise in productivity has received much attention. This has been more so with the rising tide of globalization. Openness to trade fosters dissemination of ideas and technologies embedded in traded products. This in turn leads to structural transformation in some of the relatively laggard countries and help them catch-up with the leaders (see for example, Barro and Sala-I-Martin (1995), Abramovitz and David (1996)). For the liberal emerging economies, propagation of technology is of utmost importance for their evolution in a growth trajectory on a sustained basis. The variations across nations are explained in terms of structural determinants such as schooling or education, political feasibility, governance, demographic factors. Keller and Yeaple (2013) have discussed about the embodied and disembodied knowledge transfer costs for multinational firms. However, knowledge transfer costs depend on skill-intensity and ability-biased nature of knowledge. Rapid evolution of ICT as a general-purpose technology (GPT) gives access to rapid information network, faster execution of experimental scientific revolution and thus, facilitates quicker adaptability to new lines of inventions.

World Bank's flagship publication such as World Development Report (2016, p. 2) has mentioned that: "Digital technologies have spread rapidly in much of the world. Digital dividends—the broader development benefits from using these technologies—have lagged behind. For digital technologies to benefit everyone everywhere requires closing the remaining digital divide, especially in internet access. But greater digital adoption will not be enough. To get the most out of the digital revolution, countries also need to work on the "analog complements"—by strengthening regulations that ensure competition among businesses, by adapting workers' skills to the demands of the new economy, and by ensuring that institutions are accountable."[8]

However, the "use" depends on multitude of factors like skill, education, social networks, infrastructure, and others´--to name a few—that we purport to highlight in this work. Thus, some countries lag in harbouring the benefits of such spillover and hence, wide development differentials persist among the recipients differing in constellation of factors that enable them to reap the benefits. Better policy design depends on how, in this digital revolution, new technologies could be harnessed by people. Digital advances are skewed towards skilled, educated, and socially advantageous groups. For integrating this digitalization into a coherent policy design, it is important to understand what 'capability trap' could stand in the way of digital dividends to be reaped or, in other words, what are the roles of the 'analog complements' (WDR, 2016, ibid.). Emergence of organically evolved functionalities is crucial for capability expansion. As in many developing nations the state often lack the capability to implement the human development policies, the sustained improvements in performance for spreading the digital benefits depend on host of factors, which this research will explore. 'Global Alliance' for ICT and economic development is launched to 'promote the use of ICT in fighting poverty, illiteracy and disease, in protecting the environment and empowering women and girls.' This paper considers ICT-induced intermediate-input augmenting technological change in other technology clusters. As mentioned by Lucas (2009), the pattern and magnitude of these trans-border flows can be discerned by constellation of conducive parameters that enable superseding the 'barriers to riches' (a la Parente and Prescott 2002). We want to explore the effect of global integration and associated fragmentation of production process on the **structural transformation** proxied by indexes such as '**Industrial Intensity Index'** (measuring technological upgrading and technological deepening). However, robots, AI, and automation reduces the extent of offshoring, and leads to reshoring back to the home economy, and therefore it might not be conducive for Structural

[8] All these have revolutionized lives in Kenya and Tanzania and still lots remain to be done for 'realizing the full potential' and for inclusive development 'New necessities' for these, inter alia, are 'literacy' or human capital or skill. (K. Basu in http://blogs.worldbank.org/developmenttalk/development-digital-age accessed on 27th February 2016.)

transformation for the emerging or developing economies, esp for the LDCS like Africa (Krenz et al 2018). On the other hand, the economic effects of intelligent technologies via GVC depends on the productivity spillover and adoption enabling 'trade in tasks' involving high-value added activities with cognitive skills rather than routinized manual jobs. Moreover, trade facilitation via trade policy and technological progress is also important to consider. China's OBOR or BRI project via expanding 'Silk Road' is an important factor for trade cooperation.

Thus, whether Africa-China trade cooperation could harmoniously contribute to mutual benefits in terms of welfare augmentation, propelling economic growth and its spillover, shared prosperity, and sustained inclusive growth is crucial. Role of GDP, population, relative factor endowment, human capital, education, geographical distance, as well as trade facilitation agreement have impacts when the ensuing 'trade-war' could have adverse effects. Currently, African countries are progressing well with the transformation from agriculture led economics to industrial driven economies. There are still gaps though, in the drive towards industrialization and with the *'Made in Africa initiative*'. Some of the gaps include the low levels of innovation, high competition in a few products, dependence on foreign technology and others.

Most of the papers in the context of AfCFTA have considered trade liberalization scenarios like Tariff or Non-Tariff barriers (See World Ban 2020, Abrego et al. IMF May 2019). However, our focus is from a different standpoint. Given weaken production base and lack of manufacturing capability for industrialization and predominance of agricultural and raw materials exports (see discussion in Section 2), there are discussions about premature deindustrialization as structural transformation necessary for diversification might not happen. In other words, structural transformation and economic development and growth go hand in hand for industrialization. AfCFTA's success depends on these factors.

Ours question is how the structural changes enabled by host of factors—human capital or capability, productivity spillover via technology diffusion, proper conducive institution, and government policy for infrastructure could facilitate the combined effects of trade-mediated spillover for translating AfCFTA into a sustained inclusive growth agenda of trade-development. For planned achievement of the AfCFTA, what roles do they play? Given the inter-continental exports and trade is low (despite increase but downturned via Covid-19 effects), further trade policy liberalization will increase trade surely for obvious reasons via typical textbook style Gains from Trade argument (see Caves, Frankel, and Jones 2017; Krugman, Melitz and Obstfeld 2018). But the preponderant question is: would that achieve the SDG target for global cooperation for a inclusive growth via behind the border measures? For broader objective of AfCFTA, the necessary condition for regional trade network and supply chain is important, but that is not sufficient unless and until the preconditions are satisfied. Refer the discussions in Section 2. Now, as Covid-19 has dealt a serious blow to the velocity of trade via China syndrome and other trade partners, AfCFTA might suffer a jolt. That will affect achievement of planned objective of poverty reduction via trade-led growth mechanism. Our research will show a mechanism where such conjectures are proved through consideration of simulated impacts of different scenarios based on semi-endogenous growth through trade-technology nexus via traded intermediates. Figs 1 &2 and Tables 1&2 show the importance of China and other regions in African economy as well as sectoral trade intensities.

## 4.1 Model and Methodology

A lower dimensional version of a global multi-regional, multi-sectoral computable general equilibrium (CGE) model will be used to suit our purpose. In particular, Global Trade Analysis Project's (GTAP) Version 10 global database and the modified CGE trade model will be used for undertaking the research (see Hertel ed. 1997). Version 10 of the GTAP database disaggregates the World economy into 141 regions and 65 sectors. Major regions are likely to be India, China, USA, Latin America and composite developing regions of Africa. Sectors will be classified according to technological intensity and also we consider services sector having higher

incidence of outsourcing. The model is highly non-linear with detailed sectoral and regional specifications based on micro foundations. Ours is different in several aspects as the model is CGE and a special tailor-made version of a global trade model. Basic structure is based on micro-foundations as in a Neo-Classical model. Because of our enhancement of theory via technology spillover mechanism, an augmented version of comparative static multi-regional, multi-sectoral computable general equilibrium (CGE) global trade model is used to achieve this task. For capturing direct and indirect intersectoral effects based on well-defined production and demand structure, the CGE model scores over the simplistic input-output specification and the Social Accounting Matrix (SAM) based models. The CGE framework enables us to account for behavioral responses of each representative economic agent in response to relative price changes owing to policy changes. It belongs to the Johansen class of models and uses General Equilibrium Modeling Package (GEMPACK) software to solve simultaneously the set of equations describing the behavior of the economic agents (Harrison and Pearson 1996).

'Global Alliance' for ICT and economic development is launched to 'promote the use of ICT in fighting poverty, illiteracy and disease, in protecting the environment and empowering women and girls.' This paper considers ICT-induced intermediate-input augmenting technological change in other technology clusters. As mentioned by Lucas (2009), the pattern and magnitude of these trans-border flows can be discerned by constellation of conducive parameters that enable superseding the 'barriers to riches' (a la Parente and Prescott 2002). More specifically, we construct a model to highlight the role of human-capital induced skill, R&D-intensity for enriched technological contents, and other crucial factors—the factors, lack of which creating development-failure syndromes –for assimilating the technology ferried via traded intermediates.

Most of the studies on AfCFTA (World Bank 2020, Abrego et al. IMF 2019) have considered just the welfare gain estimates and other impacts from typical trade-liberalization scenarios using Dynamic GTAP or other variant CGE model. We do not pursue that here.

### *4.2 Modeling Covid-19 Impact*

Impact of Covid-19 spans across borders despite its emergence in the Wuhan province in China in November/December 2019. By May 12$^{th}$, the pandemic spread to 213 nations and regions with 4 million people being affected with registered 280,000 deaths. Global Death rate is 6.56% (sometimes in April according to WHO). However, these types of calculations are not quite satisfactory as it depends on age and country-specific circumstances.[9]

From these two worldwide scenarios, we observe that Covid does not spare any country irrespective of economic status, and it has affected unbiasedly developed and developing economies. USA and UK are glaring examples as are Italy, Germany, France and other developed nations across the Atlantic and Pacific. It is 'equalizer' in that respect. As per Cutler and Summers (2020), the total cost is estimated to be more than $16 trillion in GDP considering loss of health, mental health impairment, long-term health impairment, premature death as well as lost economic activity (i.e., GDP). However, the trajectories of episodes and cycles of progression are country specific. Clearly, the parameters—as are enlisted in the Table---show the *consequences* are different. This could be ascribed to country-specific situations regarding public health facilities, timeliness, existing infrastructure, and civic participation with government cooperation.

In order to understand its economic impact, we need to take a *holistic view* of the problem--multi dimensionality--via: (I) global interdependence and (II) global and East Asian Regional Production Network (RPN) in global value chain (GVC) --- of global engagement due to several facets of globalization. Also, the new emerging or evolving role of global commons like the World Bank (WB, henceforth) and World Health Organization (WHO) are important to consider.

[9] https://www.weforum.org/agenda/2020/09/death-rate-fatality-covid-19-coronavirus-disease-pandemic-science/

However, given the paucity of space, we don't delve deep into the matter. We categorize the following key aspects that the readers should be aware of:

(i) Pandemic has triggered triple crisis—Economic, Health and Resilience from Disaster or Climate as a ***sui generis*** problem;

(ii) *Post-Covid 19:* now Covid is a **dual** burden of Health and Pollution Hazards accentuating the problem affecting health (via direct and indirect health impacts due to preexisting co-morbidity and risk factors like Diabetic, Lungs (COPD), toxicity-led disease (cancer, etc.), most at risk by potentially devastating "**secondary effects**" now thanks to intuitive link between chronic health conditions air pollution and vulnerability of individuals/ communities to covid-19.Therefore, we have a magnified impact.

*Global interdependence & domestic factors are two sides of the same coin.* Pandemic-induced **supply** (lockdown-workplace closures/closing borders) as well as demand collapse (consumer demand collapse) have deep impact. Lockdowns and these associated effects on Consumption and Work (Labor-hours) are demand and Supply shocks increases the severity of deep recession, exacerbate the size of it but saves lives by reducing the severity of the Epidemic. These are affecting ***domestic*** economy; the effects are transmitted ***globally*** via interconnectedness –sectoral and regional—of the economies. For example, trade tourism are affected due to restrictions on ***mobility*** for health reasons. ***Supply shock*** works due to human capital loss related to closure. Also, migration and related remittances flow have experienced a severe jolt to halt the capital flow.

Impact of the Covid-19 pandemic on economy in general, and sectors in particular are important to consider. Because China is the place where it originated and gradually spread across the world, ***the "China effect" on African continent*** is often affected by it. The 'uncertainty' faced by the world is reflected in trade, productivity, and value-chain 'linking' the economies. Policies will be shaped by the new realities for building resilience. As fiscal stimulus are designed for boosting the shrinking economic activities, the tightening of fiscal policy—when there is pandemic-induced uncertainty in the absence of vaccine or near-term solution for containment—might not work. Reprioritization of policies to promote investment, identifying expanding sectors, firms, boosting employment generation, and reskilling, training or developing human capital through better health and wealth creation is important for sustainable and inclusive growth. As fiscal stimulus will have lower 'output effects', stronger positive or favorable supply-side shocks as well as supportive domestic demand are needed.

The World Bank expects over 90% of countries to be in recession in 2020 due to the COVID-19 pandemic. Advanced economies will shrink by 7% and developing economies by 2.5%. Also, it has been predicted that due to 'financial uncertainty 'the cumulative loss in world output would be about 14% in the following year after the pandemic (Caggiano et al. 2020). The COVID-19 pandemic has dramatically impacted the manufacturing sector. In conjunction with the economic downturn, it has altered operations, supply chains, and output. The networks of manufacturing are interwoven and responsible for moving an enormous volume and variety of international and domestic goods. In June 2020, 292 million jobs in manufacturing supply chains are at high risk due to the COVID-19-related drop in consumer demand, and a further 63 million jobs were at medium risk.

Supply chains linked to manufacturing play an important role in propagating the economic impact across sectors and countries. The manufacturing sector was experiencing a disruption to 35 per cent of imported input supply due to closures of all but essential workplaces. Thus, closing down the sectors prone to *contact-intensive activities* are effective so long as affected workers are taken care of without dampening the demand. Some sub-sectors, especially fruits and vegetables and meat packing and processing, have suffered supply chain disruptions because of COVID-19 infections, logistics problems, and/or unavailability of seasonal workers. An additional 100 million people around the globe will fall into extreme poverty because of the

virus. As per ADB report (June 2020), job loss, unemployment, income loss has led to tremendous food security risks (i.e., hunger and malnutrition) in Asia and the Pacific by affecting the food supply chains regionally and globally, and rise in food prices by 10%-20% in India, Pakistan and Sri Lanka.

As mentioned in the preceding sections, counterattacking the disease needs a new arsenal of strategy utilizing the power of globalization, innovation, and digitization with proper government intervention. Especially, we observe in Korea that the pandemic has paved wide-spread adoption of digitalization of services – spanning online streaming to remote work for facilitating work from home so as to maintain social distancing (SD). It is imperative to see the role of public policy for harnessing the new technology. We can easily offer evidences of such effectiveness of new technology (Das 2020a,b&c). Given the pandemic-induced shocks in education in developing countries, there might be aggravation of the existing gap between rich and the poor, or the digital divide. For example, without technology and associated infrastructure it is hard to keep up with the quality education at primary, secondary and tertiary levels. In countries such as South Korea, this catchup is not a problem. That affect the catching-up process of children, young people, and hence, ultimately the economic growth of the poor and emerging economies. For example, in case of India, despite ICT-enabled services the public health and education is suffering a lot. Then social contact and contract are rationed during the COVID-19 pandemic, the social benefits of ICT will be realized when there are so much gaps among the rural poor.

All of the above discussion points to the fact that we consider a decline in overall TFP and/or, labor productivity shock proxying a fall in the skill of the labor force or loss in human capital. In fact, World Bank (June 2020) projection is 0.7% TFP growth of China since Global Financial Crisis and World Bank (2019) and IMF (August 2019) already projected a slowdown of TFP after the GFC.
The information below shows the major exporters of pharmaceutical products in the world.

**Table 7d: Exports of medicinal and pharmaceutical products ($ millions)**

| | 1995 | 2000 | 2005 | 2010 | 2015 | 2019 |
|---|---|---|---|---|---|---|
| World | 71,830 | 107,169 | 274,042 | 461,754 | 526,447 | 663,850 |
| Africa | 245 | 266 | 395 | 953 | 1,012 | 1,274 |
| America | 8,363 | 16,605 | 33,077 | 57,686 | 68,265 | 70,376 |
| Northern America | 7,168 | 14,361 | 29,402 | 50,089 | 60,159 | 64,278 |
| Latin America and the Caribbean | 1,196 | 2,245 | 3,675 | 7,597 | 8,106 | 6,098 |
| Eastern Asia | 4,728 | 5,661 | 8,462 | 18,204 | 21,660 | 30,471 |
| South-eastern Asia | 783 | 1,148 | 3,698 | 10,200 | 10,990 | 15,142 |
| Europe | 55,678 | 80,118 | 219,575 | 354,425 | 398,007 | 516,101 |

Source: UNCTAD

Asian Manufacturers active in Africa mainly originate in India and China and have in the last few years almost doubled their volume of exports to the continent. According to trade statistics data, India accounted for 17.7% of African pharmaceutical imports in 2011 (Over 1666 million USD) whilst China accounted for 4.1% (Gaia Trade 2020).[10]

[10] Gaia Trade http://www.gaia-trade.com/pharmaceutical-trade-supply-and-distribution-on-the-african-continent/

## 4.3 Simulation Design: Rationale and Shocks

Preceding discussion points to the fact that: (i) World Bank (2020) projects that moving towards an integrated market via AfCFTA involving 54 member countries will have economic impact in the tune of US$450 billion by 2035 and with boosted inter-continental trade by 110%, esp. for manufacturing goods, and prospects for attracting FDI; (ii) however, several issues determine the success of such grand 'single market' such as, (iii) trade volume in the region is still low except SADC, ECOWAS, and EAS; (iv) there are needs to develop RVC based on participation in GVC/GPN; (v) need for diversifying to sophisticated manufactured goods from the current exporting goods such as, agricultural products and raw materials; (vi) agri-value chain to produce value-added goods is crucial; (vii) success of AfCFTA depends on manufactured and high-tech non-commodity trade flows while production basis is weaker in Africa with some differences across countries; (viii) it depends on imported technology flows via trade in intermediates, parts and components, from major source nations; (ix) China is one among them shifting, however, low-end manufacturing to South East Asia and Africa to take advantage of surplus cheap labor; (x) inter-continent economic integration needs to be evaluated in the light of 'China Effect' as economic potential heavily rests on this; (xi) Logistics performance index (LPI) being low—based on the World Bank study-- that could be an impediment for trade-facilitation effects and hence, improving logistics is a key factor despite 'Chin effect'; (xii) Covid-19 impact could have direct impact as well as indirect impact via 'adverse' impact countering 'positive effect' and trade disruptions. Thus, optimistic view about potential impacts of AfCFTA on poverty reduction, inclusive economic growth, regional income convergence, and overall development via increase in intra-continent export volume needs to be reviewed. In other words, we need to look at how far the prospects depends on the "China-centric" effect in the context of AfCFTA, and whether in a post-pandemic world, there could be reversal of fortune with the weakened Sino-Africa alliance effect. The simulation designs purports to achieve: (i) compare the *Status quo/Business-as-usual (BAU)* structure with Pre-Covid favorable shocks induced effects comparing updated ex post database; (ii) then, run post-Covid simulation in the presence of pre-Covid positive shock; (iii) comparing BAU, Pre-Covid, and Post-Covid shock-induced results.

Following from preceding discussion, we can observe that the shocks are 'Dual' in nature, viz., favorable and adverse. Covid-shocks are both Aggregate Supply (AS) and Aggregate Demand (AD) shocks. We trace the simulated impact of the following:-

***A. Pre-pandemic Favorable Shock:***

***(A.a) Productivity shock:*** **(Business-as-Usual/Status quo).** Here we consider trade-induced productivity benefits spillover via trade-linkges in the Comparative-Static CGE GTAP model. EDAI/DAI indexes captures this. We consider: TFP shock across sectors and originating in China (and USA, EU nations) as well as intermediate-input augmenting technological change where better quality intermediates embodying technological benefits due to innovation in the Source (China) diffuse technology via traded intermediates. Rationale is that one of the objectives of AfCFTA is industrialization drive and growth via trade in parts and components, etc. The conjecture is to simulate how African economies respond to shocks originated in major trade partner, such as, China. We compare the effect with alternate important trade partners such as US or UK. We shock each of them separately to see diverse impacts in African regions.

***(A.b) Trade facilitation:*** logistics as well as ICT led ecommerce boosts Virtual Trade (with new dimension of trade boost). We simulate this effect separately as: Doubling/tripling Chinese investment into infrastructure/intra-regional connectivity. Besides the rule of origin, this is seen as the single most important determinant of success or failure of the AfCFTA. Notably, low infrastructure connectivity among African countries is primarily to blame for low inter-African trade. Likely, recent statements by Chinese authorities indicate

connectivity/infrastructures required for the AfCFTA are being considered as parts of the FOCAC and BRI plan. In addition to funding and easing connectivity among African countries, China-built industrial parks and Special Economic Zones (SEZs) have been expected to drive Africa's industrialization, especially those developed in Ethiopia, Djibouti, Kenya, Nigeria and South Africa, Zambia and Mauritius, among others.

***B. Pandemic-induced adverse Shock:***

However, studies on Covid-19 pandemic and healthcare sector impacts in the context of Africa in a CGE model is our novel value-addition. Mikic et al (2020) has reviewed this aspect in the context of US-China trade war. The pertinent point that the study highlights is the uncertainty in global trade scenario and human capital loss will be affected by the disruption of the entire production networks and supply value chains. As that leads to loss of trade across borders, the scope of medical spillover is hampered. Arrow et al (2020) has shown the importance of ICT technology in promoting tech-trade diffusion in new pharmaceuticals, as well as covering healthcare costs for prescribing or introducing new diversity of products or, generic drugs or therapeutic treatment. In fact, the Covid-19 disruption originating in China (and spilling over all across the world from Wuhan) will impact medical and chemicals (pharmaceutical sector) and the economy via secondary ripple effects as that will slow down or even debilitate the absorption or adoption rate of trade-led productivity benefits, and hence, obstruct exports even with AfCFTA.

***(B.a) Covid-19-Shock:*** Covid has made the economies vulnerable due to tremendous uncertainties[11]. As has been discussed in the context of the economies like Germany or the Nordic Countries, 'The Economist (September 12th 2020, pg.66) mentions that: "Lockdowns may not seem like incremental change, but reducing working hours to limit social contact, apportioning costs across society and gaining consent for restrictive measures are all easier when there are already institutions ion place which allow collective action. Success may be generated more by unity and consistency than by the strength of the intervention that is chosen. . Coordinated economies are well equipped to handle co-ordination problems, such as promoting public health." (i) *Health shock* causing loss of 'human capital' which is proxied via decline in labor productivity (loss in labor effectively); (ii) *Social Distancing and Trade Cost* causing China vis-à-vis Africa logistics disruption (intra-African trade)—indirect negative impact via China-Africa logistics disruption. This is kind of "*Negative trade shock*" as trade with China suffers; Imported intermediates, capital goods, technology diffusion, raw materials are all so adversely affected that African growth rates via China-Syndrome will be dominant.

***(B.b) Reinforced Effect of Inadequate IT or Digitized Infrastructure Penetration:***

Variation in internet connectivity could cause and multiply the adverse shock impact in (a). In a recent study by IMF (2020), they find that: "*[A] large variation in Internet connectivity by firms in Sub-Saharan Africa—only about 60 percent of businesses use email for business compared to about 85 percent in Europe and Central Asia. The relatively low Internet access might depress productivity in emerging and developing countries. IMF staff research finds that a one percentage point increase in the share of Internet users in the population raises per capita growth by 0.1–0.4 percentage points in Sub-Saharan Africa. The COVID-19 pandemic demonstrates that having reliable Internet allows some businesses to continue operations amidst lockdowns, which keep economies running.*[12]" Tremendous spike in riskiness and non-trade shocks heavily affecting global trade negatively. (OECD 2020a&b, Baldwin and Mauro 2020, CEPR (UK) Volume, etc.). Due to less interaction, lack of digitization benefits causing less contact tracing and deterioration, *Contact tracing via GPS* is hard to operate.

[11] https://blogs.imf.org/2020/04/04/global-uncertainty-related-to-coronavirus-at-record-high/?utm_medium=email&utm_source=govdelivery

[12] Low Internet Access Driving Inequality https://blogs.imf.org/2020/06/29/low-internet-access-driving-inequality/?utm_medium=email&utm_source=govdelivery accessed on 12/22/2020

***(B.c) Reversal of Fortune:*** As mentioned in (b) above, digital divide could be counter-productive even in the presence of favorable shocks or fiscal policies. In fact, the IMF study further notes that: "Given the increasing role of the Internet for the economy and for accessing public services, policies to foster an inclusive recovery must aim to tackle the digital divide within and between countries." This could facilitate "Contact tracing" and Medical R&D and pharmaceutical spillover. Furthermore, "Policies should also be geared to closing the Internet gap for firms. Broadening small businesses' access to financial products such as loans will allow these firms to undertake productive investments in information and communications technology. Governments could also see fiscal savings from digitalization. They can lower the public cost of tax compliance through greater access to taxpayer data and improved spending efficiency, which in turn, may help financing these policies.[13]" Thus, *Medical R&D Spillover (Digital Health Care), Telemedicine, MTiba (in Kenya) as Healthinsurance, and Pharmaceutical exports (Arrow et al 2020)* from emerging economies suffer further aggravating (i) above.

All these will show that Virtual trade will replace traditional comparative advantage-based trade and E-commerce will boom replacing physical trade and new trade will take place in post-Covid world. Local economy is important and for that macroeconomic factors such as institutions, human capital, and governance are necessary as China exposure ---degree of such intensity—will matter. The sectors with more potential for 'online trade' than offline ones will have more potential as these are based on labor-linking technologies based on ICT. Moreover, the 'contact-intensive' industries will have a setback.

Table 8 presents the regional concordance and geographical matching of constituent regions/nations. The commodity-based definition, adopted in OECD Outlook (2004b), identifies five broad categories of ICT goods. ICT services, based on industry-based sector definition and ISIC, Rev 3., are separated and grouped together in the 'services' cluster comprising mainly telecommunications, IT-enabled and related services facilitating trade and exchange. This separation is suitable for our purpose of trade-related technology diffusion from IT-production to IT-user sectors. Due to lack of methodological consensus and differences in definitions of biotechnology firms, there is difficulty of comparable statistics. Based on OECD (2006) definition of BT applications, for our purpose, depending on the sectoral details of the GTAP database, we classify the BT cluster to focus on agricultural or plant biotechnologies based on application fields in agro-food, forestry, food processing, and agriculture whereas others are grouped into consumer goods cluster (see Table 2 for the mapping of sectors with GTAP classification GSC1). [14] Based on SITC, Revision 3, and Commodity Product Classification and Harmonised System (HS, Rev 2.), WPIIS, OECD (2003a) has developed a classification of ICT-goods separately from ICT-services.[15] As our primary motivation is to explore the scope of enrichment via embodied technology spillover, we categorize the whole range of 65 product categories in the GTAP Version 10 database into 7 broad R&D-intensive technology clusters—namely, ICT, Transport Equipment, Materials, Consumption goods, Fabrication and Services.[16] Of all the manufacturing technology clusters, not all have identical intensity in R&D performances; three have high R&D-intensities—viz., ICT, Transportation Equipment and Materials whereas Consumption goods and Fabrication have low R&D-intensity. It is noteworthy that there are relatively *small intra-cluster differences* whereas there are inter-cluster differences to some extent. This conforms well to Schiff (2003). However, *unlike* his study in our analysis we consider the actual technology clusters following OECD (1997) nomenclature.

[13] Ibid.

[14] Three major fields of such applications with comparable country coverage are: health, agro-food and industry-environmental fields (p. 26, OECD 2006).

[15] Working Party on Indicators for the Information Society (OECD 2003a), A proposed classification of ICT goods, DSTI/ICCP/IIS, OECD. As the development of a 'detailed classification' of services was not easy because of lack of consensus on including activities into industry-based sector definition, the ICT-services are distinguished from ICT-goods and ICT-production based on ISIC, Rev 3.

[16] See Das (2002).

According to the 1997 OECD study[17], technology is defined as the direct and indirect R&D embodied in different types of intermediate inputs and capital equipment. Diversification of manufacturing process and shifts towards capital-intensive and knowledge-intensive products has led to rising share of science-based goods in high-technology trade (Guerrieri and Milana, 1995; Martin et al, 1997).[18] We follow OECD (2003a, 2005) classification of manufacturing activities according to technological intensity using ISIC Rev.3 breakdown of activity. Based on Hatzichronoglou (1997), OECD (2003a, 2005) methodology considers both 'technology-producer' and 'technology-user' aspects and harps on three technological intensity indicators, namely, R&D expenditures as proportion to value-added, production and R&D plus technology embodied in capital goods and intermediates as proportion of production, to determine 'technological criteria' for the industries.[19] This methodology led to classification of manufacturing industries into high-technology, medium-high-technology, medium-low and low technology groups. According to this classification, IT cluster belongs to the hi-tech cluster whereas BT, NT, and Transport equipment fall into medium-high and medium technology groups. Consumer goods and Fabrication are in the medium-low and low technology categories, respectively. However, capturing knowledge-intensivity of service sector poses challenge because of lack of consensus on definition and dearth of data. By adopting a narrow definition (ISIC Rev 3.) and based on idea of embodied technology flows estimated from input-output tables, market service activities like 'Finance and Insurance (Divn 65-67)', 'Business activities (71-74)', 'Post and telecommunications (Divn 64)' are considered knowledge-intensive.[20] The OECD (1996, 1997) divides industries into five broadly defined *technology clusters*—'industries sharing a number of common characteristics' (p.41, OECD (1997)) which are also called 'Categories of Embodied Investment' (OECD (1996)).[21] Table 1 presents the classification of industries into broad *technology clusters* following the OECD (1996, 1997, 2004) taxonomy of grouping industries.[22]

**Table 8: Technology clusters and industries** mapping of GTAP V10

| Technology Clusters | Industries |
|---|---|
| Information and Communications Technology | Computers and related equipment, Telecommunication and Semiconductor Equipment, Electrical Machinery, Audio and Video Equipment, Instruments. |
| Transport Technology | Shipbuilding, Aircraft, Motor Vehicles, Other Transportation |
| Consumer goods Technology | Food, Beverages and Tobacco, Textiles, Apparel and Footwear |
| Materials Technology | Agriculture, Construction, Mining, Paper and Printing, Wood |

[17] The manufacturing sector is the source of innovation via R&D and generates important spillover to the other sectors via the usage of the products of that sector.

[18] There are several measures for quantifying high-technology products. According to the World Bank (1999) classification, high-technology exports comprises manufactures at the 4-digit level of disaggregation in the SITC, Revision 1, Sections 5-9 excluding division 68.

[19] See OECD (2003), Annex I, pg. 155.

[20] See OECD (2003), pg. 141.

[21]OECD (1996), *Science, Technology and Industry Outlook.*

[22] OECD (1997), *Science, Technology and Industry Scoreboard of Indicators*, pp- 40-41.According to Thomas Hatzichronoglou (1997), in the proposed new classification by industrial sector, 'the concept of technology intensity has been expanded to take into account both the level of technology specific to the sector (measured by the ratio of R&D expenditure to value added) and the technology embodied in purchases of intermediate and capital goods. Four groups of industries have been identified on the basis of the degree of technology intensity. The classification by product consists solely of high-technology products (products which are the most technology-intensive). The classification was drawn up by the OECD Secretariat in collaboration with Eurostat, the object being to finalize the approach by sector and provide a more appropriate instrument for analyzing international trade. Because no detailed data were available for services, the two proposed classifications concern only manufacturing industry.'

| | |
|---|---|
| Fabrication Technology | Fabricated Metal Products, Other non-electrical machinery, Other Manufacturing |

Following the literature and empirical evidences, OECD nations account for largest of total world R&D and within them, 7 largest (G7) account for major share (CHH, 2008 and UNESCO, September 2009). UNESCO (2009) has shown that the number of researchers in developing countries has increased by 45% as compared to 9% in the DCs; however, researchers per million inhabitants were still far higher than world average in America, Europe and Oceania. Considering R&D intensity (i.e., national R&D expenditure as a percentage of the GDP), the Americas accounted for 37.6% of World R&D expenditure (mainly attributed to R&D spending in USA and Canada) followed by Europe and Asia. According to the report (p.6), 'the triad countries of the EU, the US and Japan represented almost 70% of global R&D expenditure whereas Oceania and Africa accounted for insignificant shares.'

According to OECD (2006), rapid globalization of science and technological invention has been accompanied not only by concentration of such activities in only OECD regions, but non-OECD economies also have exhibited fastest growth and sizable contribution to global R&D.[23] *However, Asia's increasing R&D intensity is largely dominated by China's contribution—registering increase from 1.1% in 2002 to 1.5% in 2007, thus, accounting for 39% of R&D expenditure and 53% of researchers in the LDCs; but in case of India, it is about 0.8%. Among Latin American bloc, Brazil reported higher (1%) followed by Mexico and others.* In Sub-Saharan Africa (SSA), the intensity is much less, about 0.3%, whereas South Africa invested almost 1% of GDP for R&D. In this context, it is important to mention that we follow the UN schemes of geographic regions to include South African Customs Union (SACU) and South African Development Community (SADC) members and lump all other Central African and Eastern African countries in the SSA group.[24] On the world as a whole, R&D expenditure has increased (1.7% of world GDP). Thus, we see that G7 countries have the significant share of R&D and still developing countries need to make significant strides in their innovative skills. Apart from that Global Competitiveness Report (World Economic Forum 2009-2010) documents those G7 countries' 'technological readiness' index score is far higher than those in Asia and African nations.

For AfCFTA, geographical proximity factor is important. As regards the bilateral trade intensity, Linnemann (1966) has made explicit reference to distance variable which is absent in Linder. Johnson (1964) suggested that the positive relationship between trade intensity and "Linder variable" (international similarity in per capita GNP) could be the result of the reality of geographical proximity among countries with similar wealth levels. Following Bergstrand (1985) & Linneman (1986), Hanink has developed a gravity model and analyzed Linder's theme as a "spatial interaction model" i.e., model based on mutual attraction between places.[22] Also, Keller (October 2003) showed that spatial features such as geography dictates the scope of expansion of interregional foreign trade. In particular, it showed that interregional distances based on geographical location (or, position) influence the possibilities of trade and its volume; shipping, an invention in transportation mode, reduces costs of transportation via shipping in new routes as compared to the land transport cost and helps expansion of trading network. Thus, technological progress causing major innovation helps considerably in averting spatial deterrent effect. Normally, technology is localized highly but as a consequence of trade facilitation via E-

[23] According to OECD (2006), compared to 7% in 1995 China, Israel, Russia, and South Africa contribute combined 17% of R&D expenditure of OECD nations in 2004.

[24] GTAP 141 regions are not exhaustive and hence, for the regions with *less data availability* these are lumped together like in the case of SSA and hence, that leaves room for some imperfection in treating trade flows in the composite regions and some results in this paper. Thus, the results are to some extent influenced by the composite regions' value flows for the variables. However, given the focus of the paper, apart from that problem the database's broad coverage and interregional linkages does not undermine our prime focus.

[22]Bergstrand, J. (1985), "The Gravity Equation in International Trade: Some Micro Economic Foundations and Empirical Evidence", *Review of Economics and Statistics*, Vol. 67, pp. 474-481.

commerce and ICT, and other associated changes, the *localized effect is diluted* and international spillover is plausible. Keller's estimates of geographic decay of technology diffusion has 'shrunk substantially' (p. 773) although it was high, for example, in case of distant Oceania. Over time, Keller (2004, p.773) mentions that "geography is an important determinant of technology diffusion… but more work is needed that reveals what geography stands for in terms of economic models."

As summarized in Table 9 below, using van Dijk (2013) we see the projected estimates of partial labor productivity growth in regions categorized according to development status.

**Table 9: Labor Productivity growth and components projections 2006-2050**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| | Industrialized countries | EU | China | India | Asian Tigers | Asian developing countries | Brazil | Latin America | Sub Saharan Africa |
| Agriculture | 3.43 | 3.43 | 4.11 | 1.48 | 4.23 | 2.59 | 4.87 | 2.39 | 2.14 |
| Construction | -1.05 | -1.05 | 3.96 | -0.18 | 0.38 | -1.49 | 0.29 | -0.64 | -2.69 |
| Other Services | -0.63 | -0.63 | 4.58 | 3.42 | 0.89 | 0.95 | 0.27 | 0.05 | -4.00 |
| Finance, Ins, Real Est | 1.32 | 1.32 | 1.72 | -4.86 | 0.28 | -1.14 | -1.52 | -1.55 | -0.57 |
| Mfg | 1.74 | 1.74 | 7.00 | 1.59 | 4.55 | 1.82 | -0.98 | 0.46 | -6.30 |
| Transport, Communication | 2.37 | 2.37 | 5.40 | 4.22 | 3.05 | 0.86 | -2.17 | 1.17 | 2.04 |
| Wholesale/Retail trade | 1.41 | 1.41 | 3.11 | 2.96 | 2.29 | -1.81 | -2.04 | -2.34 | -4.89 |
| Aggregative | 1.17 | 1.17 | 5.46 | 3.17 | 2.38 | 1.53 | -0.14 | 0.42 | 0.37 |

*Source: van Dijk (2013)*

Here productivity growth is combination of shift of the production frontier and technical efficiency representing the rate at which an economy moves towards the frontier (see Weil, 2nd ed.). Clearly, SSA nations have lower labor productivity growth rate esp. in manufacturing, wholesale and retail trade, construction, and transport & communications, and agriculture. Labor productivity gap in SSA is highest in manufacturing compared to say, China (7%), ICs (1.74%), India (1.59%), Asian Tigers (4.55%). Thus, from the table, we can infer that there are significant inter-sectoral and inter-regional gaps in labor productivity and hence, in TFP. Most of the productivity growth in China and other have been caused by technology diffusion, and efficiency improvement while in case of the ICs, most of the productivity growth is higher due to production near/on the frontier with limited catchup.

As the objective of this research –as mentioned throughout this document—is to show how African nations suffering from low productivity growth (low labor productivity) and premature industrialization (*a la* Fosu 2017, Rodrik 2017—to name a few) could benefit from overcoming relative backwardness (Findlay 1978) or technology gap causing 'differences' in labor productivity, we consider only 'productivity' related shocks, *not the trade policy simulations*. World Bank (2020) and IMF (2019) and some other studies have considered trade policy configuration studies. Therefore, we do not reinvent the wheel because, in that case, our research will generate results---might be different in magnitude depending on policy shocks—but quite similar in nature, that is more trade under trade liberalization, preferential access, and welfare gains like in typical gains from trade argument. That will not, however, serve the purpose. Given there will be trade under AfCFTA or trade liberalization, rather we show how trade-led productivity benefits –via global flows of imported intermediates embodying technological progress, or technology spillovers from major trade partners ---could induce productivity "bonus" through multi-sectoral and multi-regional linkages and gains from trade under standard Neo-

Classical trade-growth channel (say, Ricardian, Specific-Factor, or Heckscher-Ohlin Trade model and its extensions). Abegaz and Lahiri (2020) has shown the prospects of efficiency spillovers improving productivity via trade and FDI for Domestic-Exporting firms in Ethiopian Manufacturing. Fosu (2017) has talked about 'African growth miracle' in terms of these effects transmission and their utilization via appropriate policies.

In fact, Das (2007, 2012, 2018 & 2020) has shown the role of different factors—skill, capital-labor ratio, and institutions, apart from trade—in capturing trade-induced productivity spillover accrual as a 'bonus'. The following table shows inter-regional differences in such dimensions.

**Table C.1. TFP determinant indexes and their indicators for OECD countries (21) and non-OECD countries (115), average (standard deviation), 1985–2014**

| | OECD | Non-OECD by region | | | | | |
|---|---|---|---|---|---|---|---|
| | | East Asia and Pacific | Europe and Central Asia | Latin America and Caribbean | Middle East and North Africa | South Asia | Sub-Saharan Africa |
| **Overall determinant index** | 74.38 (11.66) | 35.87 (21.91) | 41.13 (11.85) | 32.10 (9.00) | 35.55 (14.52) | 20.76 (6.62) | 18.16 (7.79) |
| **I. Innovation index** | 37.49 (16.06) | 11.95 (19.73) | 9.45 (7.19) | 4.46 (2.80) | 12.32 (15.85) | 3.59 (2.00) | 3.74 (1.62) |
| Research and development expenditure (% of GDP) | 1.85 (0.85) | 0.50 (0.76) | 0.53 (0.40) | 0.26 (0.22) | 0.70 (0.88) | 0.28 (0.21) | 0.29 (0.14) |
| Number of patents (per 100 people) | 0.13 (0.14) | 0.08 (0.16) | 0.03 (0.02) | 0.01 (0.01) | 0.05 (0.08) | 0.00 (0.00) | 0.00 (0.01) |
| Number of journal articles (per 100 people) | 0.09 (0.05) | 0.01 (0.04) | 0.02 (0.03) | 0.00 (0.01) | 0.02 (0.03) | 0.00 (0.00) | 0.00 (0.00) |
| **II. Education index** | 61.12 (12.88) | 33.62 (22.01) | 49.87 (12.10) | 31.54 (10.69) | 33.47 (12.48) | 18.88 (8.05) | 15.28 (7.82) |
| Government expenditure on education, total (% of GDP) | 5.21 (1.15) | 3.11 (1.38) | 4.19 (1.24) | 3.83 (1.80) | 4.83 (1.93) | 2.75 (0.81) | 4.02 (2.54) |
| Percentage of population aged 25-64 with completed secondary schooling | 30.10 (11.93) | 16.96 (12.49) | 42.78 (16.05) | 16.91 (7.93) | 16.61 (8.74) | 12.69 (9.97) | 7.42 (7.08) |
| Percentage of population aged 25-64 with completed tertiary schooling | 14.06 (6.42) | 6.90 (7.65) | 10.17 (4.77) | 7.10 (4.55) | 7.39 (6.01) | 4.20 (2.17) | 1.17 (0.84) |
| PISA, average of math, science, and reading | 503.47 (21.43) | 438.37 (76.21) | 427.63 (44.57) | 408.83 (25.57) | 405.57 (30.81) | 370.94 (14.62) | 368.65 (2.82) |
| **III. Market efficiency index** | 82.94 (9.90) | 54.04 (19.74) | 52.06 (12.42) | 47.12 (10.67) | 45.67 (14.09) | 38.55 (5.92) | 34.47 (12.49) |
| a. World Bank Doing Business scores | 72.37 (9.61) | 48.02 (19.82) | 45.33 (18.13) | 44.14 (14.21) | 43.33 (15.88) | 38.45 (13.60) | 31.87 (15.26) |
| b. IMF Financial Development Index | 0.66 (0.16) | 0.34 (0.24) | 0.20 (0.15) | 0.22 (0.11) | 0.29 (0.14) | 0.22 (0.09) | 0.11 (0.08) |
| c. Labor market index | -0.92 (0.37) | 0.01 (0.87) | -0.67 (0.48) | 0.13 (0.54) | 0.64 (0.83) | 0.99 (0.46) | 0.58 (1.17) |
| - Ratio of minimum wage to value added per worker | 0.25 (0.14) | 0.35 (0.26) | 0.29 (0.13) | 0.56 (0.39) | 0.45 (0.41) | 0.38 (0.33) | 0.64 (0.56) |
| - Severance pay for redundancy dismissal (weeks of salary) | 4.33 (5.81) | 20.26 (15.25) | 8.74 (4.59) | 17.72 (7.73) | 14.12 (9.70) | 25.89 (13.58) | 14.52 (16.67) |
| - Share of women in wage employment in the nonagricultural sector (% of total nonagricultural employment) | 45.37 (4.39) | 39.52 (5.50) | 44.23 (8.35) | 40.10 (5.47) | 20.25 (10.64) | 20.47 (7.12) | 27.74 (10.74) |
| **IV. Infrastructure index** | 71.55 (9.53) | 33.55 (16.91) | 47.64 (10.39) | 36.80 (9.50) | 42.24 (12.60) | 24.04 (8.77) | 18.94 (7.37) |

| | OECD | Non-OECD by region | | | | | |
|---|---|---|---|---|---|---|---|
| | | East Asia and Pacific | Europe and Central Asia | Latin America and Caribbean | Middle East and North Africa | South Asia | Sub-Saharan Africa |
| Fixed telephone subscriptions (per 100 people) | 48.40 (10.77) | 13.76 (18.29) | 18.81 (10.67) | 11.05 (8.13) | 14.04 (12.30) | 2.04 (3.25) | 1.21 (1.99) |
| Mobile cellular subscriptions (per 100 people) | 53.97 (49.71) | 33.76 (49.96) | 37.77 (49.52) | 31.96 (44.52) | 34.36 (45.99) | 15.78 (26.73) | 15.21 (28.23) |
| Electricity production (kWh per 100 people) | 932462.60 (559809.30) | 199921.20 (251765.20) | 355155.10 (167625.10) | 174065.30 (173809.20) | 356559.90 (456594.60) | 28440.79 (21837.76) | 35189.09 (80191.89) |
| Paved roads (km per 100 people) | 1.20 (0.48) | 0.07 (0.07) | 0.51 (0.37) | 0.14 (0.15) | 0.17 (0.07) | 0.11 (0.13) | 0.06 (0.08) |
| Improved sanitation facilities (% of population with access) | 98.48 (2.51) | 62.70 (30.08) | 88.30 (10.93) | 71.56 (19.84) | 82.82 (17.96) | 38.58 (23.20) | 24.55 (15.58) |
| Improved water source (% of population with access) | 99.60 (0.96) | 74.15 (22.66) | 91.02 (11.69) | 85.85 (10.22) | 89.76 (12.24) | 71.65 (20.94) | 59.81 (17.14) |
| **V. Institutions index** | 89.37 (7.19) | 54.84 (17.71) | 51.30 (15.58) | 54.15 (12.67) | 52.73 (12.22) | 41.83 (12.48) | 43.90 (13.32) |
| Voice and accountability | 1.39 (0.22) | -0.46 (0.85) | -0.23 (0.89) | 0.03 (0.67) | -0.64 (0.53) | -0.58 (0.70) | -0.70 (0.71) |
| Control of corruption | 1.76 (0.61) | -0.16 (1.01) | -0.47 (0.66) | -0.27 (0.72) | -0.12 (0.69) | -0.77 (0.55) | -0.59 (0.65) |
| Government effectiveness | 1.69 (0.44) | 0.02 (0.94) | -0.35 (0.74) | -0.20 (0.64) | -0.06 (0.70) | -0.67 (0.65) | -0.70 (0.63) |
| Political stability | 1.05 (0.42) | -0.21 (0.92) | -0.25 (0.86) | -0.34 (0.66) | -0.50 (0.95) | -1.45 (0.72) | -0.71 (1.02) |
| Regulatory quality | 1.42 (0.38) | -0.02 (1.06) | -0.22 (0.89) | 0.05 (0.73) | -0.21 (0.74) | -0.72 (0.71) | -0.65 (0.66) |
| Rule of law | 1.54 (0.35) | -0.17 (0.87) | -0.46 (0.78) | -0.46 (0.71) | -0.08 (0.67) | -0.59 (0.72) | -0.77 (0.68) |

*Source: Kim and Loayza (May 2019). Productivity Growth: Patterns and Determinants across the World. World Bank, Washington DC.*

*See **Table 10 below,** which also provides rationale for our scenarios summarized below.*

| | Table 10 | Different Indicators for industrialization and diversifiction in selected lists of countries in our current implementation. | | | | | |
|---|---|---|---|---|---|---|---|
| Country Name | Indicator Id | Indicator | 2010 | 2011 | 2012 | 2013 | 2014 |
| Algeria | 3793 | Industrialization intensity index | 0.23 | 0.22 | 0.22 | 0.22 | 0.23 |
| | 3794 | Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad | 0.30 | 0.27 | 0.27 | 0.27 | 0.27 |
| | 3796 | Medium- and High-Tech manufactured Exports share in total manufactured exports | 0.00 | 0.01 | 0.01 | 0.01 | 0.02 |
| | 3804 | Industrial export quality index | 0.13 | 0.13 | 0.12 | 0.12 | 0.17 |
| | 3806 | Share of manufactured exports in total exports index | 0.26 | 0.26 | 0.23 | 0.22 | 0.32 |
| Burundi | 3793 | Industrialization intensity index | 0.17 | 0.17 | 0.18 | 0.18 | 0.19 |
| | 3794 | Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 |
| | 3796 | Medium- and High-Tech manufactured Exports share in total manufactured exports | 0.24 | 0.35 | 0.25 | 0.28 | 0.26 |
| | 3804 | Industrial export quality index | 0.22 | 0.29 | 0.23 | 0.26 | 0.30 |
| | 3806 | Share of manufactured exports in total exports index | 0.16 | 0.17 | 0.17 | 0.19 | 0.32 |
| Botswana | 3793 | Industrialization intensity index | 0.14 | 0.14 | 0.14 | 0.11 | 0.18 |
| | 3794 | Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad | 0.10 | 0.09 | 0.09 | 0.04 | 0.16 |
| | 3796 | Medium- and High-Tech manufactured Exports share in total manufactured exports | 0.05 | 0.06 | 0.05 | 0.03 | 0.03 |
| | 3804 | Industrial export quality index | 0.51 | 0.53 | 0.52 | 0.50 | 0.50 |
| | 3806 | Share of manufactured exports in total exports index | 0.96 | 0.99 | 0.98 | 0.97 | 0.96 |
| Central African Rep | 3793 | Industrialization intensity index | 0.31 | 0.32 | 0.32 | 0.32 | 0.32 |
| | 3794 | Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 |
| | 3796 | Medium- and High-Tech manufactured Exports share in total manufactured exports | 0.08 | 0.13 | 0.24 | 0.14 | 0.01 |
| | 3804 | Industrial export quality index | 0.21 | 0.23 | 0.29 | 0.32 | 0.43 |
| | 3806 | Share of manufactured exports in total exports index | 0.32 | 0.31 | 0.32 | 0.48 | 0.86 |
| Cote d'Ivoire | 3793 | Industrialization intensity index | 0.30 | 0.31 | 0.28 | 0.27 | 0.27 |
| | 3794 | Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 |
| | 3796 | Medium- and High-Tech manufactured Exports share in total manufactured exports | 0.33 | 0.19 | 0.16 | 0.46 | 0.32 |
| | 3804 | Industrial export quality index | 0.38 | 0.26 | 0.27 | 0.49 | 0.35 |
| | 3806 | Share of manufactured exports in total exports index | 0.37 | 0.30 | 0.35 | 0.45 | 0.35 |
| Cameroon | 3793 | Industrialization intensity index | 0.27 | 0.27 | 0.26 | 0.26 | 0.26 |
| | 3794 | Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 |
| | 3796 | Medium- and High-Tech manufactured Exports share in total manufactured exports | 0.11 | 0.29 | 0.14 | 0.14 | 0.16 |
| | 3804 | Industrial export quality index | 0.24 | 0.40 | 0.25 | 0.25 | 0.22 |
| | 3806 | Share of manufactured exports in total exports index | 0.33 | 0.47 | 0.34 | 0.33 | 0.27 |
| Congo, Rep. | 3793 | Industrialization intensity index | 0.06 | 0.06 | 0.07 | 0.07 | 0.07 |
| | 3794 | Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| | 3796 | Medium- and High-Tech manufactured Exports share in total manufactured exports | 0.83 | 0.88 | 0.87 | 0.86 | 0.94 |
| | 3804 | Industrial export quality index | 0.68 | 0.62 | 0.61 | 0.63 | 0.69 |
| | 3806 | Share of manufactured exports in total exports index | 0.36 | 0.24 | 0.23 | 0.27 | 0.38 |

*Continued….*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Egypt, Arab Rep. | 3793 | Industrialization intensity index | 0.37 | 0.37 | 0.35 | 0.35 | 0.37 |
| | 3794 | Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad | 0.23 | 0.23 | 0.20 | 0.20 | 0.20 |
| | 3796 | Medium- and High-Tech manufactured Exports share in total manufactured exports | 0.26 | 0.28 | 0.31 | 0.32 | 0.34 |
| | 3804 | Industrial export quality index | 0.47 | 0.48 | 0.50 | 0.51 | 0.53 |
| | 3806 | Share of manufactured exports in total exports index | 0.64 | 0.64 | 0.64 | 0.66 | 0.69 |
| Eritrea | 3793 | Industrialization intensity index | 0.12 | 0.13 | 0.13 | 0.13 | 0.14 |
| | 3794 | Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad | 0.06 | 0.07 | 0.09 | 0.09 | 0.09 |
| | 3796 | Medium- and High-Tech manufactured Exports share in total manufactured exports | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 |
| | 3804 | Industrial export quality index | 0.26 | 0.26 | 0.26 | 0.26 | 0.25 |
| | 3806 | Share of manufactured exports in total exports index | 0.35 | 0.35 | 0.35 | 0.35 | 0.34 |
| Ethiopia | 3793 | Industrialization intensity index | 0.11 | 0.12 | 0.12 | 0.16 | 0.16 |
| | 3794 | Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad | 0.11 | 0.10 | 0.11 | 0.17 | 0.16 |
| | 3796 | Medium- and High-Tech manufactured Exports share in total manufactured exports | 0.32 | 0.13 | 0.18 | 0.13 | 0.29 |
| | 3804 | Industrial export quality index | 0.24 | 0.13 | 0.15 | 0.15 | 0.19 |
| | 3806 | Share of manufactured exports in total exports index | 0.10 | 0.12 | 0.10 | 0.15 | 0.07 |
| Ghana | 3793 | Industrialization intensity index | 0.09 | 0.09 | 0.09 | 0.08 | 0.08 |
| | 3794 | Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| | 3796 | Medium- and High-Tech manufactured Exports share in total manufactured exports | 0.25 | 0.06 | 0.20 | 0.33 | 0.33 |
| | 3804 | Industrial export quality index | 0.21 | 0.22 | 0.19 | 0.27 | 0.26 |
| | 3806 | Share of manufactured exports in total exports index | 0.13 | 0.37 | 0.15 | 0.16 | 0.16 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Gambia, The** | **3793** | **Industrialization intensity index** | **0.09** | **0.09** | **0.09** | **0.09** | **0.09** |
| | **3794** | **Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad** | **0.04** | **0.04** | **0.04** | **0.04** | **0.04** |
| | **3796** | **Medium- and High-Tech manufactured Exports share in total manufactured exports** | **0.00** | **0.03** | **0.01** | **0.06** | **0.11** |
| | **3804** | **Industrial export quality index** | **0.18** | **0.20** | **0.34** | **0.08** | **0.08** |
| | **3806** | **Share of manufactured exports in total exports index** | **0.35** | **0.36** | **0.67** | **0.10** | **0.05** |
| **Kenya** | **3793** | **Industrialization intensity index** | **0.22** | **0.22** | **0.21** | **0.23** | **0.24** |
| | **3794** | **Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad** | **0.09** | **0.08** | **0.08** | **0.12** | **0.13** |
| | **3796** | **Medium- and High-Tech manufactured Exports share in total manufactured exports** | **0.25** | **0.25** | **0.22** | **0.22** | **0.22** |
| | **3804** | **Industrial export quality index** | **0.40** | **0.39** | **0.37** | **0.37** | **0.36** |
| | **3806** | **Share of manufactured exports in total exports index** | **0.50** | **0.50** | **0.50** | **0.49** | **0.48** |
| **Morocco** | **3793** | **Industrialization intensity index** | **0.37** | **0.37** | **0.36** | **0.36** | **0.37** |
| | **3794** | **Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad** | **0.28** | **0.28** | **0.27** | **0.28** | **0.28** |
| | **3796** | **Medium- and High-Tech manufactured Exports share in total manufactured exports** | **0.38** | **0.40** | **0.42** | **0.45** | **0.49** |
| | **3804** | **Industrial export quality index** | **0.63** | **0.63** | **0.65** | **0.67** | **0.67** |
| | **3806** | **Share of manufactured exports in total exports index** | **0.79** | **0.80** | **0.80** | **0.81** | **0.81** |
| **Madagascar** | **3793** | **Industrialization intensity index** | **0.22** | **0.23** | **0.22** | **0.22** | **0.23** |
| | **3794** | **Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad** | **0.04** | **0.04** | **0.04** | **0.04** | **0.04** |
| | **3796** | **Medium- and High-Tech manufactured Exports share in total manufactured exports** | **0.04** | **0.08** | **0.03** | **0.04** | **0.05** |
| | **3804** | **Industrial export quality index** | **0.39** | **0.40** | **0.35** | **0.31** | **0.27** |
| | **3806** | **Share of manufactured exports in total exports index** | **0.74** | **0.71** | **0.67** | **0.58** | **0.48** |
| **Mozambique** | **3793** | **Industrialization intensity index** | **0.24** | **0.23** | **0.24** | **0.23** | **0.24** |
| | **3794** | **Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad** | **0.11** | **0.11** | **0.11** | **0.11** | **0.11** |
| | **3796** | **Medium- and High-Tech manufactured Exports share in total manufactured exports** | **0.09** | **0.27** | **0.38** | **0.45** | **0.45** |
| | **3804** | **Industrial export quality index** | **0.09** | **0.27** | **0.37** | **0.40** | **0.38** |
| | **3806** | **Share of manufactured exports in total exports index** | **0.08** | **0.24** | **0.30** | **0.29** | **0.28** |
| **Malawi** | **3793** | **Industrialization intensity index** | **0.21** | **0.21** | **0.20** | **0.21** | **0.21** |
| | **3794** | **Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad** | **0.11** | **0.11** | **0.11** | **0.11** | **0.11** |
| | **3796** | **Medium- and High-Tech manufactured Exports share in total manufactured exports** | **0.15** | **0.15** | **0.11** | **0.13** | **0.50** |
| | **3804** | **Industrial export quality index** | **0.23** | **0.27** | **0.18** | **0.23** | **0.41** |
| | **3806** | **Share of manufactured exports in total exports index** | **0.28** | **0.36** | **0.23** | **0.30** | **0.28** |
| **Namibia** | **3793** | **Industrialization intensity index** | **0.23** | **0.22** | **0.21** | **0.21** | **0.20** |
| | **3794** | **Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad** | **0.07** | **0.07** | **0.08** | **0.07** | **0.07** |
| | **3796** | **Medium- and High-Tech manufactured Exports share in total manufactured exports** | **0.14** | **0.17** | **0.11** | **0.26** | **0.34** |
| | **3804** | **Industrial export quality index** | **0.36** | **0.38** | **0.40** | **0.50** | **0.53** |
| | **3806** | **Share of manufactured exports in total exports index** | **0.55** | **0.56** | **0.67** | **0.70** | **0.70** |
| **Niger** | **3793** | **Industrialization intensity index** | **0.20** | **0.20** | **0.21** | **0.22** | **0.22** |
| | **3794** | **Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad** | **0.23** | **0.23** | **0.23** | **0.23** | **0.23** |
| | **3796** | **Medium- and High-Tech manufactured Exports share in total manufactured exports** | **0.13** | **0.05** | **0.02** | **0.06** | **0.11** |
| | **3804** | **Industrial export quality index** | **0.42** | **0.43** | **0.43** | **0.49** | **0.51** |
| | **3806** | **Share of manufactured exports in total exports index** | **0.69** | **0.80** | **0.84** | **0.90** | **0.90** |
| **Nigeria** | **3793** | **Industrialization intensity index** | **0.28** | **0.30** | **0.31** | **0.33** | **0.35** |
| | **3794** | **Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad** | **0.33** | **0.33** | **0.33** | **0.33** | **0.33** |
| | **3796** | **Medium- and High-Tech manufactured Exports share in total manufactured exports** | **0.07** | **0.09** | **0.11** | **0.19** | **0.19** |
| | **3804** | **Industrial export quality index** | **0.15** | **0.13** | **0.13** | **0.14** | **0.18** |
| | **3806** | **Share of manufactured exports in total exports index** | **0.21** | **0.16** | **0.14** | **0.06** | **0.15** |
| **Rwanda** | **3793** | **Industrialization intensity index** | **0.11** | **0.12** | **0.11** | **0.11** | **0.11** |
| | **3794** | **Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad** | **0.07** | **0.07** | **0.07** | **0.07** | **0.07** |
| | **3796** | **Medium- and High-Tech manufactured Exports share in total manufactured exports** | **0.08** | **0.05** | **0.11** | **0.05** | **0.08** |
| | **3804** | **Industrial export quality index** | **0.28** | **0.35** | **0.34** | **0.36** | **0.36** |
| | **3806** | **Share of manufactured exports in total exports index** | **0.47** | **0.64** | **0.54** | **0.66** | **0.64** |
| **Senegal** | **3793** | **Industrialization intensity index** | **0.30** | **0.33** | **0.32** | **0.30** | **0.31** |
| | **3794** | **Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad** | **0.21** | **0.24** | **0.23** | **0.22** | **0.22** |
| | **3796** | **Medium- and High-Tech manufactured Exports share in total manufactured exports** | **0.14** | **0.13** | **0.16** | **0.15** | **0.20** |
| | **3804** | **Industrial export quality index** | **0.45** | **0.42** | **0.43** | **0.40** | **0.41** |
| | **3806** | **Share of manufactured exports in total exports index** | **0.73** | **0.70** | **0.67** | **0.63** | **0.62** |
| **Swaziland** | **3793** | **Industrialization intensity index** | **0.50** | **0.50** | **0.50** | **0.50** | **0.50** |
| | **3794** | **Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad** | **0.01** | **0.02** | **0.02** | **0.02** | **0.02** |
| | **3796** | **Medium- and High-Tech manufactured Exports share in total manufactured exports** | **0.29** | **0.29** | **0.29** | **0.29** | **0.29** |
| | **3804** | **Industrial export quality index** | **0.65** | **0.64** | **0.64** | **0.64** | **0.62** |
| | **3806** | **Share of manufactured exports in total exports index** | **0.95** | **0.95** | **0.95** | **0.94** | **0.93** |
| **Tunisia** | **3793** | **Industrialization intensity index** | **0.36** | **0.36** | **0.36** | **0.36** | **0.37** |
| | **3794** | **Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad** | **0.20** | **0.20** | **0.20** | **0.20** | **0.20** |
| | **3796** | **Medium- and High-Tech manufactured Exports share in total manufactured exports** | **0.45** | **0.46** | **0.45** | **0.47** | **0.47** |
| | **3804** | **Industrial export quality index** | **0.69** | **0.68** | **0.69** | **0.70** | **0.67** |
| | **3806** | **Share of manufactured exports in total exports index** | **0.85** | **0.84** | **0.86** | **0.86** | **0.85** |
| **Tanzania** | **3793** | **Industrialization intensity index** | **0.15** | **0.15** | **0.15** | **0.15** | **0.15** |
| | **3794** | **Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad** | **0.09** | **0.09** | **0.09** | **0.09** | **0.09** |
| | **3796** | **Medium- and High-Tech manufactured Exports share in total manufactured exports** | **0.14** | **0.17** | **0.23** | **0.22** | **0.11** |
| | **3804** | **Industrial export quality index** | **0.33** | **0.31** | **0.32** | **0.32** | **0.27** |
| | **3806** | **Share of manufactured exports in total exports index** | **0.50** | **0.43** | **0.38** | **0.37** | **0.41** |
| **Uganda** | **3793** | **Industrialization intensity index** | **0.21** | **0.21** | **0.20** | **0.20** | **0.20** |
| | **3794** | **Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad** | **0.11** | **0.11** | **0.11** | **0.11** | **0.11** |
| | **3796** | **Medium- and High-Tech manufactured Exports share in total manufactured exports** | **0.15** | **0.32** | **0.33** | **0.14** | **0.15** |
| | **3804** | **Industrial export quality index** | **0.27** | **0.44** | **0.47** | **0.27** | **0.28** |
| | **3806** | **Share of manufactured exports in total exports index** | **0.36** | **0.52** | **0.56** | **0.38** | **0.40** |
| **South Africa** | **3793** | **Industrialization intensity index** | **0.34** | **0.34** | **0.33** | **0.33** | **0.34** |
| | **3794** | **Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad** | **0.25** | **0.24** | **0.24** | **0.24** | **0.24** |
| | **3796** | **Medium- and High-Tech manufactured Exports share in total manufactured exports** | **0.46** | **0.44** | **0.45** | **0.44** | **0.46** |
| | **3804** | **Industrial export quality index** | **0.64** | **0.57** | **0.60** | **0.59** | **0.60** |
| | **3806** | **Share of manufactured exports in total exports index** | **0.73** | **0.65** | **0.68** | **0.68** | **0.70** |

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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Zambia** | **3793** | **Industrialization intensity index** | **0.25** | **0.25** | **0.25** | **0.25** | **0.25** |
| | **3794** | **Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad** | **0.21** | **0.21** | **0.21** | **0.21** | **0.21** |
| | **3796** | **Medium- and High-Tech manufactured Exports share in total manufactured exports** | **0.14** | **0.30** | **0.19** | **0.23** | **0.25** |
| | **3804** | **Industrial export quality index** | **0.19** | **0.26** | **0.21** | **0.26** | **0.22** |
| | **3806** | **Share of manufactured exports in total exports index** | **0.20** | **0.18** | **0.19** | **0.25** | **0.17** |
| **China** | **3793** | **Industrialization intensity index** | **0.73** | **0.74** | **0.74** | **0.74** | **0.76** |
| | **3794** | **Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad** | **0.41** | **0.41** | **0.41** | **0.41** | **0.41** |
| | **3796** | **Medium- and High-Tech manufactured Exports share in total manufactured exports** | **0.61** | **0.59** | **0.58** | **0.58** | **0.57** |
| | **3804** | **Industrial export quality index** | **0.86** | **0.83** | **0.83** | **0.83** | **0.79** |
| | **3806** | **Share of manufactured exports in total exports index** | **0.99** | **0.99** | **0.99** | **0.98** | **0.97** |
| **India** | **3793** | **Industrialization intensity index** | **0.44** | **0.45** | **0.43** | **0.42** | **0.43** |
| | **3794** | **Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad** | **0.39** | **0.41** | **0.40** | **0.40** | **0.40** |
| | **3796** | **Medium- and High-Tech manufactured Exports share in total manufactured exports** | **0.28** | **0.28** | **0.28** | **0.29** | **0.30** |
| | **3804** | **Industrial export quality index** | **0.61** | **0.58** | **0.59** | **0.59** | **0.58** |
| | **3806** | **Share of manufactured exports in total exports index** | **0.87** | **0.85** | **0.86** | **0.84** | **0.84** |
| **Costa Rica** | **3793** | **Industrialization intensity index** | **0.32** | **0.32** | **0.32** | **0.32** | **0.32** |
| | **3794** | **Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad** | **0.15** | **0.15** | **0.14** | **0.14** | **0.14** |
| | **3796** | **Medium- and High-Tech manufactured Exports share in total manufactured exports** | **0.59** | **0.59** | **0.60** | **0.62** | **0.62** |
| | **3804** | **Industrial export quality index** | **0.73** | **0.71** | **0.72** | **0.74** | **0.71** |
| | **3806** | **Share of manufactured exports in total exports index** | **0.75** | **0.76** | **0.76** | **0.76** | **0.75** |
| **Ecuador** | **3793** | **Industrialization intensity index** | **0.24** | **0.24** | **0.24** | **0.23** | **0.22** |
| | **3794** | **Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad** | **0.08** | **0.08** | **0.08** | **0.08** | **0.08** |
| | **3796** | **Medium- and High-Tech manufactured Exports share in total manufactured exports** | **0.23** | **0.19** | **0.21** | **0.16** | **0.16** |
| | **3804** | **Industrial export quality index** | **0.25** | **0.21** | **0.23** | **0.18** | **0.16** |
| | **3806** | **Share of manufactured exports in total exports index** | **0.22** | **0.21** | **0.21** | **0.18** | **0.16** |
| **Honduras** | **3793** | **Industrialization intensity index** | **0.29** | **0.29** | **0.28** | **0.29** | **0.28** |
| | **3794** | **Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad** | **0.07** | **0.07** | **0.07** | **0.07** | **0.07** |
| | **3796** | **Medium- and High-Tech manufactured Exports share in total manufactured exports** | **0.26** | **0.27** | **0.37** | **0.37** | **0.37** |
| | **3804** | **Industrial export quality index** | **0.42** | **0.36** | **0.47** | **0.47** | **0.48** |
| | **3806** | **Share of manufactured exports in total exports index** | **0.53** | **0.42** | **0.52** | **0.51** | **0.57** |
| **Haiti** | **3793** | **Industrialization intensity index** | **0.16** | **0.18** | **0.18** | **0.18** | **0.18** |
| | **3794** | **Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad** | **0.05** | **0.05** | **0.05** | **0.05** | **0.05** |
| | **3796** | **Medium- and High-Tech manufactured Exports share in total manufactured exports** | **0.04** | **0.04** | **0.04** | **0.04** | **0.04** |
| | **3804** | **Industrial export quality index** | **0.45** | **0.45** | **0.45** | **0.44** | **0.43** |
| | **3806** | **Share of manufactured exports in total exports index** | **0.85** | **0.85** | **0.85** | **0.84** | **0.83** |
| **El Salvador** | **3793** | **Industrialization intensity index** | **0.39** | **0.40** | **0.39** | **0.40** | **0.40** |
| | **3794** | **Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad** | **0.19** | **0.19** | **0.19** | **0.19** | **0.19** |
| | **3796** | **Medium- and High-Tech manufactured Exports share in total manufactured exports** | **0.15** | **0.15** | **0.15** | **0.14** | **0.14** |
| | **3804** | **Industrial export quality index** | **0.53** | **0.51** | **0.54** | **0.54** | **0.54** |
| | **3806** | **Share of manufactured exports in total exports index** | **0.88** | **0.84** | **0.92** | **0.92** | **0.93** |
| **Yemen, Rep.** | **3793** | **Industrialization intensity index** | **0.13** | **0.14** | **0.14** | **0.14** | **0.14** |
| | **3794** | **Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad** | **0.02** | **0.02** | **0.02** | **0.02** | **0.02** |
| | **3796** | **Medium- and High-Tech manufactured Exports share in total manufactured exports** | **0.06** | **0.12** | **0.10** | **0.06** | **0.23** |
| | **3804** | **Industrial export quality index** | **0.08** | **0.11** | **0.10** | **0.09** | **0.18** |
| | **3806** | **Share of manufactured exports in total exports index** | **0.10** | **0.09** | **0.09** | **0.12** | **0.11** |
| **Tonga** | **3793** | **Industrialization intensity index** | **0.09** | **0.10** | **0.09** | **0.10** | **0.10** |
| | **3794** | **Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad** | **0.02** | **0.02** | **0.02** | **0.02** | **0.02** |
| | **3796** | **Medium- and High-Tech manufactured Exports share in total manufactured exports** | **0.21** | **0.19** | **0.50** | **0.31** | **0.23** |
| | **3804** | **Industrial export quality index** | **0.23** | **0.17** | **0.34** | **0.24** | **0.35** |
| | **3806** | **Share of manufactured exports in total exports index** | **0.22** | **0.13** | **0.11** | **0.12** | **0.46** |
| **Canada** | **3793** | **Industrialization intensity index** | **0.32** | **0.32** | **0.33** | **0.33** | **0.34** |
| | **3794** | **Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad** | **0.30** | **0.30** | **0.31** | **0.31** | **0.31** |
| | **3796** | **Medium- and High-Tech manufactured Exports share in total manufactured exports** | **0.56** | **0.54** | **0.57** | **0.57** | **0.58** |
| | **3804** | **Industrial export quality index** | **0.65** | **0.62** | **0.64** | **0.63** | **0.60** |
| | **3806** | **Share of manufactured exports in total exports index** | **0.64** | **0.61** | **0.63** | **0.61** | **0.58** |
| **France** | **3793** | **Industrialization intensity index** | **0.43** | **0.43** | **0.44** | **0.44** | **0.45** |
| | **3794** | **Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad** | **0.48** | **0.48** | **0.49** | **0.50** | **0.48** |
| | **3796** | **Medium- and High-Tech manufactured Exports share in total manufactured exports** | **0.66** | **0.64** | **0.65** | **0.65** | **0.65** |
| | **3804** | **Industrial export quality index** | **0.85** | **0.81** | **0.82** | **0.82** | **0.79** |
| | **3806** | **Share of manufactured exports in total exports index** | **0.91** | **0.89** | **0.90** | **0.89** | **0.88** |
| **United Kingdom** | **3793** | **Industrialization intensity index** | **0.42** | **0.42** | **0.42** | **0.42** | **0.42** |
| | **3794** | **Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad** | **0.50** | **0.50** | **0.49** | **0.51** | **0.48** |
| | **3796** | **Medium- and High-Tech manufactured Exports share in total manufactured exports** | **0.63** | **0.62** | **0.63** | **0.64** | **0.68** |
| | **3804** | **Industrial export quality index** | **0.77** | **0.73** | **0.75** | **0.71** | **0.74** |
| | **3806** | **Share of manufactured exports in total exports index** | **0.79** | **0.75** | **0.78** | **0.68** | **0.76** |
| **Japan** | **3793** | **Industrialization intensity index** | **0.62** | **0.61** | **0.60** | **0.61** | **0.62** |
| | **3794** | **Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad** | **0.56** | **0.55** | **0.55** | **0.55** | **0.55** |
| | **3796** | **Medium- and High-Tech manufactured Exports share in total manufactured exports** | **0.80** | **0.79** | **0.80** | **0.78** | **0.78** |
| | **3804** | **Industrial export quality index** | **0.95** | **0.92** | **0.93** | **0.92** | **0.88** |
| | **3806** | **Share of manufactured exports in total exports index** | **0.94** | **0.94** | **0.95** | **0.93** | **0.92** |
| **Korea, Rep.** | **3793** | **Industrialization intensity index** | **0.78** | **0.84** | **0.82** | **0.81** | **0.83** |
| | **3794** | **Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad** | **0.62** | **0.69** | **0.67** | **0.63** | **0.63** |
| | **3796** | **Medium- and High-Tech manufactured Exports share in total manufactured exports** | **0.76** | **0.72** | **0.71** | **0.72** | **0.72** |
| | **3804** | **Industrial export quality index** | **0.95** | **0.91** | **0.90** | **0.91** | **0.87** |
| | **3806** | **Share of manufactured exports in total exports index** | **0.99** | **0.99** | **0.99** | **0.99** | **0.97** |
| **Singapore** | **3793** | **Industrialization intensity index** | **0.80** | **0.81** | **0.81** | **0.80** | **0.79** |
| | **3794** | **Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad** | **0.86** | **0.86** | **0.86** | **0.86** | **0.81** |
| | **3796** | **Medium- and High-Tech manufactured Exports share in total manufactured exports** | **0.69** | **0.64** | **0.64** | **0.66** | **0.66** |
| | **3804** | **Industrial export quality index** | **0.87** | **0.82** | **0.83** | **0.84** | **0.80** |
| | **3806** | **Share of manufactured exports in total exports index** | **0.92** | **0.92** | **0.91** | **0.90** | **0.89** |
| **United States** | **3793** | **Industrialization intensity index** | **0.46** | **0.45** | **0.45** | **0.45** | **0.47** |
| | **3794** | **Medium- and High-Tech Manufacturing Value Added share in total manufacturing value ad** | **0.48** | **0.47** | **0.47** | **0.47** | **0.47** |
| | **3796** | **Medium- and High-Tech manufactured Exports share in total manufactured exports** | **0.65** | **0.62** | **0.63** | **0.62** | **0.62** |
| | **3804** | **Industrial export quality index** | **0.78** | **0.74** | **0.75** | **0.74** | **0.71** |
| | **3806** | **Share of manufactured exports in total exports index** | **0.79** | **0.78** | **0.78** | **0.76** | **0.75** |

Source: World Bank 2019https://tcdata360.worldbank.org/indicators/mva.ind.int?country=BRA&indicator

As the stylized evidences show, China being the most important trade partner of Africa apart from some Industrialized nations (ICs) (See Tables 1—7 in Section 2)—in terms of importing source as well as export destinations –it is shown that for overcoming labor productivity growth 'gap' it is important to have trade more with industrialized nations in addition to the emerging economies such as, China, South Korea, and India. This is because –as mentioned elsewhere—still these nations are source of technology creation (growth progenitor) and historically speaking, European nations such as USA, Japan, and France has colonial legacy (for example, like EPA or AGOA). Then, we could have more productivity spillover via trade and capital flows from advanced developed countries (DCs) vis-à-vis emerging nations such as East Asian Tigers. The idea here is to compare the 'Status Quo (benchmark) with: (i) pre-Covid favorable shock and (ii) post-Covid adverse impacts. First, we shock 'China-effect' alone in case of labor productivity growth, intermediate-input augmenting technical change (for example, aiding Supply Chain network) in manufacturing and trade facilitation/logistics effects. Then, we consider the "China effects" with "China Plus" impacts and see the differences. We then ascribe the differences to establish stylized facts—indexes of industrialization, manufacturing value added, hi-tech value added, digitization indexes, etc.—and argue that for AfCFTA-driven industrialization agenda to be successful, it is better to diversify the sources of inputs—not only from China, for enrichment and product sophistication so that the export basket is diversified.

Followings are some of the potential policy scenarios from the analysis:

a) Effect of Technological spillovers due to R&D activities in ICT sector and impact of regional economic integration arrangements in achieving economic growth.
b) To identify the effects of technological change induced by ICT under different scenarios like trade in intermediates, technological progress.
c) Effect on welfare.

Based on preceding discussions and descriptive statistics, we consider welfare and output vis-à-vis trade effects of the following generic shocks:

(i) 'China-centric-shock' of 2.25% (Total Factor Productivity growth taken from recent World Bank and IMF studies mentioned above as per IMF (August 2019) and WB (May 2019).[25] This is pertinent as China has emerged as an innovation nation and grew faster than other Southern Engines of Economic Growth among the BRICSAM (see Zhou, Lazonick and Sun eds. 2016, Lu 2000, Das 2012 & 2013, etc.).

(ii) Similar effects in the presence of positive productivity shocks originating in *China and other industrialized countries (ICs)* who are important in terms of openness and trade. In fact, Jaworski and Keay (2020 show in the Context of Canadian region that exposure to international trade causes faster growth in industries and regions, and also manufacturing growth due to scale economies. The reason behind this is recent fall in labor productivity or TFP growth in China to 0.7% (World Bank 2020, IMF 2019). Zhang et al (2020) finds that –on the input slack-based productivity index—there has been decline in relative labor efficiency as well as slowdown in capital productivity.

(iii) Digitalization/ICT-led spillover. As IMF (2020) report shows that 'digital depth' being low, there are enormous potential for 'digital benefits'. Enhanced digital Access Index (EADI) is presented to show that with lack of penetration, such benefits for leveraging emerging and existing GPT is low. Even for Covid-led containment measures such as GPS or Digital Contact tracing (DCT), this is important. Arakpogun et al (2020), Das (2020a,b, & c) showed that such DCT could improve efficiency via 'design and deployment' with 'institutional and

[25] IMF (Ocotber 2019). file:///D:/ALL%20BUNCH%20WIPs/ALL%20CURRENT%20WIPS/JC%20GD%20AFA-AEA%202021/WRITEUPS/JC/1CHNEA2019003.pdf and https://www.lowyinstitute.org/the-interpreter/china-low-productivity-superpower

technological preparedness'. To avert 'unintended consequences' 'structural inequalities and digital divides' need to be addressed. We model this impact too.

(iv) Adverse Covid-shock affecting TFP and labor productivity, in particular, as Covid is a toll on human capital via live-livelihood (health vs wealth trade-off).

(v) Global alliance and cooperation is needed. As Zimmerman et al (2020) has shown that globalization could turn positive if forces such as benefits spillover could reduce fatality rates or human capital loss via collaborative efforts such as medical spillover via pharmaceuticals or sharing technology or telemedicine or mobile phones. This could cause 'reversal of adversity'.

(vi) As logistics infrastructure is important for trade and commerce, lack of digital depth in Africa could counter the movement of goods and people. Except financial sector, with 25% of GDP share, SSA is lagging. Logistics and infrastructural bottlenecks

**Table 11: List of Sets and their elements in GTAP**

| Sets | Description | Elements |
|---|---|---|
| REG | Regions | See Table 12 below |
| SRC | Source of Invention | USA, EU (France), China… |
| REG_NOT_SRC | Spillover Destinations | Rest of the others (depending on implementation) |
| PROD_COMM | Produced Commodities | Traded Goods, Capital Goods (CGDS) |
| TRAD_COMM | Traded Commodities | Traded Goods, Services |
| ENDW_COMM | Endowment Commodities | Land, Labor types, Capital, Natural Resources |
| DEMD_COMM | Demanded Commodities | Land, Labor, Capital, Produced commodities |
| CGDS_COMM | Capital Goods Commodities | Capital Goods (CGDS) |

**Closure of the current GTAP model ***

| Exogenous | Endogenous |
|---|---|
| pop<br>psaveslack pfactwld<br>profitslack incomeslack endwslack<br>cgdslack tradslack<br>ams atm atf ats atd<br>aosec aoreg avasec avareg<br>afcom afsec afreg afecom afesec afereg<br>aoall afall afeall<br>au dppriv dpgov dpsave<br>to tp tm tms tx txs<br>qo(ENDW_COMM,REG) ; | Rest; |

*****The contents of the table is an excerpt from the edited GEMPACK command file used to produce the simulations reported below. A short list of variables and their descriptions are not presented for parsimony. Implemented using Fortran-based GEMPACK program and Table Program Files. See Das (2003). Hertel (1997).

## 4.4 Database and Methodology:

We consider sub-regional grouping in the GTAP Database (base period 2014). The GTAP database (base period 2014) divides the world economy into 141 regions, 65sectors and 2 classes of labor. To decipher the temporal and spatial dispersion of technology and trade, we take the Global Trade Analysis Project's (GTAP) database (Version 10). This enables comparability of different industry aggregations across countries and helps identification of the sources of 'acquired' technology. For tracing the inter-regional and intersectoral effects of intra-African trade via AfCFTA, we will consider global multi-regional, multi-sectoral computable general equilibrium (CGE) model with modified extensions to suit our purpose, and calibrate the model with a 51-regions ×27-sector aggregation (Table 11) of GTAP database (Version 10).

Table 12: Sectoral and Regional Integration adopted for the Current Implementation based on GTAP Database Version 10

| No. | Sectors and Elements | | Description | | Regions and Elements | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | AgrlWood | 1 pdr | Paddy rice | 1 ANZ | Australia | New Zealan | Rest of Oceania | | | | | | | | | | |
| | | 2 wht | Wheat | 2 chn | China | | | | | | | | | | | | |
| | | 3 gro | Cereal grains nec | 3 hkg | Hong Kong | | | | | | | | | | | | |
| | | 4 v_f | Vegetables, fruit, nuts | 4 jpn | Japan | | | | | | | | | | | | |
| | | 5 osd | Oil seeds | 5 kor | Korea | | | | | | | | | | | | |
| | | 6 c_b | Sugar cane, sugar beet | 6 twn | Taiwan | | | | | | | | | | | | |
| | | 7 pfb | Plant-based fibers | 7 SEAsia | Cambodia | Indonesia | Lao People | Malaysia | Philippines | Singapore | Thailand | Viet Nam | Rest of Southeast Asia | | | | |
| | | 8 ocr | Crops nec | 8 ind | India | | | | | | | | | | | | |
| | | 12 wol | Wool, silk-worm cocoons | 9 SouthAsia | Nepal | Pakistan | Sri Lanka | Rest of South Asia | | Bangladesh | | | | | | | |
| | | 13 frs | Forestry | 10 can | Canada | | | | | | | | | | | | |
| | | 14 fsh | Fishing | 11 usa | United States of America | | | | | | | | | | | | |
| | | 30 lum | Wood products | 12 mex | Mexico | | | | | | | | | | | | |
| | | 31 ppp | Paper products, publishing | 13 arg | Argentina | | | | | | | | | | | | |
| 2 | Food | 9 ctl | Bovine cattle, sheep and goats | 14 bra | Brazil | | | | | | | | | | | | |
| | | 10 oap | Animal products nec | 15 RestSAmerica | Bolivia | Chile | Colombia | Ecuador | Paraguay | Peru | Uruguay | Venezuela | Rest of S Am | | | | |
| | | 11 rmk | Raw milk | 16 CentralAmer | Costa Rica | Guatemala | Honduras | Nicaragua | Panama | El Salvado | Rest of Ce | Dominican Republic | | | | | |
| | | 19 cmt | Bovine meat products | 17 Caribbean | Jamaica | Puerto Ric | Trinidad a | Caribbean | | | | | | | | | |
| | | 20 omt | Meat products nec | 18 aut | Austria | | | | | | | | | | | | |
| | | 21 vol | Vegetable oils and fats | 19 bel | Belgium | | | | | | | | | | | | |
| | | 22 mil | Dairy products | 20 EastEurope | Bulgaria | Croatia | Cyprus | Czech Rep | Romania | Slovakia | Slovenia | Albania | Belarus | Ukraine | Rest of Eas | Rest of Eu | |
| | | 23 pcr | Processed rice | 21 dnk | Denmark | | | | | | | | | | | | |
| | | 24 sgr | Sugar | 22 RestofEU | Estonia | Latvia | Lithuania | Luxembou | Malta | Rest of EFTA | | | | | | | |
| | | 25 ofd | Food products nec | 23 fin | Finland | | | | | | | | | | | | |
| | | 26 b_t | Beverages and tobacco produc | 24 fra | France | | | | | | | | | | | | |
| 3 | MineralGasOi | 36 nmm | Mineral products nec | 25 deu | Germany | | | | | | | | | | | | |
| 4 | tex | 27 tex | Textiles | 26 grc | Greece | | | | | | | | | | | | |
| 5 | wap | 28 wap | Wearing apparel | 27 hun | Hungary | | | | | | | | | | | | |
| 6 | lea | 29 lea | Leather products | 28 irl | Ireland | | | | | | | | | | | | |
| 7 | PetroleumCh | 32 p_c | Petroleum, coal products | 29 ita | Italy | | | | | | | | | | | | |
| | | 33 chm | Chemical products | 30 nld | Netherlands | | | | | | | | | | | | |
| | | 35 rpp | Rubber and plastic products | 31 pol | Poland | | | | | | | | | | | | |
| 8 | bph | 34 bph | Basic pharmaceutical products | 32 prt | Portugal | | | | | | | | | | | | |
| 9 | Metalproduc | 37 i_s | Ferrous metals | 33 esp | Spain | | | | | | | | | | | | |
| | | 38 nfm | Metals nec | 34 swe | Sweden | | | | | | | | | | | | |
| | | 39 fmp | Metal products | 35 gbr | United Kingdom | | | | | | | | | | | | |
| 10 | ele | 40 ele | Computer, electronic and optic | 36 che | Switzerland | | | | | | | | | | | | |
| 11 | eeq | 41 eeq | Electrical equipment | 37 nor | Norway | | | | | | | | | | | | |
| 12 | ome | 42 ome | Machinery and equipment nec | 38 rus | Russian Federation | | | | | | | | | | | | |
| 13 | mvh | 43 mvh | Motor vehicles and parts | 39 xee | Rest of Eastern Europe | | | | | | | | | | | | |
| 14 | otn | 44 otn | Transport equipment nec | 40 xer | Rest of Europe | | | | | | | | | | | | |
| 15 | omf | 45 omf | Manufactures nec | 41 CentralAsia | Kazakhsta | Kyrgyzsta | Tajikistan | Rest of Fo | Armenia | Azerbaijan | Georgia | | | | | | |
| 16 | ElecGasWater | 46 ely | Electricity | 42 RestWAsia | Bahrain | Iran Islamic Republic | | Kuwait | Oman | Qatar | Saudi Arabia | | | | | | |
| | | 47 gdt | Gas manufacture, distribution | 43 tur | Turkey | | | | | | | | | | | | |
| | | 48 wtr | Water | 44 are | United Arab Emirates | | | | | | | | | | | | |
| 17 | cns | 49 cns | Construction | 45 UMA | Egypt | Morocco | Tunisia | Rest of North Africa | | | | | | | | | |
| 18 | trd | 50 trd | Trade | 46 ECOWAS | Benin | Burkina Faso | | Cote d'Ivoi | Ghana | Guinea | Nigeria | Senegal | Togo | Rest of Western Africa | | | |
| 19 | BusinessSvcs | 51 afs | Accommodation, Food and svc | 47 CentralAfr | Cameroon | Central Af | South Central Africa | | | | | | | | | | |
| | | 65 dwe | Dwellings | 48 EAC | Ethiopia | Kenya | Madagasca | Rwanda | Uganda | | | | | | | | |
| | | 55 whs | Warehousing and support acti | 49 SADC | Malawi | Mauritius | Mozambiq | Tanzania | Zambia | Zimbabwe | Rest of Eas | Botswana | Namibia | | | | |
| | | 57 ofi | Financial services nec | 50 zaf | South Africa | | | | | | | | | | | | |
| | | 58 ins | Insurance | 51 ROW | Mongolia | Rest of Eas | Brunei Da | Rest of North America | | Israel | Jordan | Rest of the World | | | | | |
| | | 60 obs | Business services nec | | | | | | | | | | | | | | |
| 20 | otp | 52 otp | Transport nec | | | | | | | | | | | | | | |
| 21 | WatAirTransp | 53 wtp | Water transport | | | | | | | | | | | | | | |
| | | 54 atp | Air transport | | | | | | | | | | | | | | |
| 22 | cmn | 56 cmn | Communication | | | | | | | | | | | | | | |
| 23 | rsa | 59 rsa | Real estate activities | | | | | | | | | | | | | | |
| 24 | ros | 61 ros | Recreational and other service | | | | | | | | | | | | | | |
| 25 | osg | 62 osg | Public Administration and defe | | | | | | | | | | | | | | |
| 26 | edu | 63 edu | Education | | | | | | | | | | | | | | |
| 27 | hht | 64 hht | Human health and social work | | | | | | | | | | | | | | |

Source: Based on Authors' Aggmap.Txt fle based on Version 10 Database of GTAP

The model (based on Hertel, 1997) is solved using General Equilibrium Modeling Package (GEMPACK) software (Harrison and Pearson, 1996).[26] A comparative static multi-regional, multi-sectoral CGE global trade model is used for empirical implementation. The framework is based on the Global Trade Analysis Project's (GTAP) model (Hertel ed 1997). It belongs to the class of CGE based on the Australian ORANI model. For capturing direct and indirect intersectoral effects based on well-defined production and demand structure, the CGE model scores over the simplistic input-output specification and the Social Accounting Matrix (SAM) based models. It belongs to the Johansen class of models and uses General Equilibrium Modeling Package (GEMPACK) software to solve simultaneously the set of equations. The Armington **ass**umption specifies that the produced commodities be differentiated by origin of production so that the producers and consumers differentiate a commodity by its origin. We have observed that in GTAP Armington elasticities of substitution between imports from different sources are assumed to be identical across regions. That is, the substitution elasticities vary only by commodity.[27] Notice that the relative strength of substitution between imported commodities depends on the values of Armington elasticities of substitution [σM (i)].

In the standard closure, aggregate regional income in each region is allocated by the representative household between three sources of final demand—viz., private consumption (PRIVEXP), government consumption (GOVEXP), and saving expenditures (SAVING)—by maximising a Cobb-Douglas per capita utility function subject to income. That is, constant budget shares are allocated for each category of final demand.

A global bank collects regional saving into a hypothetical global saving pool. In GTAP, there is no financial sector. So saving in each region is conceptually a real 'saving commodity' (qsave). After each region receives an allocation of the saving commodity from the global saving pool, it uses the purchasing power so obtained to create new capital. The commodity composition of this new investment (qcgds) is region-specific. The global bank adopts one of two alternative methods to allocate investment to the regional households. All savers face a common price, PSAVE (which is the numeraire in the standard closure of the model), for the savings commodity. The allocation of savings commodity depends on the nature of the closure that one wants to specify i.e., on the macroeconomic environment in which the experiment is carried out. Here it is assumed that the aggregate capital stock is exogenous in all regions and that the world pool of real capital goods is allocated in fixed proportion to the base-case capital-stocks. This is known as the 'Medium-run method' (or, Alternative Component as in Hertel (ed.), 1997, pg.35) in the GTAP literature. Thus, regional and global net investment move together and the regional composition of the global investment is unaltered. This investment allocation mechanism is chosen by setting the value of a binary parameter RORDELTA to zero in the parameter file before computing solutions. The percentage change in the global rate of return (rorg) [which in reality is an expectational variable) is a weighted average of regional expected rates of return [rore(r)] with weights being the shares of regional net investment [NETINV(r)] in Global Net Investment [GLOBINV]. Thus, while no reallocation of regional shares in global investment is permitted, inter-industry capital mobility within a region is nevertheless allowed. This is the usual ***medium-run***, or ***partial long-run equilibrium*** standard closure in the GTAP literature.

***In the next step, in*** particular, the ricochet effect of the trade in intermediates in the presence of COVID-19-induced non-tariff trade disruptions will be studied. To our knowledge, this paper is one of the first to apply this dual procedure and to offer some evidence of what should be the most effective policies to contain the effects of the pandemic while pursing intra-regional integration in Africa. The policy implications drawn are suitable for developing economies experiencing the ricochet impact of the pandemics. *The following tables document the results—all the entries in the tables are %-changes from the baseline/base case scenarios.*

[26] Data, equations, and all the detailed parameters are not reported for parsimony. An appendix defining all these is available from author while full-text version is under preparation.

[27] See Chapters 2 and 4, Hertel (ed.), 1997, Global Trade Analysis: Modeling and Applications.

## 4.5 Pre-pandemic Favorable Impact (Scenario I): Main Results and Implications

| Table 13: Sectoral Impacts of in 'China only' TFP Shock (Aggregate) for Selected Sectors AND Regions | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| qo | chn | hkg | jpn | kor | ind | usa | fra | gbr | UMA | ECOWAS | CentralAfr | EAC | SADC | zaf |
| AgrlWood | 1.78 | -0.09 | -0.02 | -0.09 | 0.02 | 0.03 | 0.08 | 0.03 | -0.03 | 0.01 | -0.02 | 0.01 | -0.02 | -0.04 |
| Food | 1.70 | -0.08 | -0.01 | -0.03 | 0.03 | 0.05 | 0.11 | 0.05 | -0.01 | 0.01 | -0.01 | -0.01 | -0.02 | -0.01 |
| MineralGasOi | 2.38 | 0.08 | 0.30 | 0.08 | 0.16 | 0.18 | 0.43 | 0.23 | 0.10 | 0.13 | 0.10 | 0.28 | 0.21 | 0.26 |
| tex | 0.67 | 0.01 | 0.44 | 0.15 | 0.20 | 0.19 | 0.42 | 0.26 | 0.06 | 0.24 | -0.01 | 0.22 | 0.04 | 0.03 |
| wap | 0.67 | 0.01 | 0.16 | 0.06 | 0.30 | 0.23 | 0.44 | 0.42 | 0.07 | 0.20 | 0.04 | 0.23 | 0.03 | 0.10 |
| lea | 0.63 | -0.14 | 0.21 | 0.16 | 0.41 | 0.56 | 0.84 | 0.53 | 0.15 | 0.38 | 0.02 | 0.32 | 0.10 | 0.13 |
| PetroleumCh | 1.62 | 0.16 | 0.19 | 0.25 | 0.03 | 0.12 | 0.30 | 0.21 | 0.00 | 0.02 | -0.08 | 0.24 | -0.02 | -0.02 |
| bph | 2.55 | 0.80 | -0.02 | -0.08 | 0.07 | 0.19 | 0.43 | 0.29 | -0.05 | -0.03 | -0.13 | 0.07 | -0.13 | -0.07 |
| Metalproduc | 2.07 | 0.84 | 0.18 | -0.03 | -0.01 | 0.16 | 0.28 | 0.39 | -0.08 | 0.15 | -0.15 | 0.07 | 0.22 | 0.15 |
| ele | 0.32 | -0.08 | 0.58 | 0.49 | 0.16 | 0.40 | 0.63 | 0.56 | 0.07 | 0.04 | -0.20 | 0.22 | -0.04 | 0.07 |
| eeq | 1.44 | -0.29 | 0.34 | 0.13 | 0.03 | 0.13 | 0.47 | 0.26 | -0.12 | 0.02 | -0.27 | 0.17 | -0.10 | 0.18 |
| ome | 2.04 | -0.20 | 0.19 | 0.12 | -0.06 | 0.01 | 0.28 | 0.16 | 0.20 | -0.20 | -0.39 | 0.02 | -0.16 | 0.29 |
| mvh | 2.67 | -0.21 | 0.05 | -0.15 | -0.14 | 0.00 | 0.16 | 0.40 | 0.10 | 0.14 | -0.14 | -0.01 | -0.11 | -0.19 |
| otn | 2.16 | -0.51 | -0.31 | -0.49 | 0.01 | 0.29 | 0.42 | 0.05 | 0.14 | -0.02 | -0.43 | 0.01 | -0.23 | 0.29 |
| omf | 1.25 | -0.32 | -0.06 | -0.02 | -0.01 | 0.14 | 0.22 | 0.09 | 0.07 | 0.07 | -0.12 | 0.10 | 0.50 | 0.07 |
| cns | 3.47 | -0.33 | -0.40 | -0.26 | -0.28 | -0.34 | -0.47 | -0.44 | -0.23 | -0.34 | -0.28 | -0.28 | -0.25 | -0.40 |
| trd | 2.15 | 0.14 | -0.01 | 0.00 | -0.02 | -0.03 | 0.02 | 0.01 | 0.01 | -0.05 | -0.05 | 0.07 | 0.00 | 0.03 |
| WatAirTransp | 1.52 | 0.00 | 0.15 | 0.14 | 0.26 | 0.09 | 0.22 | 0.16 | 0.06 | 0.05 | 0.00 | 0.09 | 0.00 | 0.02 |
| edu | 2.86 | -0.01 | 0.05 | 0.00 | 0.00 | 0.01 | 0.02 | 0.00 | 0.00 | 0.02 | 0.02 | 0.02 | 0.01 | 0.00 |
| hht | 2.95 | 0.03 | 0.00 | 0.00 | -0.01 | 0.00 | -0.02 | -0.02 | 0.01 | 0.01 | 0.05 | -0.01 | 0.02 | 0.01 |
| Source: Simulated impact of the GTAP Model with vn 10 database | | | | | | | | | | | | | | |

| Table 14: Impacts of 'China only' TFP Shock (Aggregate) for Regional Imports and Exports and Macro | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| qiwreg | (Sim) | qxwreg | (Sim) | Pre | Post | DTBAL | EV_ALT | tot | yev |
| chn | 2.28 | chn | -0.73 | 2523346.00 | 2504963.25 | -64527 | 237637.7 | 0.090843 | 2.725405 |
| hkg | 0.05 | hkg | 0.13 | 190003.28 | 190249.44 | 239.1515 | 109.8185 | 0.056729 | 0.044652 |
| jpn | -0.01 | jpn | 0.55 | 919230.81 | 924309.38 | 4897.44 | -226.674 | -0.03636 | -0.00583 |
| kor | 0.15 | kor | 0.30 | 677645.50 | 679677.44 | 1048.18 | 53.21175 | 0.01329 | 0.004457 |
| twn | 0.18 | twn | 0.21 | 358012.13 | 358761.28 | 266.3346 | 188.7602 | 0.052301 | 0.041295 |
| ind | -0.16 | ind | 0.37 | 432175.69 | 433777.44 | 2188.663 | -612.145 | -0.10499 | -0.03414 |
| usa | -0.25 | usa | 0.60 | 1994320.63 | 2006346.75 | 18153.09 | -2631.32 | -0.09557 | -0.01732 |
| fra | -0.08 | fra | 0.50 | 725780.13 | 729438.06 | 4114.959 | -990.306 | -0.07692 | -0.04113 |
| gbr | -0.10 | gbr | 0.45 | 697517.75 | 700656.25 | 3948.863 | -761.883 | -0.0611 | -0.0297 |
| UMA | -0.04 | UMA | 0.15 | 186665.94 | 186953.33 | 639.6991 | 29.95877 | 0.029037 | 0.00456 |
| ECOWAS | -0.10 | ECOWAS | 0.16 | 146685.31 | 146912.81 | 468.4395 | 38.16095 | 0.044622 | 0.005707 |
| CentralAfr | 0.06 | CentralAfr | 0.09 | 103452.05 | 103548.87 | 160.5292 | 150.4633 | 0.149483 | 0.066849 |
| EAC | -0.12 | EAC | 0.34 | 30926.02 | 31031.89 | 194.7824 | -42.7108 | -0.0579 | -0.02798 |
| SADC | -0.01 | SADC | 0.20 | 65831.63 | 65965.36 | 225.3601 | 27.93308 | 0.043359 | 0.013057 |
| zaf | -0.08 | zaf | 0.19 | 117253.20 | 117480.43 | 320.2308 | -18.2292 | 0.009095 | -0.006 |

In any CGE model, it's hard to disentangle all given the number of scenario experiments being undertaken as per Table 11. We consider total factor productivity growth (TFPG) as the indicator of technological progress. From stylized facts in Tables 1,2 and 6, we see that China is the top most source and destination of exports and imports and the products whose import intensity and technological content are high are electronic, computer equipment. We identify the source sectors of acquired technology for the GTAP sectors classified into broad categories. There are several empirical studies estimating TFP indexes across regions. Very few provide industry specific TFP indexes. In Tables 13 and 14, we shock –as per Table 11—only "China-effect" isolated from any other positive productivity shock before the Covid-19. The shock impinged into the system is 2.25% (as described before in Section 4.4 and the magnitude is taken from IMF 2019/WB 2020 studies. It is TFP-augmenting Hicks-Neutral technological change and causing perturbation into the system via trade-linkages. Under current closure, the shock generates—as expected positive effects in the source as well as the other regions to register increase in output and regional exports (see Tables 13 and 14). However, there are inter-regional variations. We consider the regions of our interest and few sectors. Given very little magnitude of the shock, the percentage changes are not that pronounced, but

that accords with reality. Trade balance and Welfare improves in almost all African continent composite regions. Regional exports increase as are the outputs. Regional imports fall because of increase in outputs and Armington price competition effects. Except Central African group, other regions register positive percentage changes in small amount—given the 2.25% shock magnitude—and China being source derives most benefits of 2.29% resultant output increase. That enables China to trade more with others, but Africa's gain is dispersed and miniscule.

The next simulation—results presented in Tables 15 and 16—include the scenario where "China+" along with other two leading economies experience technological progress so that we have 3 sources of exogenous positive productivity shocks. Definitely, we see more pronounced effects from the "china only" scenario. There are some exception where output falls but with very negligible magnitude due to not much indirect impact of spillover. Most importantly, the pharmaceutical sector and other machinery equipment (probably having medical equipment sector) expands. Thus, compared to China shock, this has stronger impact with important insight that only China centric shock is not enough to register improvement in Welfare, output, export and import via production diversification to overcome weak production base.

**Table 15: Sectoral Impacts of in 'China+ICs' TFP Shock (Aggregate) for Selected Sectors AND Regions**

| qo | chn | hkg | jpn | kor | ind | usa | fra | gbr | UMA | ECOWAS | CentralAfr | EAC | SADC | zaf |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AgrlWood | 1.91 | -0.03 | 0.12 | 0.04 | 0.09 | 0.90 | 0.32 | 0.16 | 0.02 | 0.05 | 0.02 | 0.06 | 0.05 | 0.07 |
| Food | 1.74 | -0.08 | 0.05 | -0.02 | 0.09 | 0.85 | 0.49 | 0.27 | 0.01 | 0.10 | 0.02 | 0.01 | 0.08 | 0.01 |
| MineralGas | 2.31 | -0.31 | 0.43 | -0.20 | 0.18 | 0.64 | 0.74 | 0.37 | 0.17 | 0.35 | 0.20 | 0.47 | 0.34 | 0.32 |
| tex | 1.11 | -0.02 | 1.02 | 0.52 | 0.47 | 0.30 | -0.52 | 0.56 | 0.17 | 0.51 | 0.08 | 0.46 | 0.22 | 0.06 |
| wap | 1.04 | -0.04 | 0.23 | 0.11 | 0.75 | 0.29 | -0.53 | 0.76 | 0.20 | 0.34 | 0.08 | 0.79 | 0.40 | 0.10 |
| lea | 1.08 | -0.31 | 0.50 | 0.24 | 0.76 | -0.85 | -1.19 | 1.00 | 0.29 | 0.80 | -0.04 | 0.53 | 0.24 | 0.15 |
| PetroleumC | 1.83 | 0.02 | 0.53 | 0.47 | 0.16 | 0.45 | 0.01 | 0.67 | 0.22 | 0.38 | 0.04 | 0.48 | 0.12 | 0.10 |
| bph | 2.66 | 0.73 | 0.32 | 0.07 | 0.91 | -0.46 | -0.80 | 1.51 | 0.18 | 0.58 | 0.21 | 0.47 | 0.14 | 0.11 |
| Metalprodu | 2.03 | 0.65 | 0.48 | 0.07 | -0.15 | 0.11 | -0.27 | 0.77 | -0.21 | 0.75 | 0.17 | 0.04 | 0.48 | 0.46 |
| ele | 1.14 | 0.07 | 1.49 | 0.98 | 0.17 | -0.38 | -0.72 | 1.29 | 0.15 | 0.07 | -0.27 | 0.38 | 0.07 | 0.27 |
| eeq | 1.72 | -0.22 | 0.87 | 0.31 | -0.02 | 0.14 | -0.88 | 0.61 | 0.14 | -0.16 | 0.47 | 0.03 | -0.12 | 0.58 |
| ome | 2.03 | -0.58 | 0.45 | 0.29 | -0.22 | 0.52 | -0.38 | 0.58 | 0.47 | 0.37 | 0.46 | 0.20 | 0.16 | 0.54 |
| mvh | 2.48 | -0.61 | 1.08 | 0.47 | -0.32 | 1.00 | -0.36 | 0.78 | -0.10 | 0.16 | -0.39 | 0.21 | 0.13 | 0.21 |
| otn | 2.36 | -0.16 | 0.21 | -0.13 | 0.36 | -0.27 | -0.29 | 1.16 | 0.43 | 0.02 | -0.13 | 0.25 | 0.13 | 0.05 |
| omf | 1.81 | -0.19 | -0.02 | 0.21 | 0.20 | 0.11 | 0.03 | 0.48 | 0.12 | 0.02 | 0.39 | 0.18 | 0.94 | 0.00 |
| trd | 2.18 | 0.16 | -0.07 | -0.02 | -0.09 | 1.36 | 1.23 | 0.00 | -0.01 | 0.20 | -0.08 | 0.15 | -0.02 | -0.01 |
| WatAirTran | 1.71 | 0.19 | 0.53 | 0.44 | 0.63 | 0.74 | 0.35 | 0.51 | 0.32 | 0.31 | 0.16 | 0.55 | 0.31 | 0.28 |
| edu | 2.85 | 0.04 | 0.21 | 0.02 | 0.02 | 1.26 | 1.32 | 0.03 | 0.08 | 0.19 | 0.11 | 0.15 | 0.10 | 0.03 |
| hht | 2.94 | 0.06 | -0.03 | -0.03 | -0.01 | 1.38 | 1.51 | -0.08 | 0.01 | 0.01 | 0.04 | 0.00 | 0.02 | -0.01 |

Source: Simulated impact of the GTAP Model with vn 10 database

**Table 16: Impacts of 'China+ICs' TFP Shock (Aggregate) for Regional Imports, Exports and Macro**

| | qiwreg | qxwreg | DTBAL | EV_ALT | tot | yev |
|---|---|---|---|---|---|---|
| chn | 2.04 | 0.30 | -37870.934 | 232394.2 | -0.00993 | 2.665269 |
| hkg | -0.04 | 0.36 | 878.008911 | 160.7385 | 0.091763 | 0.065356 |
| jpn | -0.28 | 1.79 | 17335.3359 | -1904.02 | -0.18285 | -0.04898 |
| kor | 0.12 | 0.85 | 4294.04932 | -789.39 | -0.04687 | -0.06612 |
| twn | 0.16 | 0.54 | 1138.0708 | 71.72292 | 0.040984 | 0.01569 |
| ind | -0.38 | 1.19 | 6778.24121 | -1470.49 | -0.19263 | -0.08202 |
| usa | 2.39 | -2.25 | -92944.703 | 221934.7 | 0.487745 | 1.460655 |
| fra | 1.38 | -1.07 | -16737.135 | 37373.34 | 0.239059 | 1.552359 |
| gbr | -0.42 | 1.43 | 12903.7314 | -2484.19 | -0.21204 | -0.09682 |
| UMA | -0.21 | 0.59 | 2069.33862 | -189.216 | -0.02452 | -0.0288 |
| ECOWAS | -0.55 | 0.63 | 1739.3501 | -250.152 | -0.04508 | -0.03741 |
| CentralAfr | -0.37 | 0.33 | 661.986084 | 19.42482 | 0.086728 | 0.008631 |
| EAC | -0.34 | 1.17 | 612.14563 | -107.41 | -0.14154 | -0.07036 |
| SADC | -0.24 | 0.67 | 802.526001 | -51.3526 | -0.01309 | -0.024 |
| zaf | -0.37 | 0.66 | 1115.11523 | -148.137 | -0.05229 | -0.04878 |

Source: Simulated impact of the GTAP Model with vn 10 database

Comparing these two sets of tables, surely we can infer that exports, output effects are more pronounced in the second sets of shocks with additional dynamic trade partners like the USA, France (long-time established roots). Looking at Tables 17--20, we can see the bi-lateral exports on the wake of China-centric effect vis-à-vis additional IC-led exogenous source of TFP spillover via trade. All of them register positive changes not only from China to others, but also from composite African regions to others via inter-regional and inter-continental trade as is envisaged via AfCFTA. Similar, but more pronounced effects are observed with "China+ICs" scenario shocks. But, for want of space and parsimony those are not reported. However, only exception is the Central African group and the SADC minus South Africa which is a separate region. We do not report except the important ones, for want of space.

**Table 17: Impacts of 'China only' TFP Shock (Aggregate) for Bilateral export sales from China**

| qxs[**chn] | hkg | jpn | kor | ind | usa | UMA | ECOWAS | CentralAfr | EAC | SADC | zaf |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AgrlWood | 1.19 | 1.58 | 1.46 | 1.97 | 2.08 | 1.71 | 1.79 | 1.29 | 1.93 | 1.49 | 1.54 |
| Food | 1.56 | 1.93 | 1.79 | 2.29 | 2.37 | 2.03 | 2.12 | 1.63 | 2.24 | 1.82 | 1.90 |
| MineralGas | 1.80 | 3.25 | 2.72 | 3.20 | 3.33 | 2.77 | 2.45 | 1.51 | 2.63 | 1.81 | 1.99 |
| tex | 0.89 | 1.31 | 1.10 | 1.95 | 2.11 | 1.61 | 1.74 | 1.03 | 1.82 | 1.30 | 1.41 |
| wap | 1.79 | 2.27 | 2.01 | 2.96 | 3.09 | 2.52 | 2.68 | 1.95 | 2.80 | 2.23 | 2.38 |
| lea | 0.94 | 1.55 | 1.26 | 2.26 | 2.27 | 1.72 | 1.88 | 1.15 | 2.10 | 1.39 | 1.55 |
| PetroleumC | 1.85 | 2.02 | 1.87 | 2.13 | 2.48 | 2.09 | 2.19 | 1.81 | 2.45 | 1.94 | 2.00 |
| bph | 2.52 | 2.96 | 2.69 | 3.36 | 3.62 | 3.07 | 3.22 | 2.59 | 3.39 | 2.85 | 2.95 |
| Metalprodu | 1.99 | 2.49 | 2.18 | 2.90 | 3.27 | 2.68 | 2.78 | 2.04 | 2.87 | 2.31 | 2.54 |
| ele | 1.11 | 1.65 | 1.26 | 2.04 | 2.42 | 1.84 | 2.04 | 1.24 | 2.07 | 1.51 | 1.65 |
| eeq | 2.31 | 2.91 | 2.52 | 3.39 | 3.77 | 3.09 | 3.21 | 2.47 | 3.39 | 2.76 | 2.92 |
| ome | 2.76 | 3.39 | 3.02 | 3.86 | 4.21 | 3.54 | 3.68 | 2.94 | 3.87 | 3.22 | 3.38 |
| mvh | 2.86 | 3.30 | 3.06 | 3.61 | 3.81 | 3.40 | 3.53 | 3.00 | 3.63 | 3.18 | 3.31 |
| otn | 2.41 | 3.06 | 2.70 | 3.62 | 3.94 | 3.25 | 3.40 | 2.58 | 3.48 | 2.89 | 3.13 |
| omf | 2.55 | 2.95 | 2.60 | 3.34 | 3.75 | 3.04 | 3.23 | 2.49 | 3.42 | 2.76 | 2.92 |
| cns | 3.40 | 3.76 | 3.55 | 4.01 | 4.15 | 3.75 | 3.86 | 3.51 | 3.94 | 3.59 | 3.67 |
| trd | 2.17 | 2.53 | 2.30 | 2.87 | 2.93 | 2.58 | 2.68 | 2.27 | 2.80 | 2.42 | 2.50 |
| BusinessSv | 2.20 | 2.54 | 2.33 | 2.88 | 2.95 | 2.60 | 2.70 | 2.30 | 2.82 | 2.43 | 2.52 |
| otp | 2.21 | 2.51 | 2.32 | 2.74 | 2.86 | 2.54 | 2.63 | 2.30 | 2.73 | 2.41 | 2.45 |
| cmn | 2.95 | 3.30 | 3.09 | 3.65 | 3.71 | 3.36 | 3.46 | 3.05 | 3.59 | 3.19 | 3.27 |
| edu | 2.53 | 2.88 | 2.69 | 3.32 | 3.30 | 2.93 | 3.04 | 2.59 | 3.18 | 2.80 | 2.87 |
| hht | 2.84 | 3.13 | 2.93 | 3.53 | 3.53 | 3.18 | 3.28 | 2.85 | 3.40 | 3.05 | 3.12 |
| Simulated impact with Vn 10 Database | | | | | | | | | | | |

**Table 18: Impacts of 'China only' TFP Shock (Aggregate) for Bilateral export sales from Central Africa**

| qxs[*CentralAfr | chn | hkg | jpn | kor | UMA | ECOWAS | CentralAfr | EAC | SADC | zaf |
|---|---|---|---|---|---|---|---|---|---|---|
| AgrlWood | 1.29 | -0.26 | -0.47 | -0.44 | -0.52 | -0.50 | -0.26 | -0.53 | -0.33 | -0.38 |
| Food | 1.63 | -0.27 | -0.34 | -0.29 | -0.43 | -0.42 | -0.21 | -0.50 | -0.26 | -0.35 |
| MineralGasOi | 1.51 | -0.65 | -0.43 | -0.41 | -1.20 | -0.79 | -0.69 | -0.77 | -0.39 | -0.49 |
| tex | 1.03 | 0.06 | 0.15 | 0.09 | -0.42 | -0.17 | -0.09 | -0.23 | -0.16 | -0.23 |
| wap | 1.95 | -0.01 | 0.09 | 0.08 | -0.22 | -0.05 | 0.08 | -0.19 | -0.10 | -0.06 |
| lea | 1.15 | -0.20 | -0.12 | -0.13 | -0.18 | 0.11 | 0.12 | -0.16 | 0.06 | -0.04 |
| PetroleumCh | 1.81 | -0.05 | -0.08 | 0.08 | -0.34 | -0.34 | -0.18 | -0.18 | -0.20 | -0.25 |
| bph | 2.59 | -0.29 | -0.54 | -0.51 | -0.64 | -0.68 | -0.46 | -0.66 | -0.56 | -0.61 |
| Metalproduc | 2.04 | -0.15 | -0.21 | -0.25 | -0.73 | -0.38 | -0.51 | -0.45 | -0.32 | -0.39 |
| ele | 1.24 | 0.02 | 0.01 | 0.34 | -0.40 | -0.55 | -0.45 | -0.19 | -0.35 | -0.39 |
| eeq | 2.47 | -0.05 | -0.18 | -0.06 | -0.71 | -0.36 | -0.43 | -0.29 | -0.37 | -0.63 |
| ome | 2.94 | -0.27 | -0.47 | -0.49 | -0.73 | -0.78 | -0.66 | -0.55 | -0.51 | -0.80 |
| mvh | 3.00 | -0.29 | -0.33 | -0.42 | -0.44 | -0.58 | -0.28 | -0.38 | -0.38 | -0.55 |
| otn | 2.58 | -0.85 | -0.87 | -0.88 | -0.91 | -0.54 | -0.57 | -0.70 | -0.64 | -1.02 |
| omf | 2.49 | -0.45 | -0.60 | -0.06 | -0.60 | -0.29 | -0.19 | -0.45 | -0.31 | -0.54 |
| cns | 3.51 | -0.21 | -0.76 | -0.44 | -0.48 | -0.54 | -0.44 | -0.65 | -0.45 | -0.64 |
| trd | 2.27 | -0.10 | -0.23 | 0.01 | -0.32 | -0.37 | -0.19 | -0.30 | -0.22 | -0.23 |
| otp | 2.30 | -0.15 | -0.23 | -0.19 | -0.29 | -0.30 | -0.12 | -0.37 | -0.25 | -0.22 |
| WatAirTransp | 2.25 | -0.12 | -0.17 | -0.11 | -0.25 | -0.25 | -0.17 | -0.21 | -0.18 | -0.19 |
| cmn | 3.05 | -0.24 | -0.48 | -0.30 | -0.40 | -0.53 | -0.23 | -0.59 | -0.28 | -0.36 |
| hht | 2.85 | -0.13 | -0.34 | -0.26 | -0.38 | -0.41 | -0.18 | -0.49 | -0.33 | -0.35 |

**Table 19: Impacts of 'China only' TFP Shock (Aggregate) for Bilateral export sales from ECOWAS group**

| qxs[*ECOWA | chn | hkg | jpn | kor | fra | UMA | ECOWAS | CentralAfr | EAC | SADC | zaf |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AgrlWood | 1.79 | 0.24 | 0.04 | 0.08 | -0.12 | -0.02 | -0.03 | 0.23 | -0.03 | 0.18 | 0.11 |
| Food | 2.12 | 0.21 | 0.14 | 0.19 | -0.12 | 0.03 | 0.05 | 0.25 | -0.03 | 0.20 | 0.12 |
| MineralGasC | 2.45 | 0.26 | 0.45 | 0.47 | -0.04 | -0.28 | -0.02 | 0.08 | 0.12 | 0.34 | 0.39 |
| tex | 1.74 | 0.77 | 0.86 | 0.79 | 0.20 | 0.27 | 0.52 | 0.58 | 0.44 | 0.52 | 0.47 |
| wap | 2.68 | 0.70 | 0.80 | 0.79 | 0.29 | 0.48 | 0.65 | 0.77 | 0.51 | 0.61 | 0.65 |
| lea | 1.88 | 0.53 | 0.61 | 0.60 | 0.31 | 0.53 | 0.81 | 0.82 | 0.54 | 0.76 | 0.69 |
| PetroleumCh | 2.19 | 0.35 | 0.30 | 0.47 | -0.02 | 0.05 | 0.04 | 0.20 | 0.21 | 0.19 | 0.13 |
| bph | 3.22 | 0.32 | 0.07 | 0.10 | -0.05 | -0.03 | -0.08 | 0.14 | -0.06 | 0.04 | 0.00 |
| Metalproduc | 2.78 | 0.57 | 0.50 | 0.47 | 0.00 | -0.01 | 0.32 | 0.18 | 0.25 | 0.41 | 0.32 |
| ele | 2.04 | 0.80 | 0.80 | 1.13 | 0.36 | 0.38 | 0.23 | 0.33 | 0.59 | 0.43 | 0.39 |
| eeq | 3.21 | 0.67 | 0.54 | 0.64 | -0.10 | 0.00 | 0.34 | 0.26 | 0.41 | 0.33 | 0.07 |
| ome | 3.68 | 0.44 | 0.24 | 0.20 | -0.17 | -0.04 | -0.10 | 0.02 | 0.13 | 0.19 | -0.11 |
| mvh | 3.53 | 0.23 | 0.19 | 0.10 | -0.18 | 0.07 | -0.08 | 0.22 | 0.13 | 0.12 | -0.04 |
| otn | 3.40 | -0.06 | -0.07 | -0.09 | -0.05 | -0.12 | 0.23 | 0.22 | 0.09 | 0.14 | -0.23 |
| omf | 3.23 | 0.27 | 0.12 | 0.66 | -0.18 | 0.10 | 0.40 | 0.51 | 0.24 | 0.39 | 0.17 |
| cns | 3.86 | 0.14 | -0.42 | -0.10 | -0.72 | -0.14 | -0.20 | -0.10 | -0.31 | -0.11 | -0.29 |
| trd | 2.68 | 0.30 | 0.17 | 0.41 | 0.02 | 0.08 | 0.03 | 0.22 | 0.10 | 0.19 | 0.17 |
| otp | 2.63 | 0.18 | 0.10 | 0.14 | -0.12 | 0.04 | 0.02 | 0.20 | -0.05 | 0.08 | 0.11 |
| WatAirTrans | 2.50 | 0.13 | 0.08 | 0.15 | -0.02 | 0.01 | 0.01 | 0.08 | 0.04 | 0.07 | 0.06 |
| cmn | 3.46 | 0.16 | -0.08 | 0.10 | -0.34 | 0.00 | -0.13 | 0.17 | -0.19 | 0.12 | 0.04 |
| hht | 3.28 | 0.29 | 0.08 | 0.16 | -0.06 | 0.04 | 0.00 | 0.24 | -0.07 | 0.09 | 0.06 |

**Table 20: Impacts of 'China only' TFP Shock (Aggregate) for Bilateral export sales from EAC group**

| qxs[*EAC*] | chn | hkg | jpn | kor | twn | ind | fra | UMA | ECOWAS | CentralAfr | EAC | SADC | zaf |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AgrlWood | 1.93 | 0.37 | 0.18 | 0.22 | 0.29 | 0.09 | 0.02 | 0.12 | 0.11 | 0.37 | 0.11 | 0.26 | 0.25 |
| Food | 2.24 | 0.33 | 0.26 | 0.31 | 0.38 | 0.13 | 0.00 | 0.12 | 0.17 | 0.33 | 0.08 | 0.23 | 0.24 |
| MineralGas | 2.63 | 0.50 | 0.64 | 0.65 | 0.88 | 0.36 | 0.15 | -0.07 | 0.15 | 0.48 | 0.49 | 0.73 | 0.61 |
| tex | 1.82 | 0.84 | 0.94 | 0.87 | 0.83 | 0.45 | 0.27 | 0.35 | 0.60 | 0.65 | 0.52 | 0.60 | 0.54 |
| wap | 2.80 | 0.81 | 0.91 | 0.90 | 0.95 | 0.43 | 0.40 | 0.59 | 0.77 | 0.89 | 0.62 | 0.72 | 0.76 |
| lea | 2.10 | 0.75 | 0.83 | 0.83 | 0.82 | 0.53 | 0.53 | 0.77 | 1.05 | 1.04 | 0.76 | 0.97 | 0.90 |
| PetroleumC | 2.45 | 0.62 | 0.57 | 0.73 | 0.75 | 0.49 | 0.24 | 0.31 | 0.31 | 0.46 | 0.47 | 0.45 | 0.39 |
| bph | 3.39 | 0.50 | 0.24 | 0.28 | 0.22 | 0.40 | 0.13 | 0.14 | 0.09 | 0.31 | 0.11 | 0.22 | 0.17 |
| Metalprodu | 2.87 | 0.66 | 0.59 | 0.56 | 0.62 | 0.14 | 0.08 | 0.08 | 0.39 | 0.26 | 0.33 | 0.48 | 0.40 |
| ele | 2.07 | 0.84 | 0.83 | 1.16 | 1.02 | 0.56 | 0.39 | 0.41 | 0.26 | 0.36 | 0.62 | 0.46 | 0.42 |
| eeq | 3.39 | 0.85 | 0.72 | 0.81 | 0.82 | 0.35 | 0.07 | 0.17 | 0.51 | 0.44 | 0.58 | 0.50 | 0.24 |
| ome | 3.87 | 0.62 | 0.42 | 0.38 | 0.48 | 0.20 | 0.01 | 0.14 | 0.08 | 0.20 | 0.31 | 0.36 | 0.06 |
| mvh | 3.63 | 0.33 | 0.29 | 0.20 | 0.23 | -0.01 | -0.08 | 0.17 | 0.02 | 0.32 | 0.22 | 0.21 | 0.05 |
| otn | 3.48 | 0.01 | -0.01 | -0.01 | 0.01 | 0.03 | 0.02 | -0.05 | 0.31 | 0.29 | 0.16 | 0.22 | -0.16 |
| omf | 3.42 | 0.48 | 0.31 | 0.86 | 0.58 | 0.13 | 0.02 | 0.30 | 0.59 | 0.70 | 0.44 | 0.58 | 0.36 |
| cns | 3.94 | 0.21 | -0.35 | -0.03 | 0.14 | -0.25 | -0.65 | -0.07 | -0.13 | -0.03 | -0.24 | -0.04 | -0.22 |
| trd | 2.80 | 0.42 | 0.29 | 0.53 | 0.52 | 0.07 | 0.14 | 0.20 | 0.14 | 0.33 | 0.22 | 0.30 | 0.29 |
| otp | 2.73 | 0.27 | 0.19 | 0.23 | 0.37 | -0.06 | -0.02 | 0.13 | 0.11 | 0.30 | 0.04 | 0.17 | 0.20 |
| WatAirTran | 2.57 | 0.20 | 0.15 | 0.21 | 0.20 | 0.04 | 0.04 | 0.07 | 0.07 | 0.15 | 0.11 | 0.13 | 0.13 |
| cmn | 3.59 | 0.29 | 0.04 | 0.23 | 0.39 | 0.03 | -0.22 | 0.13 | 0.00 | 0.30 | -0.06 | 0.25 | 0.17 |

Thus, as explained before the over dependence on China does not translate necessarily into overcoming the absorption of spillovers. It is better to diversify the sources of trade dependence to overcome lower labor productivity growth and weaker production base in order to realize the industrialization agenda via AfCFTA. It is like not '*putting the cart before the horse'*. In fact the table from World Bank (2019) and (2020)—Tables 10 and C1in pages 30-34 show that 'Africa has lowest 'Industrial intensity index" and 'low mfg value-added' apart from what we showed in stylized facts on R&D and human capital intensity---see Tables 7a,b,c in Sections 2

and 3. As mentioned before in Tables 5, 6, and 7 that import product shares of Capital goods and intermediate goods, machine and electrical equipment, metals have higher import product share in Sub-Saharan Africa as destination and sourced from China. Also, we see from 2001—2018 these shares have higher CAGR (see Table7). Nest we describe scenario II.

## 4.6 Pre-Pandemic Logistics Shock (Scenario II):

Now Tables 7a, 7b and 7c show that Africa has lower Logistics Performance Index (LPI), R&D intensity and Human Development Index (HDI). Thus, in the Second sets of Scenarios for logistics—as is documented in Table 21—we consider 'what if digitization is accelerated and logistics improve via ICT or 4IR led trade and transportation upgrading so that 'cost' advantage is reaped. Clearly, we see drastic improvement in welfare for all these composite African regions, rise in regional imports and exports, and real GDP improves along with income (y). Terms-of-trade (TOT) improves as well. Welfare (EV) goes up.

**Table 21:Impact of Logistics, Digitization-led change, Shipping technology on Macroresults for African nations**

| | EV_ALT | pxwreg | piwreg | qgdp | qiwreg | qxwreg | rorc | y | DTBAL | piwreg | pxwreg | qgdp | qiwreg | qxwreg | rorc | tot |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UMA | 1113.725 | 0.027 | -0.007 | 0.15 | 0.01 | 0.199 | 0.32 | 0.212 | -191.2 | -0.012 | 0.161 | 0.010 | 0.317 | 0.16 | 0.10 | 0.17 |
| ECOWAS | 1185.91 | 0.021 | -0.004 | 0.157 | 0.082 | 0.145 | 0.282 | 0.291 | -87.1 | -0.016 | 0.173 | 0.012 | 0.275 | 0.04 | 0.08 | 0.19 |
| CentralAfr | 722.6862 | 0.01 | -0.005 | 0.278 | 0.14 | 0.124 | 0.524 | 0.405 | -29.9 | -0.022 | 0.162 | 0.012 | 0.293 | 0.04 | 0.12 | 0.18 |
| EAC | 467.61 | 0.189 | 0.006 | 0.245 | 0.069 | 0.797 | 0.648 | 0.547 | -57.2 | -0.028 | 0.177 | 0.007 | 0.309 | 0.09 | 0.09 | 0.21 |
| SADC | 372.5088 | 0.042 | 0.024 | 0.153 | 0.02 | 0.249 | 0.32 | 0.249 | -95.6 | -0.052 | 0.151 | 0.006 | 0.357 | 0.11 | 0.13 | 0.20 |
| zaf | 969.1187 | 0.118 | -0.006 | 0.236 | 0.246 | 0.311 | 0.535 | 0.551 | -105.2 | -0.010 | 0.200 | 0.006 | 0.413 | 0.11 | 0.12 | 0.21 |

*Simulated impact with GTAP vn 10 database*

Tables 22 and 22a show the same results in the context of bi-lateral exports and sectoral performance. Those are pretty much consistent—as expected--and in keeping with the macro results. Except Central Africa—which is deficient in many aspects such as captured in Tables 7a, 7b, and CI, 9, and 10—which showed some negative percentage changes as entries in the tables. Of course, General Equilibrium adjustment and price-competition across regions, and sectors work in these adjustment processes. For want of space, we don't detail the mechanism. Rate of return to capital also goes up in this scenario. That means more investment will come in, and that, in turn, will cause more growth in industries via which AfCFTA will get a significant boost. In fact, this kind of possibilities are discussed in Investment Climate Survey of World Bank (2020)[28]

**Table 22a:Impact of Logistics and Digitization-led change on Regional Outputs**

| qo | UMA | ECOWAS | CentralAfr | EAC | SADC | zaf |
|---|---|---|---|---|---|---|
| AgrlWood | -0.027 | -0.003 | 0.122 | -0.043 | -0.001 | -0.09 |
| Food | 0.035 | 0.015 | 0.22 | 0.121 | 0.037 | 0.101 |
| MineralGas | -0.087 | -0.041 | -0.106 | -0.118 | -0.171 | 0.116 |
| PetroleumC | -0.187 | -0.537 | -0.36 | -0.442 | -0.252 | -0.423 |
| bph | 0.114 | -0.056 | 0.042 | -0.179 | -0.016 | 0.118 |
| Metalprodu | 0.113 | 0.424 | 0.508 | 0.922 | -0.128 | -0.734 |
| ele | 0.346 | -0.364 | 0.289 | 0.177 | -2.921 | 5.538 |
| eeq | 0.121 | 0.092 | 0.948 | 1.036 | 0.138 | -0.003 |
| ome | 0.265 | 0.147 | 1.349 | 1.203 | 0.266 | -0.053 |
| mvh | 0.136 | 0.041 | 1.314 | 1.104 | 0.353 | -0.046 |
| omf | 0.104 | 0.142 | 0.493 | -0.012 | -0.03 | -0.084 |
| cns | 0.261 | 0.328 | 0.628 | 0.579 | 0.313 | 0.766 |
| trd | 0.093 | 0.17 | 0.19 | 0.188 | 0.042 | 0.067 |
| BusinessSvc | 0.093 | 0.114 | -0.062 | -0.064 | 0.044 | 0.053 |
| cmn | 0.108 | 0.158 | 0.145 | 0.076 | 0.082 | 0.156 |
| edu | 0.12 | 0.434 | 0.099 | 0.199 | 0.079 | 0.131 |
| hht | 0.135 | 0.364 | 0.162 | 0.267 | 0.117 | 0.222 |
| CGDS | 0.275 | 0.338 | 0.718 | 0.633 | 0.341 | 0.892 |

Simulated impact of GTAP model.

[28] https://www.worldbank.org/en/topic/investment-climate#results

**Table 22:Impact of Logistics and Digitization-led change on Regional Exports**

| | qxs[*EAC*] | | | | | | | qxs[*CentralAfr*] | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | chn | UMA | ECOWAS | CentralAfr | EAC | SADC | zaf | chn | UMA | ECOWAS | CentralAfr | EAC | SADC | zaf |
| AgrlWood | -1.83 | -1.51 | -1.03 | -1.15 | -0.62 | -0.88 | -1.31 | -0.81 | -0.51 | 0.00 | -0.15 | 0.37 | -0.16 | -0.35 |
| Food | -1.42 | -1.06 | -0.95 | -0.80 | -0.37 | -0.60 | -0.80 | -0.30 | -0.07 | 0.19 | 0.14 | 0.75 | 0.16 | 0.28 |
| PetroleumCh | -0.76 | -0.98 | -1.25 | -1.07 | -1.12 | -0.93 | -0.96 | -0.39 | -0.60 | -0.85 | -0.69 | -0.74 | -0.56 | -0.55 |
| Metalprodu | 1.33 | 1.49 | 1.38 | 1.58 | 1.48 | 1.65 | 1.51 | 0.48 | 0.64 | 0.56 | 0.78 | 0.68 | 0.87 | 0.67 |
| ele | 0.99 | 47.91 | 0.12 | 43.61 | -2.03 | 33.70 | 2.20 | 2.60 | 2.70 | 1.69 | -0.30 | -0.49 | -7.18 | 3.80 |
| eeq | 1.08 | 1.26 | 1.40 | 1.25 | 1.41 | 1.56 | 2.06 | 1.79 | 1.93 | 2.07 | 1.92 | 2.08 | 2.23 | 2.75 |
| ome | 2.23 | 2.32 | 2.56 | 2.26 | 2.13 | 2.64 | 3.13 | 2.38 | 2.46 | 2.72 | 2.40 | 2.28 | 2.82 | 3.30 |
| mvh | 1.99 | 1.95 | 2.36 | 1.79 | 1.95 | 2.30 | 2.36 | 3.03 | 2.97 | 3.37 | 2.79 | 3.02 | 3.34 | 3.38 |
| otn | 3.12 | 3.06 | 3.38 | 2.11 | 2.14 | 2.96 | 3.13 | 3.02 | 2.97 | 3.22 | 2.03 | 2.10 | 2.84 | 3.04 |
| omf | -1.24 | -0.98 | -0.87 | -1.11 | -0.49 | -0.76 | -0.16 | 0.99 | 1.23 | 1.28 | 1.04 | 1.70 | 1.42 | 2.05 |
| cns | -0.70 | -0.49 | -0.15 | 0.15 | 0.26 | -0.17 | 0.56 | -0.46 | -0.25 | 0.10 | 0.39 | 0.50 | 0.07 | 0.81 |
| trd | -1.27 | -1.35 | -1.09 | -0.66 | -0.44 | -1.01 | -0.71 | -0.74 | -0.82 | -0.55 | -0.13 | 0.10 | -0.48 | -0.18 |

| | qxs[*ECOWAS*] | | | | | | | qxs[*SADC*] | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | chn | UMA | ECOWAS | CentralAfr | EAC | SADC | zaf | chn | UMA | ECOWAS | CentralAfr | EAC | SADC | zaf |
| AgrlWood | -1.23 | -0.96 | -0.47 | -0.55 | -0.05 | -0.61 | -0.78 | -0.74 | -0.43 | 0.00 | -0.03 | 0.47 | -0.07 | -0.26 |
| Food | -0.74 | -0.52 | -0.26 | -0.33 | 0.29 | -0.29 | -0.16 | -0.43 | -0.21 | 0.06 | 0.01 | 0.63 | 0.03 | 0.18 |
| PetroleumCh | -0.27 | -0.47 | -0.73 | -0.57 | -0.61 | -0.42 | -0.42 | -0.16 | -0.37 | -0.62 | -0.43 | -0.51 | -0.32 | -0.32 |
| Metalprodu | 0.46 | 0.61 | 0.55 | 0.76 | 0.66 | 0.83 | 0.66 | -0.21 | -0.05 | -0.10 | 0.12 | 0.02 | 0.18 | -0.01 |
| ele | -0.84 | 45.26 | -1.67 | 41.04 | 40.78 | 31.31 | 0.37 | 0.39 | 47.05 | -0.46 | 42.77 | -2.59 | -9.15 | 1.61 |
| eeq | -0.41 | -0.23 | -0.08 | -0.22 | -0.06 | 0.09 | 0.58 | -0.21 | -0.03 | 0.12 | -0.03 | 0.13 | 0.28 | 0.77 |
| ome | -0.47 | -0.32 | -0.06 | -0.36 | -0.48 | 0.03 | 0.49 | -0.01 | 0.13 | 0.38 | 0.09 | -0.03 | 0.48 | 0.94 |
| mvh | -0.68 | -0.69 | -0.28 | -0.82 | -0.62 | -0.30 | -0.27 | 0.27 | 0.25 | 0.66 | 0.11 | 0.31 | 0.64 | 0.67 |
| otn | -1.24 | -1.24 | -0.93 | -2.13 | -2.09 | -1.35 | -1.18 | 1.33 | 1.29 | 1.60 | 0.29 | 0.41 | 1.19 | 1.27 |
| omf | -0.34 | -0.07 | 0.01 | -0.24 | 0.42 | 0.13 | 0.73 | -0.23 | 0.04 | 0.12 | -0.14 | 0.52 | 0.24 | 0.84 |
| cns | -0.58 | -0.37 | -0.02 | 0.27 | 0.38 | -0.05 | 0.69 | -0.40 | -0.19 | 0.16 | 0.45 | 0.56 | 0.13 | 0.87 |
| trd | 0.09 | 0.01 | 0.28 | 0.71 | 0.94 | 0.35 | 0.66 | -0.45 | -0.53 | -0.26 | 0.17 | 0.39 | -0.19 | 0.12 |

| | qxs[*UMA*] | | | | | | | qxs[*zaf*] | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | chn | UMA | ECOWAS | CentralAfr | EAC | SADC | zaf | chn | UMA | ECOWAS | CentralAfr | EAC | SADC | zaf |
| AgrlWood | -0.63 | -0.25 | 0.18 | 0.08 | 0.62 | 0.09 | -0.13 | -0.68 | -0.36 | 0.11 | 0.02 | 0.54 | 0.01 | -0.26 |
| Food | -0.40 | -0.17 | 0.09 | 0.03 | 0.66 | 0.06 | 0.18 | -0.69 | -0.45 | -0.20 | -0.27 | 0.35 | -0.24 | -0.15 |
| PetroleumCh | -0.08 | -0.28 | -0.54 | -0.38 | -0.43 | -0.24 | -0.24 | -0.35 | -0.54 | -0.80 | -0.64 | -0.69 | -0.50 | -0.52 |
| Metalprodu | -0.05 | 0.10 | 0.05 | 0.27 | 0.16 | 0.33 | 0.14 | -1.16 | -0.97 | -1.00 | -0.79 | -0.89 | -0.73 | -0.98 |
| ele | 0.16 | 0.28 | 45.29 | -2.63 | 42.19 | 32.63 | 48.32 | -1.17 | -1.05 | 43.38 | 40.58 | 40.32 | 30.88 | 0.02 |
| eeq | 0.06 | 0.23 | 0.37 | 0.23 | 0.39 | 0.54 | 1.03 | -1.29 | -1.09 | -0.95 | -1.10 | -0.93 | -0.79 | -0.35 |
| ome | 0.10 | 0.24 | 0.49 | 0.20 | 0.08 | 0.59 | 1.06 | -1.11 | -0.97 | -0.72 | -1.01 | -1.13 | -0.63 | -0.20 |
| mvh | -0.01 | -0.03 | 0.38 | -0.16 | 0.04 | 0.37 | 0.40 | -0.68 | -0.69 | -0.29 | -0.82 | -0.62 | -0.30 | -0.28 |
| otn | -0.14 | -0.15 | 0.17 | -1.05 | -1.02 | -0.25 | -0.08 | -1.33 | -1.36 | -1.05 | -2.23 | -2.20 | -1.45 | -1.30 |
| omf | -0.23 | 0.05 | 0.13 | -0.14 | 0.53 | 0.24 | 0.85 | -1.54 | -1.27 | -1.12 | -1.38 | -0.73 | -1.02 | -0.50 |
| cns | 0.04 | 0.25 | 0.60 | 0.90 | 1.01 | 0.57 | 1.31 | -0.86 | -0.65 | -0.30 | -0.01 | 0.10 | -0.33 | 0.40 |
| trd | 0.24 | 0.16 | 0.43 | 0.86 | 1.09 | 0.51 | 0.81 | -0.99 | -1.07 | -0.80 | -0.38 | -0.15 | -0.73 | -0.43 |

Simulated impact of GTAP model.

Having painted a 'rosy picture' in pre-pandemic status quo—despite Global Financial Crisis hitting the world economy at large—now we turn to the gloomy scenario of 'Pandemic of the Century' case where there are no discrimination across economies; that is, all developed, developing, emerging, and poor economies have suffered the negative shock with divergence is the extent of absorbing or weathering the adverse scenario. That brings us to the next section.

## 4.7 Adverse Covid-Shock and 'Silver Lining' (Scenario III)

In Tables 23 and 24, we see—quite intuitively that due to Covid-19 induced labor productivity fall (decline in efficiency and loss of human capital) and fall in TFP growth—that all output shrank with pronounced effects in developing and some DCs including some in African continent.

**Table 23: Impacts of across the board 'Covid-19' Shock (Aggregate) for Macroresults**

| | DTBAL | EV_ALT | qgdp | qxwreg | qiwreg | yev | ypev | rorc |
|---|---|---|---|---|---|---|---|---|
| ANZ | -243.59 | -16671.5 | -0.99698 | -0.9894 | -0.84 | -1.13 | -1.12 | -1.76 |
| chn | -19987.83 | -98927.3 | -0.98743 | -1.61537 | -0.65 | -1.13 | -1.06 | -1.74 |
| hkg | -62.56 | -2990.5 | -0.99983 | -0.98403 | -1.00 | -1.22 | -1.21 | -1.58 |
| jpn | 901.64 | -46303.9 | -0.9976 | -0.79308 | -0.95 | -1.19 | -1.18 | -1.61 |
| kor | -774.67 | -13904.1 | -0.99173 | -1.04079 | -0.91 | -1.16 | -1.15 | -1.68 |
| twn | -858.29 | -5172.46 | -0.99706 | -1.16991 | -0.87 | -1.13 | -1.10 | -1.56 |
| SEAsia | -5302.39 | -24047.3 | -0.98849 | -1.22177 | -0.80 | -1.09 | -1.05 | -1.36 |
| ind | -3690.80 | -19705.2 | -0.98399 | -1.50569 | -0.69 | -1.10 | -1.07 | -1.56 |
| SouthAsia | -1132.10 | -5218.67 | -0.9853 | -1.71122 | -0.66 | -1.06 | -1.05 | -1.16 |
| can | 4057.12 | -18328.6 | -1.01694 | -0.28942 | -1.08 | -1.21 | -1.21 | -2.2 |
| usa | 43378.94 | -182137 | -1.00526 | 0.592028 | -1.68 | -1.20 | -1.20 | -2.37 |
| mex | -1354.29 | -12652 | -0.99365 | -1.03452 | -0.68 | -1.12 | -1.11 | -1.35 |
| bra | -1951.65 | -23338.3 | -0.98309 | -1.36495 | -0.60 | -1.09 | -1.07 | -1.46 |
| aut | 18.63 | -4400.32 | -1.00857 | -0.89037 | -0.90 | -1.19 | -1.18 | -1.63 |
| bel | -522.09 | -5114.9 | -0.98948 | -0.98641 | -0.86 | -1.14 | -1.13 | -1.42 |
| fra | 6634.68 | -30455.5 | -1.02263 | -0.06658 | -1.13 | -1.27 | -1.26 | -2.15 |
| deu | 3777.69 | -39592 | -1.01162 | -0.7143 | -0.97 | -1.21 | -1.21 | -1.8 |
| gbr | 3046.09 | -30920.6 | -1.01071 | -0.54246 | -1.05 | -1.21 | -1.20 | -1.73 |
| UMA | -1826.54 | -6718.43 | -0.98344 | -1.49123 | -0.58 | -1.02 | -0.99 | -1.14 |
| ECOWAS | -1125.56 | -6923.37 | -0.98508 | -1.48453 | -0.60 | -1.04 | -0.98 | -1.21 |
| CentralAfr | -346.17 | -2360.37 | -0.97469 | -1.10197 | -0.59 | -1.05 | -1.01 | -1.31 |
| EAC | -454.10 | -1583.59 | -0.98135 | -1.92304 | -0.61 | -1.04 | -1.02 | -1.15 |
| SADC | -416.99 | -2310.28 | -0.98984 | -1.26157 | -0.70 | -1.08 | -1.06 | -1.4 |
| zaf | -115.83 | -3444.51 | -0.99355 | -0.9417 | -0.82 | -1.13 | -1.10 | -1.53 |

Simulated impact of GTAP model with vn 10 Database

**Table 24:Across the board 'Covid-19' Shock (Aggregate) for Sectoral Impacts (prices and outputs)**

| ***pm*** | chn | hkg | jpn | kor | twn | ind | can | usa | bra | fra | gbr | UMA | ECOWAS | CentralAfr | EAC | SADC | zaf |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AgrlWood | 1.21 | 1.04 | 1.04 | 1.10 | 1.14 | 1.28 | 0.85 | 0.73 | 1.19 | 0.90 | 0.97 | 1.28 | 1.47 | 1.24 | 1.34 | 1.22 | 1.11 |
| Food | 1.20 | 1.03 | 1.03 | 1.08 | 1.09 | 1.24 | 0.81 | 0.73 | 1.18 | 0.87 | 0.96 | 1.23 | 1.32 | 1.21 | 1.33 | 1.19 | 1.10 |
| MineralGas | 1.24 | 1.23 | 1.06 | 1.11 | 1.16 | 1.25 | 1.10 | 1.00 | 1.20 | 0.93 | 1.12 | 1.21 | 1.20 | 1.19 | 1.23 | 1.20 | 1.18 |
| PetroleumC | 1.19 | 1.05 | 1.09 | 1.13 | 1.13 | 1.18 | 0.93 | 0.88 | 1.17 | 0.97 | 1.01 | 1.20 | 1.23 | 1.18 | 1.28 | 1.18 | 1.13 |
| bph | 1.19 | 1.03 | 1.02 | 1.07 | 1.06 | 1.17 | 0.82 | 0.72 | 1.17 | 0.87 | 0.95 | 1.20 | 1.31 | 1.19 | 1.31 | 1.17 | 1.10 |
| Metalprodu | 1.19 | 1.10 | 1.04 | 1.10 | 1.11 | 1.17 | 0.88 | 0.75 | 1.17 | 0.90 | 0.97 | 1.19 | 1.26 | 1.17 | 1.28 | 1.18 | 1.10 |
| ele | 1.16 | 1.07 | 1.04 | 1.09 | 1.10 | 1.15 | 0.85 | 0.78 | 1.15 | 0.92 | 0.97 | 1.18 | 1.32 | 1.18 | 1.27 | 1.18 | 1.10 |
| eeq | 1.18 | 1.05 | 1.04 | 1.09 | 1.10 | 1.16 | 0.85 | 0.75 | 1.16 | 0.89 | 0.97 | 1.18 | 1.29 | 1.18 | 1.28 | 1.18 | 1.10 |
| ome | 1.18 | 1.04 | 1.03 | 1.08 | 1.10 | 1.17 | 0.83 | 0.73 | 1.16 | 0.88 | 0.96 | 1.19 | 1.30 | 1.18 | 1.29 | 1.18 | 1.10 |
| mvh | 1.18 | 1.02 | 1.04 | 1.08 | 1.09 | 1.16 | 0.84 | 0.77 | 1.15 | 0.93 | 0.98 | 1.14 | 1.31 | 1.18 | 1.28 | 1.18 | 1.09 |
| otn | 1.17 | 1.00 | 1.03 | 1.08 | 1.08 | 1.15 | 0.82 | 0.74 | 1.13 | 0.90 | 0.96 | 1.15 | 1.33 | 1.18 | 1.26 | 1.17 | 1.09 |
| omf | 1.19 | 1.06 | 1.03 | 1.09 | 1.11 | 1.18 | 0.85 | 0.72 | 1.17 | 0.88 | 0.96 | 1.20 | 1.31 | 1.18 | 1.31 | 1.18 | 1.10 |
| trd | 1.19 | 1.02 | 1.02 | 1.08 | 1.11 | 1.17 | 0.77 | 0.68 | 1.18 | 0.83 | 0.94 | 1.24 | 1.27 | 1.19 | 1.34 | 1.19 | 1.10 |

| ***qo*** | chn | hkg | jpn | kor | twn | ind | can | usa | bra | fra | gbr | UMA | ECOWAS | CentralAfr | EAC | SADC | zaf |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AgrlWood | -0.99 | -0.87 | -0.91 | -0.95 | -0.88 | -0.92 | -0.51 | -0.78 | -0.97 | -0.52 | -0.71 | -0.86 | -0.80 | -0.89 | -0.96 | -0.90 | -0.87 |
| Food | -0.85 | -0.98 | -0.96 | -0.93 | -0.87 | -0.90 | -0.78 | -0.87 | -0.83 | -0.73 | -0.91 | -0.86 | -1.10 | -0.90 | -1.05 | -0.97 | -0.74 |
| MineralGas | -0.84 | -0.66 | -0.33 | -0.49 | -0.42 | -0.87 | -0.65 | -0.55 | -0.93 | -0.09 | -0.64 | -1.05 | -1.18 | -1.00 | -1.16 | -0.97 | -0.83 |
| tex | -1.22 | -0.97 | -0.63 | -0.83 | -0.96 | -1.02 | -0.09 | -0.42 | -0.87 | -0.02 | -0.57 | -1.10 | -1.55 | -0.98 | -1.40 | -1.06 | -0.78 |
| wap | -1.14 | -0.92 | -0.78 | -0.91 | -0.97 | -1.16 | 0.05 | -0.37 | -0.80 | -0.14 | -0.23 | -1.04 | -1.15 | -0.94 | -1.52 | -1.12 | -0.73 |
| lea | -1.15 | -0.69 | -0.75 | -0.82 | -0.82 | -1.16 | 0.57 | 0.40 | -0.89 | 0.45 | -0.16 | -1.23 | -1.43 | -0.86 | -1.39 | -0.98 | -0.67 |
| PetroleumC | -1.10 | -0.80 | -0.95 | -1.01 | -1.04 | -1.03 | -0.74 | -0.68 | -1.06 | -0.51 | -0.78 | -1.25 | -1.44 | -1.05 | -1.31 | -1.05 | -1.00 |
| bph | -1.34 | -1.13 | -1.25 | -1.28 | -1.39 | -1.62 | -0.59 | -0.39 | -1.31 | -0.45 | -1.00 | -1.47 | -1.88 | -1.27 | -1.64 | -1.27 | -1.27 |
| ele | -1.51 | -0.93 | -0.69 | -1.07 | -1.21 | -0.83 | 0.25 | 0.11 | -0.74 | 0.16 | -0.29 | -1.09 | -1.08 | -0.90 | -1.27 | -1.06 | -0.75 |
| eeq | -1.16 | -0.70 | -0.55 | -0.83 | -0.91 | -0.77 | -0.26 | -0.24 | -0.69 | 0.26 | -0.35 | -1.31 | -0.85 | -0.76 | -0.91 | -0.96 | -0.58 |
| ome | -0.93 | -0.66 | -0.59 | -0.87 | -0.89 | -0.68 | -0.40 | -0.50 | -0.69 | -0.07 | -0.47 | -0.50 | -0.81 | -0.82 | -0.75 | -0.94 | -0.72 |
| mvh | -0.85 | -0.76 | -1.04 | -1.16 | -1.04 | -0.69 | -0.92 | -0.89 | -0.82 | -0.53 | -0.76 | -0.95 | -1.07 | -0.73 | -0.87 | -1.03 | -0.96 |
| otn | -1.09 | -1.06 | -0.91 | -1.14 | -1.55 | -1.18 | -0.14 | -0.17 | -1.26 | -0.34 | -0.76 | -1.40 | -1.27 | -1.13 | -1.40 | -1.18 | -0.98 |
| omf | -1.38 | -0.89 | -0.79 | -0.97 | -1.06 | -0.94 | -0.77 | -0.36 | -0.88 | -0.42 | -0.82 | -0.92 | -1.03 | -0.69 | -1.06 | -1.25 | -1.07 |
| cns | -0.38 | -0.39 | -0.52 | -0.45 | -0.29 | -0.28 | -1.29 | -1.45 | -0.23 | -1.28 | -0.83 | 0.11 | 0.15 | -0.06 | 0.10 | -0.10 | -0.36 |
| trd | -1.05 | -1.00 | -1.02 | -1.02 | -0.90 | -1.04 | -1.08 | -1.06 | -0.96 | -1.03 | -1.07 | -1.07 | -1.05 | -1.01 | -1.11 | -1.04 | -0.90 |
| BusinessSv | -1.11 | -1.09 | -1.10 | -1.02 | -1.06 | -1.27 | -1.07 | -1.05 | -1.16 | -1.08 | -1.06 | -1.24 | -1.55 | -1.26 | -1.24 | -1.25 | -1.11 |
| WatAirTran | -1.09 | -1.00 | -0.96 | -1.00 | -1.11 | -1.14 | -0.83 | -0.83 | -1.06 | -0.85 | -0.96 | -1.25 | -1.34 | -1.15 | -1.39 | -1.23 | -1.09 |
| ros | -1.26 | -1.11 | -1.15 | -1.21 | -1.18 | -1.26 | -1.05 | -1.14 | -1.22 | -1.11 | -1.14 | -1.35 | -1.83 | -1.40 | -1.43 | -1.38 | -1.19 |
| edu | -1.25 | -1.22 | -1.09 | -1.22 | -1.14 | -1.27 | -1.14 | -1.10 | -1.18 | -1.14 | -1.14 | -1.24 | -1.39 | -1.22 | -1.42 | -1.23 | -1.23 |
| hht | -1.29 | -1.23 | -1.20 | -1.19 | -1.16 | -1.23 | -1.19 | -1.16 | -1.15 | -1.24 | -1.20 | -1.18 | -1.26 | -1.16 | -1.29 | -1.19 | -1.22 |

Simulated impact with GTAP vn10 Database

Prices increased a bit due to Supply bottleneck and lack of demand—AS shifting left along with AD shifting inward or even remaining the same. With fiscal stimulus (Keynesian multiplier) demand jacked up, price rises—exactly we saw that in Table 24. That causes fall in Welfare, real GDP, household regional income (y) all fall. Also RORC also falls, implying deterrent to new investment.

Not only that, Table 25 show although fall in bi-lateral exports sourced from China. That means, China-centric dependence—in the face of Covid-led distortions and non-trade human capital loss—could jeopardize the mission or agenda of deep industrialization through trade promotion a la AfCFTA. 'Behind the border' domestic factors---as mentioned in previous sections 2 and 3—need to be harnessed so that African economies could become resilient to absorb the adverse shock and achieve sustained inclusive growth in the post-pandemic period. As expected in Tables 26 and 27, for all composite African regions under AfCFTA suffered from these strong negative effects reflected in their sharp percentage decline in exports (qxs (i, r, s)).

As products are differentiated by origin, divergences between the export price for Stuff produced in any region and the average world price for Stuff have given rise to changes in TOT. Taking any region 'r' as the destination of exports of Stuff from two sources viz., 's' and 'k', *given* the Armington elasticity, the expansionary effect on aggregate imports of stuff (*qim (stuff,*

*r)*) and the import share of 'k' in aggregate imports of 'r', then import of Stuff from 's' to 'r' [*qxs (i,s,r)* ]depends on the changes in relativities between the price of imports of stuff from 'k' vis-a-vis that from 's' [29]. We discuss the change in *composition* of bilateral export sales which is contingent on these shock-induced relative price effects. The key equation explaining such mechanism is: In GTAP, we assume that imports of region 'r' from region 's' are exactly the same as the exports of region 's' to 'r'. Hence, the percentage change in demand for exports of 'i' from 's' to 'r' can be expressed as:

$qxs(i, s, r)=qim(i, r)-ESUBM\times MSHRS(i, k, r)\times[pms(i, s, r)-pms(i, k, r)]$ , *where* $k \neq s$.

**Table 25:Impact of across the board 'Covid-19' Shock (Aggregate) for Regional Trade from China**

| qxs[*chn*] | chn | hkg | jpn | kor | twn | ind | usa | fra | UMA | ECOWAS | CentralAfr | EAC | SADC | zaf |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AgrlWood | -1.37 | -1.61 | -1.73 | -1.59 | -1.52 | -0.96 | -2.58 | -1.72 | -0.99 | -0.52 | -1.06 | -0.75 | -1.03 | -1.35 |
| Food | -1.23 | -1.64 | -1.72 | -1.54 | -1.48 | -0.85 | -2.42 | -1.93 | -1.07 | -0.91 | -1.08 | -0.78 | -1.05 | -1.13 |
| MineralGasOi | -1.55 | -1.28 | -1.37 | -1.48 | -1.44 | -1.33 | -1.99 | -1.43 | -1.25 | -1.35 | -0.90 | -0.93 | -1.09 | -1.36 |
| tex | -1.50 | -1.80 | -1.21 | -1.30 | -1.41 | -1.06 | -2.31 | -1.50 | -1.12 | -1.12 | -1.18 | -1.10 | -1.12 | -1.18 |
| wap | -1.25 | -1.87 | -1.29 | -1.29 | -1.12 | -0.90 | -2.23 | -1.39 | -0.93 | -0.88 | -1.04 | -0.80 | -1.05 | -1.06 |
| lea | -1.40 | -1.76 | -1.53 | -1.39 | -1.26 | -0.96 | -1.82 | -1.42 | -1.03 | -0.95 | -0.98 | -0.86 | -1.02 | -1.04 |
| PetroleumCh | -1.31 | -1.31 | -1.39 | -1.39 | -1.43 | -1.12 | -1.91 | -1.55 | -1.30 | -1.58 | -1.20 | -0.99 | -1.08 | -1.30 |
| bph | -1.98 | -2.19 | -2.48 | -2.45 | -2.55 | -1.85 | -2.78 | -2.48 | -2.06 | -1.96 | -1.78 | -1.41 | -1.55 | -2.15 |
| Metalproduc | -1.40 | -1.77 | -1.41 | -1.47 | -1.51 | -1.11 | -2.36 | -1.67 | -1.05 | -1.12 | -1.03 | -0.59 | -1.01 | -1.39 |
| ele | -1.80 | -1.41 | -1.35 | -1.57 | -1.76 | -1.02 | -2.21 | -1.71 | -1.25 | -0.70 | -1.21 | -1.07 | -0.91 | -1.22 |
| eeq | -1.49 | -1.22 | -1.40 | -1.62 | -1.14 | -1.13 | -2.97 | -1.95 | -1.24 | -0.58 | -1.02 | -0.56 | -0.85 | -1.24 |
| ome | -1.30 | -1.62 | -1.57 | -1.83 | -1.46 | -1.09 | -3.27 | -2.21 | -1.18 | -0.87 | -1.59 | -0.82 | -1.01 | -1.52 |
| mvh | -1.18 | -1.57 | -1.73 | -1.61 | -1.53 | -0.87 | -2.73 | -1.93 | -1.26 | -1.13 | -0.91 | -1.09 | -0.97 | -1.52 |
| otn | -2.17 | -2.81 | -2.04 | -2.28 | -2.43 | -2.25 | -3.14 | -2.64 | -2.13 | -0.88 | -1.07 | -1.54 | -1.18 | -1.78 |
| omf | -1.43 | -1.80 | -1.83 | -1.84 | -1.43 | -0.79 | -2.78 | -2.40 | -0.84 | -0.64 | -0.88 | -0.67 | -0.92 | -1.44 |
| cns | -0.66 | -1.53 | -1.04 | -0.97 | -0.76 | -0.50 | -2.70 | -2.27 | -0.21 | -0.30 | -0.36 | 0.07 | -0.37 | -0.66 |
| trd | -1.35 | -1.56 | -1.63 | -1.43 | -1.54 | -1.40 | -2.22 | -1.62 | -1.26 | -1.48 | -1.35 | -1.27 | -1.55 | -1.62 |
| BusinessSvcs | -1.44 | -1.59 | -1.77 | -1.55 | -1.55 | -1.43 | -2.31 | -1.98 | -1.27 | -1.51 | -1.54 | -1.26 | -1.53 | -1.64 |
| otp | -1.20 | -1.56 | -1.51 | -1.67 | -1.45 | -1.09 | -1.97 | -1.70 | -1.23 | -1.40 | -1.27 | -1.00 | -1.22 | -1.38 |
| WatAirTransp | -1.37 | -1.52 | -1.60 | -1.48 | -1.53 | -1.35 | -1.95 | -1.69 | -1.33 | -1.63 | -1.40 | -1.13 | -1.36 | -1.43 |
| cmn | -0.95 | -1.66 | -1.59 | -1.47 | -1.36 | -1.43 | -2.25 | -2.13 | -1.16 | -1.01 | -1.22 | -0.71 | -1.40 | -1.53 |
| *Simulated impact with GTAP model* | | | | | | | | | | | | | | |

[29] In GTAP, we assume that imports of region 'r' from region 's' are exactly the same as the exports of region 's' to 'r'. Hence, the percentage change in demand for exports of 'i' from 's' to 'r' can be expressed as:
$qxs(i, s, r)=qim(i, r)-ESUBM\times MSHRS(i, k, r)\times[pms(i, s, r)-pms(i, k, r)]$ , where $k \neq s$.
where MSHRS (i, k, r) is the share of imports from 'k' to 'r' in aggregate imports from both 'k' and 's' to 'r' and ESUBM (=5 in the database) is the Armington elasticity for imports from sources 'k' and 's'. Thus, we write MSHRS (i, k, r)+ MSHRS (i, s, r)=1.

**Table 26:Impact of across the board 'Covid-19' Shock (Aggregate) for Regional Trade from ECOWAS and EAC**

| qxs[*ECOWAS | chn | hkg | jpn | kor | twn | ind | usa | fra | UMA | ECOWAS | CentralAfr | EAC | SADC | zaf |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AgrlWood | -2.6 | -2.95 | -3.08 | -2.98 | -2.88 | -2.32 | -3.93 | -2.97 | -2.36 | -1.81 | -2.34 | -2.06 | -2.39 | -2.7 |
| Food | -1.76 | -2.26 | -2.28 | -2.11 | -2.05 | -1.42 | -2.98 | -2.49 | -1.62 | -1.46 | -1.65 | -1.35 | -1.59 | -1.7 |
| MineralGasOi | -0.97 | -0.99 | -1.12 | -1.17 | -1.13 | -1.01 | -1.69 | -1.11 | -0.98 | -1.05 | -0.78 | -0.73 | -0.86 | -1.1 |
| tex | -2.49 | -2.87 | -2.28 | -2.37 | -2.49 | -2.11 | -3.35 | -2.52 | -2.13 | -2.09 | -2.16 | -2.05 | -2.1 | -2.2 |
| wap | -1.8 | -2.44 | -1.88 | -1.87 | -1.71 | -1.49 | -2.8 | -1.97 | -1.51 | -1.42 | -1.59 | -1.37 | -1.62 | -1.6 |
| lea | -2.01 | -2.41 | -2.22 | -2.09 | -1.93 | -1.61 | -2.47 | -2.11 | -1.69 | -1.60 | -1.62 | -1.5 | -1.69 | -1.7 |
| PetroleumCh | -1.52 | -1.59 | -1.67 | -1.64 | -1.68 | -1.33 | -2.14 | -1.84 | -1.56 | -1.83 | -1.46 | -1.25 | -1.34 | -1.5 |
| bph | -2.77 | -2.99 | -3.28 | -3.25 | -3.35 | -2.64 | -3.57 | -3.27 | -2.84 | -2.74 | -2.57 | -2.2 | -2.34 | -2.9 |
| Metalproduc | -1.89 | -2.28 | -1.93 | -1.98 | -2.02 | -1.65 | -2.91 | -2.22 | -1.58 | -1.67 | -1.54 | -1.1 | -1.53 | -2 |
| ele | -3.16 | -2.78 | -2.73 | -2.95 | -3.14 | -2.4 | -3.56 | -3.07 | -2.63 | -2.07 | -2.57 | -2.44 | -2.28 | -2.6 |
| eeq | -2.38 | -2.16 | -2.34 | -2.5 | -2.09 | -2.02 | -3.86 | -2.84 | -2.15 | -1.47 | -1.91 | -1.45 | -1.74 | -2.1 |
| ome | -2.23 | -2.57 | -2.53 | -2.74 | -2.42 | -2.01 | -4.17 | -3.11 | -2.11 | -1.77 | -2.50 | -1.73 | -1.93 | -2.4 |
| mvh | -1.9 | -2.32 | -2.49 | -2.36 | -2.28 | -1.62 | -3.46 | -2.64 | -1.98 | -1.84 | -1.62 | -1.82 | -1.7 | -2.2 |
| otn | -3.46 | -4.11 | -3.38 | -3.55 | -3.76 | -3.56 | -4.43 | -3.94 | -3.42 | -2.17 | -2.37 | -2.81 | -2.47 | -3.1 |
| omf | -2.26 | -2.67 | -2.70 | -2.72 | -2.31 | -1.68 | -3.64 | -3.24 | -1.7 | -1.48 | -1.70 | -1.5 | -1.77 | -2.3 |
| cns | -1.14 | -2 | -1.52 | -1.45 | -1.24 | -0.98 | -3.17 | -2.74 | -0.69 | -0.78 | -0.84 | -0.41 | -0.85 | -1.1 |
| trd | -1.64 | -1.85 | -1.92 | -1.72 | -1.83 | -1.69 | -2.51 | -1.91 | -1.55 | -1.77 | -1.64 | -1.56 | -1.84 | -1.9 |
| BusinessSvcs | -1.6 | -1.75 | -1.93 | -1.71 | -1.71 | -1.59 | -2.47 | -2.14 | -1.43 | -1.68 | -1.70 | -1.42 | -1.69 | -1.8 |
| otp | -1.29 | -1.65 | -1.61 | -1.76 | -1.54 | -1.18 | -2.06 | -1.80 | -1.32 | -1.49 | -1.36 | -1.1 | -1.32 | -1.5 |
| WatAirTransp | -1.39 | -1.54 | -1.62 | -1.5 | -1.55 | -1.37 | -1.97 | -1.71 | -1.35 | -1.65 | -1.42 | -1.15 | -1.38 | -1.5 |

| qxs[*EAC*] | chn | hkg | jpn | kor | twn | ind | usa | fra | UMA | ECOWAS | CentralAfr | EAC | SADC | zaf |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AgrlWood | -2.01 | -2.32 | -2.448 | -2.33 | -2.26 | -1.66 | -3.3 | -2.381 | -1.69 | -1.20 | -1.76 | -1.43 | -1.51 | -2 |
| Food | -1.81 | -2.28 | -2.325 | -2.17 | -2.11 | -1.46 | -3.01 | -2.514 | -1.55 | -1.52 | -1.51 | -1.37 | -1.31 | -1.7 |
| MineralGasOi | -1.42 | -1.34 | -1.56 | -1.6 | -1.55 | -1.43 | -2.11 | -1.548 | -1.37 | -1.47 | -0.76 | -0.83 | -0.82 | -1.4 |
| tex | -2.15 | -2.53 | -1.929 | -2.02 | -2.13 | -1.76 | -3.02 | -2.157 | -1.81 | -1.79 | -1.81 | -1.75 | -1.77 | -1.8 |
| wap | -2 | -2.64 | -2.039 | -2.05 | -1.88 | -1.68 | -2.96 | -2.126 | -1.7 | -1.66 | -1.78 | -1.54 | -1.79 | -1.8 |
| lea | -2.27 | -2.67 | -2.456 | -2.34 | -2.2 | -1.88 | -2.73 | -2.34 | -2 | -1.92 | -1.87 | -1.75 | -1.91 | -1.9 |
| PetroleumCh | -1.75 | -1.87 | -1.953 | -1.94 | -1.99 | -1.63 | -2.46 | -2.098 | -1.83 | -2.12 | -1.70 | -1.5 | -1.59 | -1.8 |
| bph | -2.74 | -2.97 | -3.259 | -3.22 | -3.32 | -2.61 | -3.55 | -3.257 | -2.83 | -2.72 | -2.54 | -2.17 | -2.31 | -2.9 |
| Metalproduc | -1.99 | -2.39 | -2.058 | -2.11 | -2.14 | -1.75 | -3 | -2.271 | -1.69 | -1.71 | -1.60 | -1.17 | -1.59 | -2 |
| ele | -2.72 | -2.35 | -2.287 | -2.49 | -2.67 | -1.94 | -3.13 | -2.616 | -2.17 | -1.62 | -2.13 | -1.98 | -1.82 | -2.1 |
| eeq | -2.33 | -2.13 | -2.294 | -2.49 | -2.02 | -1.99 | -3.83 | -2.84 | -2.12 | -1.45 | -1.89 | -1.43 | -1.7 | -2.1 |
| ome | -2.16 | -2.5 | -2.455 | -2.69 | -2.32 | -1.94 | -4.12 | -3.052 | -2.04 | -1.71 | -2.43 | -1.66 | -1.84 | -2.4 |
| mvh | -1.74 | -2.14 | -2.313 | -2.19 | -2.11 | -1.44 | -3.3 | -2.499 | -1.82 | -1.69 | -1.46 | -1.62 | -1.51 | -2.1 |
| otn | -2.87 | -3.52 | -2.76 | -3 | -3.16 | -2.95 | -3.84 | -3.335 | -2.84 | -1.59 | -1.76 | -2.23 | -1.89 | -2.5 |
| omf | -2.26 | -2.71 | -2.73 | -2.76 | -2.35 | -1.69 | -3.66 | -3.295 | -1.75 | -1.49 | -1.71 | -1.56 | -1.79 | -2.3 |
| ElecGasWater | -1.96 | -2.4 | -2.517 | -2.58 | -2.45 | -1.99 | -3.43 | -3.015 | -1.81 | -2.10 | -1.80 | -1.67 | -1.91 | -1.9 |
| cns | -1.01 | -1.87 | -1.391 | -1.32 | -1.11 | -0.85 | -3.05 | -2.616 | -0.56 | -0.65 | -0.71 | -0.28 | -0.72 | -1 |
| trd | -1.88 | -2.09 | -2.156 | -1.96 | -2.07 | -1.93 | -2.75 | -2.15 | -1.79 | -2.01 | -1.88 | -1.8 | -2.08 | -2.2 |
| BusinessSvcs | -1.97 | -2.12 | -2.299 | -2.08 | -2.08 | -1.96 | -2.83 | -2.511 | -1.8 | -2.05 | -2.07 | -1.79 | -2.06 | -2.2 |
| otp | -1.58 | -1.94 | -1.897 | -2.05 | -1.83 | -1.47 | -2.35 | -2.086 | -1.61 | -1.79 | -1.65 | -1.39 | -1.61 | -1.8 |
| WatAirTransp | -1.7 | -1.84 | -1.92 | -1.81 | -1.86 | -1.68 | -2.28 | -2.011 | -1.66 | -1.95 | -1.73 | -1.46 | -1.69 | -1.8 |

**Table 27:Impact of across the board 'Covid-19' Shock (Aggregate) for Regional Trade from Central Africa, UMA, SADC**

| qxs[*Central Afr*] | chn | hkg | jpn | kor | twn | ind | usa | fra | UMA | ECOWAS | CentralAfr | EAC | SADC | zaf |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AgrlWood | -1.44 | -1.78 | -1.901 | -1.78 | -1.67 | -1.11 | -2.74 | -1.84 | -1.14 | -0.6102 | -1.21812 | -0.9 | -1.19 | -1.5 |
| Food | -1.28 | -1.75 | -1.792 | -1.62 | -1.52 | -0.94 | -2.48 | -1.992 | -1.1 | -0.9716 | -1.11644 | -0.84 | -1.09 | -1.2 |
| MineralGasOi | -0.9 | -0.84 | -0.978 | -1.02 | -0.98 | -0.86 | -1.54 | -0.968 | -0.86 | -0.842 | -0.55608 | -0.57 | -0.61 | -0.9 |
| tex | -1.5 | -1.84 | -1.261 | -1.35 | -1.46 | -1.11 | -2.36 | -1.55 | -1.16 | -1.1473 | -1.18084 | -1.1 | -1.15 | -1.2 |
| wap | -1.22 | -1.87 | -1.3 | -1.29 | -1.13 | -0.91 | -2.24 | -1.395 | -0.94 | -0.8836 | -1.02192 | -0.8 | -1.05 | -1.1 |
| lea | -1.32 | -1.72 | -1.492 | -1.35 | -1.21 | -0.92 | -1.76 | -1.368 | -0.97 | -0.8917 | -0.9045 | -0.79 | -0.94 | -1 |
| PetroleumCh | -1.24 | -1.31 | -1.373 | -1.36 | -1.4 | -1.09 | -1.89 | -1.519 | -1.3 | -1.5614 | -1.18196 | -0.98 | -1.09 | -1.3 |
| bph | -1.96 | -2.19 | -2.48 | -2.45 | -2.54 | -1.83 | -2.77 | -2.479 | -2.05 | -1.9461 | -1.77008 | -1.4 | -1.54 | -2.1 |
| Metalproduc | -1.27 | -1.64 | -1.306 | -1.39 | -1.42 | -1 | -2.28 | -1.557 | -0.98 | -1.0229 | -0.92904 | -0.49 | -0.94 | -1.3 |
| ele | -2 | -1.63 | -1.558 | -1.78 | -1.97 | -1.23 | -2.41 | -1.919 | -1.46 | -0.9043 | -1.41243 | -1.27 | -1.11 | -1.4 |
| eeq | -1.48 | -1.24 | -1.434 | -1.61 | -1.16 | -1.13 | -2.98 | -1.968 | -1.25 | -0.5861 | -1.03033 | -0.57 | -0.85 | -1.3 |
| ome | -1.28 | -1.62 | -1.586 | -1.83 | -1.46 | -1.08 | -3.27 | -2.206 | -1.18 | -0.8602 | -1.58406 | -0.81 | -1 | -1.5 |
| mvh | -1.21 | -1.61 | -1.785 | -1.66 | -1.58 | -0.92 | -2.78 | -1.978 | -1.29 | -1.1591 | -0.93521 | -1.13 | -1.01 | -1.6 |
| otn | -2.26 | -2.91 | -2.175 | -2.39 | -2.56 | -2.36 | -3.25 | -2.738 | -2.25 | -0.9617 | -1.16512 | -1.65 | -1.27 | -1.9 |
| omf | -1.39 | -1.79 | -1.84 | -1.84 | -1.43 | -0.8 | -2.78 | -2.395 | -0.84 | -0.596 | -0.8764 | -0.65 | -0.92 | -1.4 |
| cns | -0.55 | -1.42 | -0.938 | -0.86 | -0.66 | -0.4 | -2.6 | -2.169 | -0.1 | -0.1965 | -0.25219 | 0.179 | -0.27 | -0.6 |
| trd | -1.32 | -1.54 | -1.602 | -1.41 | -1.52 | -1.37 | -2.2 | -1.596 | -1.23 | -1.459 | -1.32474 | -1.24 | -1.53 | -1.6 |
| BusinessSvcs | -1.4 | -1.55 | -1.723 | -1.5 | -1.5 | -1.39 | -2.26 | -1.937 | -1.22 | -1.4687 | -1.49252 | -1.22 | -1.48 | -1.6 |
| otp | -1.15 | -1.51 | -1.465 | -1.62 | -1.4 | -1.04 | -1.92 | -1.655 | -1.18 | -1.3534 | -1.22159 | -0.95 | -1.18 | -1.3 |
| WatAirTransp | -1.29 | -1.44 | -1.515 | -1.4 | -1.45 | -1.27 | -1.87 | -1.606 | -1.25 | -1.5474 | -1.32292 | -1.05 | -1.28 | -1.4 |

| qxs[*UMA*] | chn | hkg | jpn | kor | twn | ind | usa | fra | UMA | ECOWAS | CentralAfr | EAC | SADC | zaf |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AgrlWood | -1.71 | -2 | -2.042 | -1.94 | -1.92 | -1.3 | -2.91 | -1.954 | -1.29 | -0.8411 | -1.39744 | -1.06 | -1.35 | -1.7 |
| Food | -1.34 | -1.83 | -1.843 | -1.67 | -1.61 | -0.99 | -2.55 | -2.048 | -1.18 | -1.0235 | -1.20008 | -0.89 | -1.15 | -1.3 |
| MineralGasOi | -1.1 | -1.02 | -1.215 | -1.26 | -1.2 | -1.1 | -1.71 | -1.207 | -1.01 | -1.0067 | -0.73672 | -0.62 | -0.83 | -1.1 |
| tex | -1.77 | -2.13 | -1.527 | -1.63 | -1.72 | -1.34 | -2.6 | -1.783 | -1.39 | -1.386 | -1.45147 | -1.38 | -1.4 | -1.5 |
| wap | -1.46 | -2.11 | -1.515 | -1.52 | -1.34 | -1.14 | -2.45 | -1.606 | -1.15 | -1.1141 | -1.26361 | -1.04 | -1.28 | -1.3 |
| lea | -1.64 | -2.05 | -1.816 | -1.67 | -1.53 | -1.25 | -2.1 | -1.678 | -1.3 | -1.2197 | -1.24214 | -1.14 | -1.3 | -1.3 |
| PetroleumCh | -1.33 | -1.38 | -1.448 | -1.44 | -1.48 | -1.15 | -1.97 | -1.598 | -1.36 | -1.6345 | -1.26577 | -1.04 | -1.15 | -1.4 |
| bph | -2.05 | -2.27 | -2.563 | -2.53 | -2.62 | -1.92 | -2.86 | -2.554 | -2.13 | -2.0307 | -1.8551 | -1.48 | -1.62 | -2.2 |
| Metalproduc | -1.36 | -1.76 | -1.435 | -1.48 | -1.51 | -1.1 | -2.35 | -1.657 | -1.04 | -1.1184 | -1.02921 | -0.59 | -1.01 | -1.4 |
| ele | -2.02 | -1.65 | -1.573 | -1.8 | -1.98 | -1.25 | -2.44 | -1.939 | -1.48 | -0.9248 | -1.43661 | -1.28 | -1.13 | -1.4 |
| eeq | -1.44 | -1.21 | -1.396 | -1.6 | -1.12 | -1.11 | -2.95 | -1.939 | -1.21 | -0.5647 | -1.00857 | -0.54 | -0.82 | -1.2 |
| ome | -1.32 | -1.68 | -1.628 | -1.88 | -1.51 | -1.14 | -3.33 | -2.259 | -1.23 | -0.919 | -1.65019 | -0.87 | -1.06 | -1.6 |
| mvh | -1.01 | -1.42 | -1.583 | -1.46 | -1.38 | -0.72 | -2.58 | -1.775 | -1.09 | -0.9573 | -0.74713 | -0.93 | -0.81 | -1.4 |
| otn | -1.98 | -2.64 | -1.89 | -2.12 | -2.28 | -2.08 | -2.98 | -2.467 | -1.92 | -0.7085 | -0.89024 | -1.36 | -0.91 | -1.6 |
| omf | -1.53 | -1.93 | -1.98 | -1.98 | -1.57 | -0.93 | -2.91 | -2.526 | -0.94 | -0.7502 | -1.00757 | -0.79 | -1.03 | -1.6 |
| cns | -0.71 | -1.58 | -1.096 | -1.02 | -0.82 | -0.56 | -2.76 | -2.325 | -0.26 | -0.3558 | -0.41147 | 0.019 | -0.43 | -0.7 |
| trd | -1.51 | -1.73 | -1.794 | -1.6 | -1.71 | -1.57 | -2.39 | -1.788 | -1.42 | -1.6513 | -1.51735 | -1.44 | -1.72 | -1.8 |
| BusinessSvcs | -1.57 | -1.72 | -1.9 | -1.68 | -1.68 | -1.56 | -2.44 | -2.113 | -1.4 | -1.6458 | -1.66958 | -1.39 | -1.66 | -1.8 |
| otp | -1.23 | -1.59 | -1.546 | -1.7 | -1.48 | -1.12 | -2 | -1.735 | -1.26 | -1.4342 | -1.3025 | -1.04 | -1.26 | -1.4 |
| WatAirTransp | -1.37 | -1.51 | -1.594 | -1.48 | -1.53 | -1.35 | -1.95 | -1.685 | -1.33 | -1.6265 | -1.40216 | -1.13 | -1.36 | -1.4 |

| qxs[*SADC*] | chn | hkg | jpn | kor | twn | ind | usa | fra | UMA | ECOWAS | CentralAfr | EAC | SADC | zaf |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AgrlWood | -1.34 | -1.69 | -1.796 | -1.68 | -1.59 | -1.01 | -2.65 | -1.769 | -1.05 | -0.5868 | -1.07152 | -0.78 | -1.07 | -1.4 |
| Food | -1.18 | -1.66 | -1.696 | -1.54 | -1.45 | -0.83 | -2.4 | -1.902 | -1.05 | -0.8897 | -1.0425 | -0.74 | -1 | -1.1 |
| MineralGasOi | -1.01 | -0.93 | -1.078 | -1.09 | -1.03 | -0.98 | -1.71 | -0.822 | -0.96 | -0.7981 | -0.52413 | -0.54 | -0.82 | -1 |
| tex | -1.45 | -1.81 | -1.215 | -1.32 | -1.41 | -1.06 | -2.33 | -1.506 | -1.12 | -1.0998 | -1.15669 | -1.07 | -1.09 | -1.2 |
| wap | -1.2 | -1.85 | -1.274 | -1.27 | -1.1 | -0.87 | -2.2 | -1.355 | -0.92 | -0.865 | -1.00292 | -0.77 | -1.01 | -1 |
| lea | -1.31 | -1.7 | -1.49 | -1.35 | -1.22 | -0.91 | -1.76 | -1.356 | -1 | -0.9208 | -0.91541 | -0.8 | -0.95 | -1 |
| PetroleumCh | -1.27 | -1.32 | -1.408 | -1.4 | -1.43 | -1.12 | -1.93 | -1.562 | -1.31 | -1.5632 | -1.08085 | -0.99 | -1.07 | -1.3 |
| bph | -1.9 | -2.12 | -2.413 | -2.38 | -2.48 | -1.78 | -2.71 | -2.412 | -1.99 | -1.8808 | -1.70323 | -1.33 | -1.47 | -2.1 |
| Metalproduc | -1.31 | -1.7 | -1.366 | -1.43 | -1.45 | -1.06 | -2.31 | -1.599 | -1.01 | -1.0602 | -0.96534 | -0.54 | -0.95 | -1.3 |
| ele | -2 | -1.61 | -1.556 | -1.78 | -1.96 | -1.22 | -2.41 | -1.917 | -1.46 | -0.9016 | -1.40344 | -1.26 | -1.1 | -1.4 |
| eeq | -1.48 | -1.23 | -1.434 | -1.62 | -1.17 | -1.14 | -2.99 | -1.968 | -1.25 | -0.5823 | -1.02983 | -0.57 | -0.85 | -1.2 |
| ome | -1.28 | -1.62 | -1.575 | -1.83 | -1.46 | -1.07 | -3.28 | -2.201 | -1.18 | -0.8526 | -1.57967 | -0.81 | -1 | -1.5 |
| mvh | -1.19 | -1.6 | -1.771 | -1.64 | -1.56 | -0.91 | -2.76 | -1.966 | -1.28 | -1.147 | -0.92413 | -1.11 | -0.99 | -1.5 |
| otn | -2.18 | -2.83 | -2.087 | -2.31 | -2.47 | -2.26 | -3.17 | -2.653 | -2.16 | -0.8901 | -1.02092 | -1.55 | -1.19 | -1.7 |
| omf | -1.36 | -1.75 | -1.807 | -1.8 | -1.38 | -0.76 | -2.75 | -2.371 | -0.82 | -0.611 | -0.81435 | -0.63 | -0.87 | -1.4 |
| cns | -0.58 | -1.45 | -0.966 | -0.89 | -0.69 | -0.43 | -2.63 | -2.196 | -0.13 | -0.2246 | -0.28028 | 0.15 | -0.3 | -0.6 |
| trd | -1.34 | -1.55 | -1.616 | -1.42 | -1.53 | -1.39 | -2.21 | -1.61 | -1.25 | -1.4733 | -1.33905 | -1.26 | -1.54 | -1.6 |
| BusinessSvcs | -1.4 | -1.55 | -1.728 | -1.51 | -1.51 | -1.39 | -2.27 | -1.942 | -1.23 | -1.4733 | -1.49712 | -1.22 | -1.49 | -1.6 |
| otp | -1.12 | -1.48 | -1.44 | -1.6 | -1.38 | -1.01 | -1.9 | -1.629 | -1.15 | -1.3278 | -1.19591 | -0.93 | -1.15 | -1.3 |
| WatAirTransp | -1.29 | -1.43 | -1.509 | -1.4 | -1.45 | -1.27 | -1.87 | -1.6 | -1.25 | -1.5412 | -1.31672 | -1.04 | -1.27 | -1.3 |

*mulated impact with GTAP model*

Now, the silver lining underlying the 'dark cloud' looming on the horizon due to Covid-shock could be realized under the trade-induced spillover benefits from countries like India and China, as well as western ICs, viz., France (former African colonization history) and USA. Table 7d in Section2 above corroborates the conjecture that India and China are major exporter of medical items. Bhattacharya et al (2020) also shows the empirical evidences supporting this claim. Looking at table 7d, we see that African export of medicinal and pharmaceutical products are quite low even in 2019. Following this, medical spillover of pharmaceutical and partial absorption of that spillover in African continent is simulated. The results—reported in Table 28—confirms the conjecture that this 'Reversal of Fortune' improved welfare (EV_ALT) across the board, real GDP increased. Regional exports and imports increased with very few exception for the laggard. Terms of trade (TOT) increased as well. Thus, it's favorable to counter the adversity via medical research diffusion into Africa. For Sectors, we see from the bottom part of Table 28 that the pharmaceutical (bph) and health care and social work sector (hht), as well as educational services (edu) show positive effects.

**Table 28:Impact of Medical spillover from China and India at the Macrolevel and Regional Outputs**

| | qgdp | DTBAL | EV_ALT | qxwreg | qiwreg | ypev | tot | | |
|---|---|---|---|---|---|---|---|---|---|
| ANZ | 0.07 | 4750.58 | 2823.37 | 0.70 | -0.16 | 0.19 | 0.50 | | |
| chn | 1.51 | -30808.25 | 157531.06 | -0.67 | 0.56 | 1.68 | 0.06 | | |
| ind | 0.60 | 1702.25 | 12446.35 | 0.11 | -0.02 | 0.67 | 0.11 | | |
| SouthAsia | 0.06 | 1582.74 | 725.48 | 0.69 | -0.03 | 0.15 | 0.53 | | |
| can | 0.15 | 2578.68 | 4194.00 | -0.13 | -0.20 | 0.28 | 0.31 | | |
| usa | 0.46 | -70901.92 | 87248.45 | -2.45 | 1.38 | 0.57 | 0.37 | | |
| fra | 0.21 | 8849.67 | 3522.95 | 1.31 | -0.05 | 0.15 | -0.31 | | |
| UMA | 0.09 | 1972.00 | 1836.62 | 0.09 | 0.04 | 0.27 | 0.61 | | |
| ECOWAS | 0.03 | 1775.72 | 796.52 | 0.48 | -0.25 | 0.11 | 0.43 | | |
| CentralAfr | 0.06 | 501.41 | 772.72 | 0.08 | 0.07 | 0.33 | 0.61 | | |
| EAC | 0.08 | 612.23 | 332.32 | 0.66 | -0.04 | 0.21 | 0.60 | | |
| SADC | 0.06 | 653.97 | 580.15 | 0.09 | 0.07 | 0.27 | 0.63 | | |
| zaf | 0.31 | -360.95 | 1571.79 | -0.29 | 0.44 | 0.50 | 0.43 | | |
| | | | | | | | | | |
| qo | chn | ind | UMA | ECOWAS | CentralAfr | EAC | SADC | zaf | |
| AgrlWood | -0.59 | -0.08 | 0.00 | 0.10 | 0.14 | 0.18 | 0.19 | 0.45 | |
| Food | -0.08 | -0.09 | 0.08 | 0.14 | 0.13 | 0.16 | 0.14 | 0.31 | |
| PetroleumCh | -1.12 | -0.12 | 0.41 | 0.47 | 0.13 | 0.67 | 0.24 | 0.23 | |
| bph | 5.84 | 14.88 | 0.19 | 3.31 | 2.66 | 6.13 | 4.11 | 0.65 | |
| edu | 0.51 | 0.20 | 0.05 | 0.22 | 0.18 | 0.21 | 0.12 | 0.25 | |
| hht | 4.37 | 0.83 | 0.53 | 0.28 | 0.31 | 0.42 | 0.46 | 0.89 | |
| *Simulated impact of medical spillover* | | | | | | | | | |

Overall, the results show that: (i) China-only shock is beneficial but not full benefits can be reaped under certain conditions; (ii) China and other emerging economies as well as the industrialized nations are important for African continent to promote the AfCFTA-led industrialization drive; (iii) Covid-19 showed the overly exposure to China only could be counterproductive in long run and hence global alliance or cooperation is important; (iv) with global alliance and cooperation, Covid-19 eradication could cause reversal of fortune via ushering in welfare-augmenting changes and more investments, and rise in real GDP.

Given all these simulated impact, in the light of the facts and evidences—presented in Section 2 and in the Tables 7a,b,c,d and Table CI as well as Table 10 with all these indexes for industrialization, value-added in manufacturing, share of hi-tech and manufacturing value-added in total trade, etc. the results accord well with our a priori expectations and conjectures. The lack of human development proxying absorption capacity, infrastructural bottleneck (LPI), knowledge capital deficiency (R&D% as proxy), as well as other deficiencies are 'barriers to riches' (Parente and Prescott JME 2002), and hence these are necessary prerequisites for

realization of full-potential of AfCFTA's grand agenda. Of course, AfCFTA has a grand mission and vision, but to be effective these preconditions are imperative. Building those as backbone would serve as catalyst for local production networks to flourish (say inter-continental trade within Africa) and that would further accelerate trade-driven inclusive development 'beyond the border' of African continent. Global cooperation and local development are two sides of the same coin. A stylized mechanism is shown below to capture such dynamics. It is not mounted for want of space.

## 5. A Stylized Model of Semi-endogenous Spillover Mechanism

### 5.1 Underlying Rationale:

Focus is on the role of trade induced technology diffusion as primary source of enriched technological contents. More specifically, we construct a model to highlight the role of human-capital induced skill, R&D-intensity for enriched technological contents, and other crucial factors—the factors, lack of which creating development-failure syndromes –for assimilating the technology ferried via traded intermediates. This is a theoretical extension of Global Trade Analysis Project's (GTAP) Computable General Equilibrium (CGE) model (see Hertel ed. (1997)) by modifying the extant framework with rigorous specification of a structural model. Based on the previous Section 4 impact assessment, we confine our attention to the crucial role that absorptive capacity and factors such as, logistics, knowledge intensity, and structural congruence play in determining the conditions for applicability and effective assimilation of the transferred technology via TFP spillovers as exhibited in the previous section 4. More specifically, we construct a stylized version of the model to highlight the role of human-capital induced skill for assimilating the technology ferried via traded intermediates and focus on the role of R&D-intensity in production as primary source of enriched technology. The objective is to provide a conceptual framework to elicit the role of public support policies in the evolution of international competitiveness, technological innovativeness and effective absorption, and Africa's industrialization drive. Schiff, Wang and Olarrega (June 2003) and Schiff and Wang (2006) are identical papers with direct and indirect North-South R&D spillovers between 15 OECD and 24 developing nations across 16 manufacturing industries with differing degrees of technological intensities as measured by their R&D-flows. However, Schiff and Wang (2004) extends the previous two papers (same theory and data sets) to include the role of 'education' and 'governance' in the context of 9 Latin America and the Caribbean (LAC) nations and 16 other developing nations as considered in their previously mentioned papers. Wang (2003) extends the earlier papers by including the role of 'absorptive capacity' proxied by 'secondary school completion ratio of the population aged 25 and above', to same sets of countries for almost the same time period (1976-1998). The results, however, do not differ much except due to the fact that different econometric techniques were adopted to tackle for the influences of all the additional independent variables added separately in each of the papers. Coe, Helpman and Hoffmaister, **CHH** (1997, 2008) and Schiff and Wang (2004, 2006) do not consider LDCs' domestic R&D for lack of availability of data on the assumption that they invest paltry amount on domestic research, rather they acquire foreign R&D from foreign source via diverse channels. Regional or Aggregate-level analyses are offered by, among others: Coe and Helpman (1995), Coe, Helpman and Hoffmaister (1997, 2008), Lichtenberg and van Pottelsberghe de la Potterie (1998), Keller (1998), Lee (2006), Tang and Koveos (2008). Industry level analyses are found in Keller (1998, 1997, 2002), Schiff and Wang (2003), Wang (2007), Das (2012, 2017) (multi-regional and multi-sectoral analyses). In fact, Roe (2001) has offered an elegant discussion of role of trade in final goods, differentiated capital goods, and intermediates in enhancing growth via spillovers due to advancement in information technology. The discussion also talks about the case of embedded knowledge spillover from North to South via 'reverse engineering' or imitation. Jones and Romer (2009) emphasize the importance of such methodological framework (p.6).

## 5.2 The Model

In case of multi-sectoral analysis, the amount of trade-induced knowledge spillover from a source sector in the donor region to a particular sector in the client regions via traded intermediates depends on the input-specific trade intensity of production of that sector. Hence the embodiment index needs to be defined in terms of trade intensities for different specific material inputs; i.e., source and using sector-specific trade-embodiment index r import-content intensity.

We define this index [$E_{ijrs}$] as the flow of imported intermediate produced in sector 'i' in source region 'r' that is exported to firms in sector 'j' in recipient region 's' [$M_{irjs}$] per unit of composite intermediate input of 'i' used by sector 'j' in destination 's' [$Y_{ijs}$]. The latter—$M_{ijs}$—is a simple aggregate of nominal values and is the total (i.e., domestically sourced as well as composite imported inputs) usage of intermediate input 'i' by sector 'j' in region 's'. Thus,

$$E_{irjs} = M_{irjs}/Y_{ijs} \qquad (1)$$

where $F_{irjs}$ is the imports of 'i' from source 'r' used by sector 'j' in recipient 's'. In GTAP notation, $M_{ijs}$ is the value of purchases of tradeable intermediate i by firms in industry j of region r. It is to be noted that the definition for the spillover coefficient bears an additional subscript for source sector 'i' so that we write it as

$$\gamma_{ijrs}\left(\mathbf{E}_{ijrs}, \theta_s\right) = \mathbf{E}_{ijrs}^{1-\theta_s} \quad 0 \le \theta_s \le 1 \qquad (2)$$

$\gamma_s\left(E_{rs}, \theta_s\right) \le E_{rs} \le 1$ for $0 < \theta_s < 1$, $0 \le E_{rs} \le 1$ and

$\frac{d\gamma_s'}{d\theta_s} = -E_{rs}^{-\theta_s}[1 + \ln \gamma_s] < 0 \quad \frac{d\gamma_s'}{d\theta_s} < 0$

.

implies that marginal returns of $\gamma_s$ to $E_{rs}$ are a decreasing function of $\theta_s$ is the product of human capital-induced 'Absorptive Capacity'—based on Skill-Unskilled labor payment shares, Institutional similarity (like governance, rule of law), infrastructural development, innovation index or indexes for digitalization, and structural similarity—based on Land or Capital /Labour Ratio of African nations and China or other countries with whom mostly trade takes place. Also, Digitization indexes (as selected from established sources as proxies for technological readiness or technology sophistication for embracing modern tech led by 4IR) are incorporated multiplicatively.

It is to be noted that trade intensity is treated as a *binary* variable indexed both for the recipient sector 'j' in a given region 's' and for the source sector 'i' and region 'r' of the intermediate products that it uses as inputs. The GTAP database, however, does not allow this degree of disaggregation: while we know by source region the total imports of the

composite intermediate good used by any given sector in any given region (i.e. $M_{ij\bullet s}$), we do not know the regional composition of imports for individual using sectors in s.[30] In particular, we assume that an imported input is proportionally distributed across all user sectors; that is, the share of imported input 'i' from source 'r' in receiving region 's' holds for all industries in 's' using imported 'i'. Thus, if $M_{irjs}$ indicates usage in region's' by industry j of imported intermediate i from source r, we assume that

$$F_{irjs}/F_{ij\bullet s} = F_{ir\bullet s}/F_{i\bullet\bullet s} \qquad (3)$$

where $F_{i\bullet\bullet s}$ is the aggregate imports of tradeable commodity 'i' in region 's' from all source regions. The left-hand ratio in (2) is the quantity share of source r in the imports of i by sector j in its total imports of i. The right-hand ratio in (4) is the market share of source 'r' in the aggregate imports of tradeable 'i' in region 's' evaluated at market prices.

In the source region, the benefits of a technological change arising exogenously in a particular sector is reaped *directly* by the other sectors via the locally produced material inputs embodying advanced technology and *indirectly* via the changes in price relativities of imported intermediates. Hence, the exogenous TFP improvement in the source sector in the region of origin endogenises the TFP improvement in the receiving sectors via a *domestic* spillover effect. Therefore, the relevant sectoral embodiment index [$E_{ijr}$] for the sectors in the source region of innovation is given by

$$E_{ijr} = D_{ijr}/Y_{ijr} \qquad (i\neq j) \qquad (4)$$

where $D_{ijr}$ is the quantity of domestic tradeable commodity 'i' used by firms in sector 'j' of source region 'r' and $M_{ijr}$ is composite intermediate inputs of 'i' (from all sources) used by sector 'j' in 'r'. In fact, the right-hand ratio is the domestic input-output coefficient from the source sector 'i' to the recipient sector 'j' in 'r'. However, for the source country the relevant capture parameter is defined in terms of the human capital-induced absorption capacity (AC) only. Thus, we assume that the higher is AC in 'r', the higher will be the domestic sectoral spillover such that the spillover coefficient for source region is written as

$$\gamma_{ijr}(E_{ijr}, \theta_r) = E_{ijr}^{1-\alpha_r} \qquad (5)$$

where $\alpha_r \in [0, 1]$ is the human capital [HK] induced capture-parameter or absorptive capacity for spillover adoption for source 'r'. In conformity with our notation for the capture-parameter, $\theta_r$ maps one-to-one with $\alpha_r$ (where 'r' is the source region). As before, $\gamma_{ijr}(\bullet)$ is a

[30] This particular assumption is driven by limitations of data availability. However, in the literature on embodied international technology diffusion, this is a common assumption. See OECD (1997), *Science and Technology Indicators Scoreboard*, p 105.

convex function of $\alpha_r$ and strictly concave function of $E_{ijr}$. In the next section, we present the equations for technology diffusion for source and the client regions.

Having chosen a particular source sector of technical change in a particular region r, and following our discussion above, the productivity transmission equation for the client regions can be written as

$$ava(j, s) = E_{ijrs}^{1-\Theta_s} .ava(i, r) \qquad (6)$$

where ava (i,r) and ava(j,s) are respectively the percentage changes in TFP levels (HNTP parameters, AVA) in source and destinations [i≠j, r≠s]. For the source region, the transmission equation is given by

$$ava(j, r) = E_{ijr}^{1-\alpha_r} .ava(i, r) \qquad (7)$$

where i and j (i≠j) are the innovating sector and the receiving sectors in the source region 'r'. However, since in our experiment the source of TFP improvement is *uniquely* in sector 'i' in the single donor region 'r', the equations involving i- and r-subscripted variables on the right do not necessarily carry these indexes on their left hand sides.

### 5.3 Logistics Disruptions and Trade Facilitation.

In GTAP model, there is a global transportation sector assembling regional sales/exports of trade, transport and insurance services via a Cobb-Douglas production technology to produce a composite homogeneous transport good for moving merchandise across the borders (Hertel and Tsigas, 1997). Specifically, to facilitate shipping this transport good is used in fixed proportion with the volume of shipment of a good along a specific route. Therefore, any technical efficiency [ams (i, r, s)] in commercial transactions along a specific commodity 'i' or route will lead to decline in transaction cost and hence, will result in technology diffusion in the destinations 's' from source 'r'. Any augmentation in ams (i, r, s) will lead to higher exports of goods 'i' from region 'r' to 's' [qxs (i, r, s)] for a given transportation service of commodity 'i' from 'r' to 's' [qts (i, r, s)].

ICT, ipso facto, does not promote trade. It depends on the extent of social acceptance $(SA_s)$ of technology-based business modes and technological symmetry $(TD_{rs})$ Cultural or structural homogeneity is closely related to geographical proximity (see Das 2007, 2012). E-commerce adoption depends on IT infrastructure and education for accessing such facilities (Panagariya, 2000).[31] IT-intensity in clusters $(j)$ *in* $'s'$ *is:*

$$\psi_{ijrs} = \frac{V_{irs}}{W_{jrs}} \qquad (12) \qquad \textit{where}$$

$V_{irs}$ *: Intermediate-imports* $'i'$ *(IT-cluster) from* $'r'$ *to* $'s'$.

[31] Information Technology Agreement is signed for opening trade in IT-related equipment and facilitating access to communication networks for E-commerce.

$w_{jrs}$ *: Total imports of* $'j'$ *from* $'r'$ *to* $'s'$.

*E-commerce transmission to* $'j'$ *in* $'s'$ *is given by:*

$$ams_{jrs} = [\psi_{ijrs}]^{(1-\omega_{rs})}.ao_{ir} \qquad (13)$$

With technological change like containerization of international trade, given the shipping-route ITS freight charges shrink due to global trade facilitation via 'intermodalism' (Hummels and Skiba, 2002).

## 6. Concluding Remarks and Insights:

In case of low-income countries, esp. the Sub-Saharan Africa, although some of them are registering growth, in a post-economic crisis world of uncertainty—led by trade conflict, engendered by pandemic--sound macroeconomic policies, and enabling environment could be necessary to overcome development trap. The results offer valuable insights that: (i) differences in access to technology, and domestic investment matter for productivity gap and threshold; (ii) concomitant flows of technological benefits due to trade liberalization under FTA is often hindered by non-trade factors like epidemic or pandemic resulting in skill deficiencies, and translating into productivity slowdown. In fact, Naude (2018) mentions that in the context of Africa, manufacturing is vital when convergence of New Technologies via 4IR or ICT-led digitization is taking place rapidly opening 'windows of opportunity'. Despite risks, there are opportunities and complementary investments are sine qua non for this to happen. Thus 'a new narrative for structural transformation' is necessary and this paper provides that in the context of 'rising tide' of expectations about boons of AfCFTA. In fact, Naude (2019) shows that manufacturing growth—aided by new and emerging technologies—could experience varieties of industrialization where along with labor-intensive mfg, acquiring manufacturing capabilities via technological innovation-led 'bonus' is important. Thus, new and advanced manufacturing is important through entrepreneurship for AfCFTA and reintegrating into global economy via supply chain.

With improper healthcare, inadequate infrastructure, dilapidated medical facilities, lack of trained professionals, scarcity of health facilities, a sudden spurt in death due to COVID-19 will run havoc among the citizens. Public health and institutions are important for readiness. In addition, containment of virus is dependent on readiness. Government should give due emphasis on creating supportive health-care plans and infrastructure. Government needs to strike a balance between the trade-offs between collateral damage of lockdown, containment, and the economic fallout without socio-economic disasters. When informal sector's share is so high and most of the people are migrating from rural to urban for daily wages, or even long-term livelihood, the impact of mitigation efforts is highly debatable. Climate policies, labor-intensive green infrastructure projects, planting trees, reduced labor taxation, wealth tax for reducing inequality, large scale green infra projects, green R&D investment are part of a bigger agenda of combating the Covid-19. We need policy that will cure the lives versus livelihood tradeoff--the "Twin Crisis"--health as well as pandemic-led economic repression, address solving the problem of building human capital, social safety net, health and climate policy as dual combination. However, fiscal and monetary policy combined package are necessary for long-run growth objectives. As the 'weaknesses of development model is exposed as we observe failures on many fronts like failure of public health in North as well as in Global South, infrastructure, job growth, etc. even before Covid-19, in terms of social science discipline, there must be a new paradigm shift in the public health and development literature where new dimension of global challenges emerge. Education lays the foundation for the success of digital architecture. For broader objective of 'growth and structural transformation' and drive of industrialization by 2035, AfCFTA is not a panacea; it is necessary, but not sufficient as some preconditions need to be fulfilled.

Our research has some shortcomings. But, we want to see how the extent of Covid-19 induced impact depends on China-factor vis-à-vis the domestic internal macroeconomic constellation of variables. We will use the estimates from the OLS model to confirm the roles of these enabling factors as explained in Section 4 impact analysis and Section5's stylized model. We simulated scenarios of price-competition in the CGE model and, scenarios of technology-imports contents in the CGE model. Thus, on the basis of the results in Section 4, we will consider individual member and/or, regional grouping and see impact of trade-exposure to China of the countries in the regional categories under AfCFTA in the econometric validation. This offers insights on where each members will have a separate COVID-19 impact due to differences in trade-intensity. In other words, the impact in the GTAP simulations—irrespective of exposure intensity and macroeconomic features—will be studied econometrically to corroborate the findings. This will be the extension of this paper in another version.

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## Databases

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