Research Article

Trade, GDP value adding activities and income inequality in the East African community

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Abstract

This paper investigates the extent to which the East African Community (EAC) countries have developed economically over time and whether income inequality decreases with economic growth. The relationship between trade and GDP per capita amongst EAC member countries is evaluated using the World Bank’s meta-data of development indicators and the EAC Secretariat’s data spanning from 2000–2019. Convergence in GDP per capita and inequality are tested using Coefficient of variation (CV) and weighted beta. The results show that agriculture, manufacturing, trade and repair, construction, and transport and storage constituted the top five GDP value adding activities, contributing about 38 percent to total annual GDP. The EAC GDP per capita were diverging in the long run but converging in short to medium terms, implying increase and decrease in the regional income inequality respectively. Agriculture, electricity and gas, transport and storage, real estate activities, public administration, and education were income inequality-increasing sectors. Together with finance and insurance, these sectors were also positively associated with GDP per capita. The exports of EAC member countries were found to be highly concentrated in few sectors and destination markets, implying limited diversification of products and markets. In their quest to diversify, these countries should choose the right mixes of export goods and services keeping in view of the prevailing market factors in importing countries, such as, changing taste and demands.

Author summary

Regional Trade Agreements (RTAs) are perceived as potential institutional arrangements for encouraging free movement of goods and services across the borders of their member countries. They are generally considered as an engine of growth that creates jobs, reduces poverty and increases economic opportunities. However, little is known about the extent to which RTAs’ member countries have developed economically over time and whether income inequality has decreased with economic growth or not. The current study uses novel approaches to investigate the role of trade in economic growth and income inequality amongst EAC countries. Trade flows for five EAC countries (Kenya, Tanzania, Uganda, Rwanda and Burundi) are compared using the EAC Secretariat’s trade data. The
GDP added by each activity, GDP per capita, as well as inequality and factors influencing it are evaluated using the World Bank's meta-data of development indicators. The study found that, in the long run (2000–2019), the GDP per capita increased overtime though at a diverging trend. GDP per capita convergence was observed in the short to medium term (2007–2014). Overall, the study provides some new insights into how the EAC countries’ trade policies can simultaneous address issues of economic growth and income inequality.

1. Introduction

The past few years have experienced an increase in the number of Regional Trade Agreements (RTAs) globally. The available statistics for example show that RTAs have increased from 82 in 2000 to 306 in September 2020 [1]. One of the most prominent RTAs is the agreement establishing the African Continental Free Trade Area (AfCFTA) which entered into force on 30th May 2019 and was expected to boost intra-African trade by as much as 52% in 2022 [2]. Other RTAs include the Comprehensive and Progressive Agreement for TransPacific Partnership (CPTPP) and the Regional Comprehensive Economic Partnership (RCEP) Agreement. CPTPP was approved on 8th March 2018 by 11 countries while RCEP was signed on 15th November 2020 by 15 countries of East Asia and Oceania [3,4]. Other major RTAs in Africa include the East African Community (EAC), the Southern African Development Community (SADC), the Common Market for Eastern and Southern Africa (COMESA), the Southern African Customs Union (SACU), the Economic Community of West African States (ECOWAS) and the Economic Community of Central African States (ECCAS).

The increase of RTAs in Africa is perceived as an outcome of many economic and geopolitical factors, including their recognition as potential institutional arrangements for encouraging free movement of goods and services across the borders of their member countries as well as for strengthening regional integration and creation of trade [5–8]. If efficiently designed, RTAs can improve policy cooperation across countries, thereby increasing international trade and investment, economic growth, as well as, overall social welfare [9–14]. RTAs are generally considered as an engine of growth that creates jobs, reduces poverty and increases economic opportunities and growth [10,15,16]. They reduce trade costs [9,17–19] and define many rules in which economies operate [17].

Since RTAs usually come with investment guarantees, investors who want to invest in developing countries are also protected against political risk [20–24]. RTAs open a lot of doors for businesses and cover a significant share of world trade. For example, in 2019 the combined GDP of signatory countries to the AfCFTA agreement represented 3 percent of world gross product (WGP); the combined GDP of signatory countries to CPTPP represented 13 percent of WGP; and the combined GDP of signatory countries to the RCEP Agreement represented 30 percent of WGP [1]. RTAs’ member countries also enjoy greater incentives to trade in new markets due to attractive conditions and policies included in the agreements [10]. As member countries gain access to new markets, the competition becomes more intense compelling businesses to produce high quality products [25]. It also leads to more variety for consumers and hence improves customer satisfaction [25–27].

Regarding the EAC, member countries have been strategizing to widen and deepen cooperation among them and other regional economic communities politically, economically and socially for their mutual benefit. The countries established a Customs Union in 2005 and have been working towards the establishment of a Common Market by 2010, a Monetary Union by 2012 and ultimately a Political Federation of the East African States [28]. Their work...
is guided by the Treaty which established the EAC and was signed on 30th November 1999 [29]. The Treaty entered into force on 7th July 2000 following its ratification by the original three Partner States–Kenya, Uganda and Tanzania. The Republic of Rwanda and the Republic of Burundi acceded to the EAC Treaty on 18th June 2007 and became full members of the Community with effect from 1st July 2007 [30].

The Republic of South Sudan acceded to the Treaty on 5th April 2016 and became a full member on 15th August 2016 [30]. Recently, the Democratic Republic of Congo has been endorsed by the Council of Ministers to join the EAC as the seventh member country [30]. The regional integration process and negotiations of the East African Common Market, as well as, the consultations on fast tracking the process towards East African Federation (EAF) still continue. The idea is to construct a powerful and sustainable East African economic and political bloc. One of the desirable and expected outcomes of EAF is the enhancement of economic growth and reduction of income inequality across member states [31,32].

Motivated by the enduring efforts amongst the EAC member countries to widen and deepen economic, political and social co-operation, the current study explores the extent to which the EAC member countries have developed economically over time and whether income inequality in these countries decreases with economic growth. The study is also motivated by the recent statistics which showed that some economies of member countries in EAC have performed relatively better than the rest of the world, especially during the COVID-19 pandemic, with seven out of ten (7/10) of the fastest growing economies in Africa in 2020 comprising Uganda (2.1%), Rwanda (1.3%), and Kenya (1%) [33].

Specifically, the study tested the hypothesis that increases in the level of income inequality lead to lower transitional GDP per capita growth [34]. Galor and Zeira’s model predicted that the effect of rising inequality on GDP per capita is negative in relatively rich countries but positive in poor countries. Galor and Zeira [34] showed that inequality affects GDP per capita in both short run and long run. The study used the EAC Secretariat’s data [35] to explore economic activities and trade components that add value to the prosperity of member countries and those which reduce income inequality among member countries. Identifying factors which influence economic growth and income inequality is important to inform policies and strategies that would enhance economic welfare in EAC [36].

In terms of trade agreements economic welfare is globally viewed as unbalanced, with some countries experiencing welfare loss instead [37]. This viewpoint is also in line with the argument of Trommer [38] who noted that “the network of preferential agreements . . . benefits those with the technical and political capacity to successfully navigate the fragmented governance architecture”.

The synergy of trade, GDP value adding activities and income inequality is worth exploring because many scholars have indicated inconsistent results [39]. On the one hand, there are scholars who found trade as a key factor for fighting poverty and achieving sustainable economic growth [40–44]. They view trade as reducing income inequality by positively impacting the growth rate of income accruing from different GDP value adding activities in three main ways. First, trade leads to efficient distribution of resources; and scale efficiency due to greater access to expanded markets and greater capacity utilisation [41–44] which in turn leads to higher income and rate of domestic savings. Second, trade induces capital inflow and thus causes higher real return to capital in unskilled labour abundant countries that exploit their comparative advantage [45–47]. It is believed that international trade brings about increased factor mobility, encourages diffusion of new products and technology and structural and organisational improvements which in turn lead to reduction in income inequality. Third, trade mediates international flow of technology and knowledge spill-over which in turn triggers changes in factor prices and per capita income [48–54].
On the other hand, there are several scholars who argue that trade agreements have also yielded adverse effects on economic growth such as a rising skill premium (i.e. high-skilled workers reaping most of the benefits) pushing up overall income inequality and rendering some groups worse off in absolute terms [55]. In particular, the uneven distribution of the benefits and costs from trade integration both within and across countries adversely affects the implementation of RTAs.

In fact, the failure to address the issue uneven distribution of the benefits and costs has already triggered criticisms against free trade agreements and caused distrust regarding their prospect in some parts of the world [56]. As such, Saggi and Yildiz [57] underscored the importance of recognizing the existing heterogeneity across countries–concerning their endowments and, therefore, to the size of their economies–that determine the effectiveness of a free trade environment. Their assertion suggests the need to understand regional and or country specific factors that influence performance of RTAs. Equally important, the proposition that trade reduces income inequality has also been interrogated by many scholars, including Fornio-Barusman & Sulfarano Barusman [58] who found that trade was increasing income inequality in the United States.

Attempting to prove the importance of factor endowments in analysing the relationship between trade and income inequality, Gourdon, et al. [59] found that trade was associated with increase in income inequality in high-income countries though it reduced inequality in low-income countries. In particular, the current study contributes to the trade-value adding activities-income inequality dialogue by exploring the following key questions.

a. Has the net trade (net exports) for EAC member countries improved following the signing of Community treaty in November 1999?

b. Has the GDP amongst EAC member countries improved?

c. What are the major GDP value adding activities for EAC member countries?

d. Has the GDP per capita for EAC member countries improved?

e. Which value adding activities have an inequality increasing or decreasing effect on GDP for EAC member countries?

f. Which value adding activities influence GDP per capita for EAC member countries?

g. Do export concentration and export diversification influence GDP per capita in EAC member countries?

2. Study region, data sources and empirical analysis

2.1. The region and data sources

This paper focuses on EAC which is the regional intergovernmental organisation of the Republics of Kenya, Uganda, the United Republic of Tanzania, Republic of Burundi, Republic of Rwanda and South Sudan (see Fig 1) with its headquarters in Arusha, Tanzania. These six countries have a total population of 177 million, of which 22% resides in urban areas [35]. Of the six member states, Tanzania, South Sudan, and Kenya are the largest countries in the region accounting for 88% of the surface area and 81% of the total population [60]. Rwanda and Burundi constitute the two smallest countries, each representing about 1% of the surface area and they are the most densely populated countries in EAC with human population amounting to 6–7% of the total regional population [ibid]. According to the EAC Statistics for 2019, the six EAC countries cover a total land area of 2.5 million square kilometres and have a combined GDP of US$ 193 billion [35].
The data and information used in this paper were gathered from different open data sources, including the World Bank’s meta-data of the world development indicators (trade and GDP per capita data) and the EAC Secretariat’s [35] report (i.e. the GDP values at market and purchaser prices for individual value adding activities). It should also be noted that where data for the new member of EAC (South Sudan) were missing, the analysis is based only on the five countries (i.e. Kenya, Tanzania, Uganda, Rwanda, and Burundi).

2.2. Empirical analysis

The study analyses the trends of economic growth amongst EAC member countries to identify whether their economies are converging or diverging using the Coefficient of variation (CV) and weighted beta tests. The study has chosen GDP as an indicator of economic growth because it is renowned as the best measure in displaying the economic performance of a country [61]. It summarizes all economic activities in particular units of money over a specified period. The total GDP is then decomposed by value adding activities to pinpoint activities which either decrease or increase “income-inequality.” The decomposition analysis also allows assessment of contributions to GDP growth and identification of individual value adding activities which have an equalizing effect on GDP per capita [62].
The individual value adding activities were tested if they increase or decrease income inequality using the approach proposed by Adams [63]. This was useful because conventionally, most studies have often attempted to evaluate the distributional impact of certain types of GDP sources by merely comparing the individual shares or sizes of distribution of the sources with that of the total GDP as a whole [63,64]. Because it neglects the twin issues of GDP weights and covariance between its sources, any approach, which solely compares the size distribution of one particular source with that of total GDP, is likely to arrive at erroneous conclusions regarding the distributional impact of that particular source or value adding activity [64,65]. Corresponding to the CV test, Adams [63] applied the decomposition formula expressed in Eq 1.

\[ \sum w_i c_i = w_i = \frac{\mu_i}{\mu} \]  

where, \( w_i c_i \) is the factor inequality weight of the \( i \)-th source in overall GDP per capita inequality, \( \mu_i \) is the mean value added to GDP from the \( i \)-th source, \( c_i \) is the relative concentration coefficient of the \( i \)-th source in overall inequality, \( \rho_i \) is the correlation coefficient between the \( i \)-th source and the total GDP at purchaser prices, and \( \sigma_i \) is the covariance involving the \( i \)-th income source. The mean value of GDP, \( \mu \), is calculated as in Eq 2.

\[ \mu = \frac{1}{n} \sum_{i=1}^{n} y_i \]  

where, \( y_i \) is the series of added value from the \( i \)-th source, and \( n \) is the sample size or in this case, the number of EAC countries included in the analysis.

The decomposition of total GDP by value adding activities was deemed important because there have been emerged arguments which indicated changing patterns and contribution of key value adding activities in EAC. EADB [66], for example, reported that with the exception of Tanzania the contribution of the industrial sector to regional GDP growth has generally slowed down in almost all EAC countries. The declining contribution of the industrial sector in EAC is attributed to insufficient investment in industrial transformation by the East Africa Development Bank (EADB) [ibid].

The decomposition of total GDP by value adding activities in this paper is lastly complemented by running 24 simple linear regressions to model the relationships between GDP per capita, \( y_i \), and individual value adding activities, as well as, selected trade performance indices of export concentration and export diversification (Table 1). The individual regression model is specified as in Jena and Barua [67]:

\[ y_i = \beta_0 + \beta_1 x_i + \epsilon_x \]  

where \( \epsilon_x \) is a random value \( x_i \) of \( X \), which depends on the value, \( x_i \) of \( X \) with the following properties:

a. For every value of \( x_i \) of \( X \), \( \epsilon_x \) is normally distributed with 0 mean, For every value of \( \epsilon_x \) has the same standard deviation, \( \sigma \), and
b. The random variables \( \epsilon_x \) for all \( x_i \) are mutually independent.
The specified models were first subjected to selected statistical tests, including the use of coefficient of determination or R-square (\(R^2\)) to test for the models’ goodness-of-fit (i.e. to assess whether the input variables or regressors statistically significantly predict the responding variable). \(R^2\) is the proportion of the variance in the dependent variable which is explained by the linear regression model. It is a scale-free score, (i.e. irrespective of the values being small or large, the value of \(R^2\) will be less than one) and is computed as expressed in Eq 4 [68].

\[
R^2 = \frac{\sum (y_i - \hat{y})^2}{\sum (y_i - \bar{y})^2}
\]

Table 1. List of value adding activities and trade regression models.

<table>
<thead>
<tr>
<th>Models</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Value adding activities</td>
<td></td>
</tr>
<tr>
<td>1. Agriculture</td>
<td>AGRI</td>
</tr>
<tr>
<td>2. Manufacturing</td>
<td>MANU</td>
</tr>
<tr>
<td>3. Trade &amp; repairs</td>
<td>TRAD</td>
</tr>
<tr>
<td>4. Construction</td>
<td>CONS</td>
</tr>
<tr>
<td>5. Transport &amp; storage</td>
<td>TRAN</td>
</tr>
<tr>
<td>6. Real estate activities</td>
<td>REAL</td>
</tr>
<tr>
<td>7. Financial &amp; insurance activities</td>
<td>FINA</td>
</tr>
<tr>
<td>8. Public administration</td>
<td>PUBL</td>
</tr>
<tr>
<td>9. Education</td>
<td>EDUC</td>
</tr>
<tr>
<td>10. Forestry</td>
<td>FORE</td>
</tr>
<tr>
<td>11. Mining &amp; quarrying</td>
<td>MINI</td>
</tr>
<tr>
<td>12. Human health &amp; social work</td>
<td>HEAL</td>
</tr>
<tr>
<td>13. Administrative &amp; support services</td>
<td>ADMI</td>
</tr>
<tr>
<td>14. Information &amp; communication</td>
<td>INFO</td>
</tr>
<tr>
<td>15. Accommodation &amp; food services</td>
<td>ACCO</td>
</tr>
<tr>
<td>16. Other service activities</td>
<td>OTHS</td>
</tr>
<tr>
<td>17. Electricity &amp; gas</td>
<td>ELEC</td>
</tr>
<tr>
<td>18. Fishing</td>
<td>FISH</td>
</tr>
<tr>
<td>19. Professional, scientific &amp; technical</td>
<td>PROF</td>
</tr>
<tr>
<td>20. Water supply &amp; sewerage</td>
<td>WATE</td>
</tr>
<tr>
<td>21. Domestic services</td>
<td>DOME</td>
</tr>
<tr>
<td>22. Arts, entertainment &amp; recreation</td>
<td>ARTS</td>
</tr>
<tr>
<td>b) Trade indices</td>
<td></td>
</tr>
<tr>
<td>23. Export concentration</td>
<td>HHI</td>
</tr>
<tr>
<td>24. Export diversification</td>
<td>EDI</td>
</tr>
</tbody>
</table>

Dependent variable: average GDP per capita for the period 2000–2019

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The specified models were first subjected to selected statistical tests, including the use of coefficient of determination or R-square (\(R^2\)) to test for the models’ goodness-of-fit (i.e. to assess whether the input variables or regressors statistically significantly predict the responding variable). \(R^2\) is the proportion of the variance in the dependent variable which is explained by the linear regression model. It is a scale-free score, (i.e. irrespective of the values being small or large, the value of \(R^2\) will be less than one) and is computed as expressed in Eq 4 [68].

\[
R^2 = \frac{\sum (y_i - \hat{y})^2}{\sum (y_i - \bar{y})^2}
\]

where \(y_i\) is the observed response, \(\hat{y}\) is the fitted response for the full model, and \(\bar{y}\) is the fitted response for the reduced model.

Models which yielded negative values of adjusted \(R^2\) were dropped because they did not follow the trend of the data, therefore leading to worse fits than the horizontal line (\(\bar{y}\)) or fitted responses for their respective reduced models. This occurs when the residual sum of square (the numerator in Eq 4) is more than the variance of Y (the denominator in Eq 4) hence the ratio of residual sum of the square to the variance of Y is greater than 1, therefore, leading to a negative \(R^2\). In this case, the models do not make sense given the trend of the actual data points, and they are clearly wrong models.
Second, the study used the $F$-test of overall significance which indicates whether a linear regression model provides a better fit to data than a model that contains no input variables. The general linear $F$-test involves three basic steps. The first step entails the specification of a larger full model, which is sometimes referred to as the “unrestricted model” (one with more parameters) (Eq 3). The second step is to define a smaller reduced model or “restricted model” (one with fewer parameters) [68]:

$$y_i = \beta_0 + \epsilon_x$$

The third step is to use an $F$-statistic to decide whether or not to reject the smaller reduced model in favour of the larger full model. For simple linear regression, the general linear $F$-test is just the same as ANOVA $F$-test and the appropriate null and alternative hypotheses can be specified as in Eq 6 [68].

$$H_0 : y_i = \beta_0 + \epsilon_x$$

$$H_A : y_i = \beta_0 + \beta_1 x_i + \epsilon_x$$

or as in Eq 7.

$$\beta_1 = 0$$

$$\beta_1 \neq 0$$

The degrees of freedom associated with the error sum of squares for the reduced and full models are: $-1$, and $n-2$ respectively. The error sums of squares for the reduced and full models can be expressed as in Eq 8 [68].

$$\text{SSE}(R) = \sum (y_i - \bar{y})^2 = \text{SSTO}$$

$$\text{SSE}(F) = \sum (y_i - \hat{y})^2 = \text{SSE}$$

Thus, the general $F$-test reduces to ANOVA $F$-test as shown in Eqs 9 and 10 [68].

$$F^* = \left( \frac{\text{SSE}(R) - \text{SSE}(F)}{df_R - df_f} \right) \div \left( \frac{\text{SSE}(F)}{df_f} \right)$$

By substituting the degrees of freedom and the error sums of square in Eq 9 with the values expressed in Eq 8 the general $F$-statistic can be rewritten as in Eq 10 [68].

$$F^* = \left( \frac{\text{SSTO} - \text{SSE}}{(n-1) - (n-2)} \right) \div \left( \frac{\text{SSE}}{(n-2)} \right) = \frac{\text{MSR}}{\text{MSE}}$$

$$F^* = \frac{\text{MSR}}{\text{MSE}}$$

Third, the study used the Akaike Information Criterion (AIC) to complement the evaluation of how well the regression models fit the data they are generated from [69–71]. According to the AIC, the best-fit model is the one that explains the highest amount of disparity using the fewest possible independent variables [ibid]. Thus, lower AIC scores are better, and AIC punishes models that apply more parameters. So if two models explain the same amount of disparity, the one with fewer parameters will have a lower AIC score and will be the better-fit of the
model. The basic formula for AIC, is defined as in Eq 11 [69].

$$AIC = -2 \log(\text{likelihood}) + 2K$$

(11)

where, $K$ is the number of model parameters (the number of variables in the model plus the intercept); $\log(\text{likelihood})$ is a measure of model fit (the higher the number, the better the fit). This is usually obtained from statistical output.

For small sample sizes, ($\frac{n}{K} < \approx 40$), the second-order AIC is used (Eq 12) [69].

$$AIC = -2 \log(\text{likelihood}) + 2K + \left( \frac{2K(K + 1)}{(n - K - 1)} \right)$$

(12)

According to Heo et al. [69], an alternative formula for least squares regression type analyses for normally distributed errors is given in Eq 13, where $n$ is the sample size, and $K$ as defined previously in Eq 11.

$$AIC = n \log(\hat{\sigma}^2) + 2K$$

(13)

where $(\hat{\sigma}^2)$ is the residual sum of squares divided by the sample size, $n$. It should be noted that with this formula, the estimated variance must be included in the parameter count.

Fourth, the study used the Durbin Watson (DW) statistic [72,73] to test for autocorrelation in the residuals of the regression models. If $\epsilon$ is the residual given by $\epsilon_t = \rho \epsilon_{t-1} + V_t$, the DW statistics states the null hypothesis: $\rho = 0$, the alternative hypothesis: $\rho \neq 0$, then the test statistic is as shown in Eq 14 [72,73].

$$DW = \frac{\sum_{t=2}^{T} (\epsilon_t - \hat{\epsilon}_{t-1})^2}{\sum_{t=1}^{T} \epsilon_t^2}$$

(14)

where, $T$ is the number of observations.

The value of $DW$ always lies between 0 and 4 [74]. If the $DW$ statistic is substantially less than 2, then there is evidence of positive serial correlation. As a rough rule of thumb, if $DW$ is less than 1.0, there may be a problem because small values suggest that successive error terms are positively correlated. If $DW > 2$, successive error terms are negatively correlated which implies an underestimation of the level of statistical significance. Thus, the value of $DW \approx 2.0$ implies absence of autocorrelation in the data.

3. Empirical result

3.1. Trade

Figs 2 through 4 and Table 2 show trends of exports, imports, as well as, the net values of trade of goods and services (during the period between 2000 and 2019) for five EAC member countries namely Kenya, Tanzania, Uganda, Rwanda and Burundi. It should be noted here that ‘net exports’ are a measure of country’s total trade calculated by subtracting the value of all goods and services it imports from the total value of goods and services it exports [27]. A country’s net exports is therefore a component of its overall balance of trade (BoT) which is also referred to as the trade balance, the international trade balance, commercial balance, or the net exports [27]. As such, BoT is the difference between the value of a country’s exports and the value of a country’s imports for a given period. Balance of trade is the largest component of a country’s balance of payments (BOP).

Elsewhere in the literature, Loayza et al. [75] define a net importer as “a country which runs a current account deficit on whole.” They contrast a net importer with a net exporter, which is a country that sells abroad more than they purchase. They further argue that, a country may
Fig 2. Exports of goods and services for EAC member countries, South Sudan excluded. Source: World Bank’s meta-data of development indicators (https://data.worldbank.org/country/).

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Fig 3. Imports of goods and services for EAC member countries, South Sudan excluded. Source: World Bank’s meta-data of development indicators (https://data.worldbank.org/country/).

https://doi.org/10.1371/journal.pstr.0000036.g003


https://doi.org/10.1371/journal.pstr.0000036.g004
also run individual deficits or surpluses with particular countries depending on the types of goods and services it trades, their competitiveness, exchange rates, levels of government spending, and trade barriers, just to mention few. As Loayza et al. [75] noted, higher saving rates, higher growth rates in industrial economies, and higher international interest rates tend to have the opposite effect.

Overall, the results of our study showed that Kenya has been the largest exporter, followed by Tanzania and Uganda (Fig 2). In 2017, Kenya, Tanzania and Uganda exported goods and services valued at about 11.564; 8.460; and 6.083 Billion US$ respectively (Fig 2B). The values of exports for Rwanda and Burundi amounted to about 2.043 and 0.285 Billion US$ respectively.

As for exports, the values of imports have also been increasing (Fig 3A and Table 2) and Kenya was the leading importer amongst EAC member countries in 2018 importing goods and services worth 20.167 Billion US$ (Fig 3B). During the same year, the values of imports for Tanzania, Uganda, and Rwanda amounted to approximately 10.201; 8.730 and 3.341 Billion US$ respectively. Burundi registered the smallest value of imports amounting to only 0.905 Billion US$.

Based on the results of net trade analysis (Table 2), all the EAC countries were net importers or countries whose values of imported goods and services were higher than their respective values of exported goods and services. This implies increases in current account deficit for these countries. A further reiterate of the results presented in both Table 2 and Fig 4A indicate that, in the long run (2000–2019), the EAC member countries have registered mean annual rates of increase in trade deficit ranging from the lowest of 6.26 percent for Rwanda, to the highest of 15.34 percent for Kenya. In 2018, trade deficits of 8.603; 1.741; 2.647; 1.298; and 0.620 Billion US$ were registered for Kenya, Tanzania, Uganda, Rwanda, and Burundi respectively (Fig 4B).

Most interesting however is the trend of trade deficits for Tanzania, which shows substantial improvement between 2013 and 2019 registering a decrease of trade deficits from 5.057

### Table 2. Trends of trade in EAC member countries (South Sudan exclusive).

<table>
<thead>
<tr>
<th>Period</th>
<th>Trend Equation (BoP Current Mil. US$)</th>
<th>Gradient</th>
<th>Mean Annual Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Exports</td>
<td></td>
<td>% Increase</td>
<td></td>
</tr>
<tr>
<td>Kenya 2000–2018</td>
<td>Exp = 513.04x + 3003.70</td>
<td>Positive</td>
<td>8.2</td>
</tr>
<tr>
<td>Tanzania 2000–2018</td>
<td>Exp = 468.63x + 1203.10</td>
<td>Positive</td>
<td>10.48</td>
</tr>
<tr>
<td>Uganda 2000–2019</td>
<td>Exp = 327.33x + 149.18</td>
<td>Positive</td>
<td>12.64</td>
</tr>
<tr>
<td>Rwanda 2000–2019</td>
<td>Exp = 159.33x + 580.80</td>
<td>Positive</td>
<td>11.39</td>
</tr>
<tr>
<td>b) Imports</td>
<td></td>
<td>% Increase</td>
<td></td>
</tr>
<tr>
<td>Kenya 2000–2019</td>
<td>Imp = 1018.9x + 1797.20</td>
<td>Positive</td>
<td>10.03</td>
</tr>
<tr>
<td>Tanzania 2000–2019</td>
<td>Imp = 596.34x + 1655.00</td>
<td>Positive</td>
<td>10.04</td>
</tr>
<tr>
<td>Uganda 2000–2019</td>
<td>Imp = 449.56x + 473.45</td>
<td>Positive</td>
<td>11.46</td>
</tr>
<tr>
<td>Rwanda 2010–2019</td>
<td>Imp = 185.8x + 1705.30</td>
<td>Positive</td>
<td>9.88</td>
</tr>
<tr>
<td>Burundi 2000–2018</td>
<td>Imp = 50.42x + 57.51</td>
<td>Positive</td>
<td>11.81</td>
</tr>
<tr>
<td>c) Net trade</td>
<td></td>
<td>% Decrease</td>
<td></td>
</tr>
<tr>
<td>Kenya 2000–2019</td>
<td>Net = -502.56x + 647.84</td>
<td>Negative</td>
<td>15.34</td>
</tr>
<tr>
<td>Tanzania 2000–2019</td>
<td>Net = -129.96x - 889.01</td>
<td>Negative</td>
<td>9.48</td>
</tr>
<tr>
<td>Uganda 2000–2019</td>
<td>Net = -129.57x - 548.82</td>
<td>Negative</td>
<td>10.94</td>
</tr>
<tr>
<td>Rwanda 2010–2019</td>
<td>Net = -38.00x - 1078.60</td>
<td>Negative</td>
<td>6.26</td>
</tr>
<tr>
<td>Burundi 2000–2018</td>
<td>Net = -36.87x - 46.11</td>
<td>Negative</td>
<td>12.26</td>
</tr>
</tbody>
</table>
Billion US$ in the former year to 0.70351 Billion US$ in the latter. The smallest trade deficit for the country (of 0.244 Billion US$) was registered in 2002. Burundi also slightly improved her trade deficits from 0.692.69 Billion US$ in 2013 to 0.62019 Billion US$ in 2018. Kenya registered not only the highest mean annual rates of increase in trade deficit but also substantial deterioration in net trade. The country’s current trade deficit was the lowest in 2003 (0.645 Billion US$) and highest in 2014 (9.036 Billion US$), before making slight improvement of 6.259 Billion US$ in 2016 and increasing further to 8.918 Billion US$ in 2019. Trade deficits for Uganda increased from 1.708 Billion US$ in 2016 to 3.458 Billion US$ in 2019 and those of Rwanda also increased from 1.167 Billion US$ in 2017 to 1.482 Billion US$ in 2019. 

In fact, the increase in current account deficit is not unique to the EAC countries but it is reported as a common phenomenon in developing countries, associated with a rise in domestic output growth and shocks that increase the terms of trade and cause the real exchange rate to appreciate [75]. As it will be illustrated further in the next subsections, overreliance on the agriculture sector has contributed substantially to the increase in current account deficits in the region. The agriculture sector in the region has continually suffered from shocks which relate to international trade, especially the low market prices and shares of agricultural commodities [75].

### 3.2. GDP by value adding activities

**Fig 5A** shows a graph of average annual GDP value added by each activity and **Fig 5B** shows the average annual GDP (at purchaser current prices) for EAC member countries plotted using data reported by the EAC Secretariat for the period 2015 to 2018. The study considered ‘value added’ as reflecting the value generated by producing goods and services, and is measured as the value of output minus the value of intermediate consumption. In this regard, the study also considered ‘value added’ as representing the income available for the contributions of labour and capital to the production process. As such, value added by activity shows the value added created by the various industries, such as agriculture, industry, utilities, and other service activities.
As already noted, agriculture (crop and livestock production, fishery, and forestry) was the major GDP value adding activity amongst EAC member countries, followed by manufacturing, trade and repair, construction, and transport/storage, altogether contributing about 38 percent to total annual GDP. The rest of value adding activities contributed about 62 percent. On average again, the annual GDP at current purchase prices was highest for Kenya (74.988 Billion US$), followed by Tanzania (51.944 Billion US$), Uganda (31.384 Billion US$), and Rwanda (8.855 Billion US$). Burundi registered the lowest mean annual GDP at current purchase prices of 2.986 Billion US$.

Beside the largest mean annual increase in current trade deficits, Kenya continued to be the best EAC performer, in terms of exports of goods and services due to the country’s vibrant financial sector, well developed and diversified economy, as well as relatively more stable inflation, interest rates and exchange rates compared to other EAC member countries [76]. The banking sector in the country is relatively well capitalized and profitable with moderately high liquidity ratios [76]. The government of Kenya has been promoting rapid economic growth through public investment, encouraged smallholder agricultural production and provided incentives for private (often foreign) industrial investment since the country’s independence in 1963.

Tanzania, the second performer in the region, has sustained macroeconomic stability that supported growth, and the country is not only rich in natural resources but it also benefits from her strategic geographic position [77]. Though the country’s inflation rate rose to 4.1 percent in November 2021, it remained among the lowest and least volatile in the EAC [77]. Burundi was the poorest performer. The country’s lowly performance can be attributed to many factors, including the weaker external demand and slower export growth caused by receding conflicts [78]. In addition, Burundi is one of the low-income-countries in Sub-Saharan Africa which have suffered from severe conflicts, especially in the 1990s and early 2000s [78]. Nevertheless, the country itself is landlocked lacking resources, and with almost non-existent industrialization.

3.3. Trends of GDP per capita

Fig 6 and Table 3 show the trends of GDP per capita amongst five EAC member countries for the period 2000 to 2019, plotted using the World Bank’s meta-data of the world development indicators. With the exception of South Sudan, the values of GDP per capita for EAC member countries have been also improved overtime implying positive economic growth (Table 3). It should be noted at this point that the GDP per capita data for South Sudan were only available for 2007 to 2014. In 2019, Kenya registered the largest GDP per capita (US$ 1,816.55), followed by Tanzania (US$ 1,122.12). Of the five countries, Burundi has continually registered the smallest GDP per capita amounting to as low as US$ 261.25 in 2019. As shown in Table 3, the unit increase in GDP per capita (per annum) for the period 2000–2014 was the highest for Kenya (US$ 76.86), followed by Tanzania (US$ 42.11), Uganda (US$ 37.62), Rwanda (US$ 35.87), and Burundi (US$ 10.86). The results of analysis of GDP per capita for South Sudan during the period 2007 to 2014 indicated a declining trend with negative unit value of US$ -42.019 per annum (Table 4) which implies a deterioration of overall economy for the country.

3.4. Trends of inequality in GDP per capita

The results of CV and weighted beta tests using the World Bank’s meta-data of development indicators for 2000–2019 show diverging GDP per capita, implying increasing income inequality among the EAC member countries. Note that the window period 2000–2019 represents the scenario of “long term period with South Sudan excluded” and the window period 2007–2014
represents the scenario of “short to medium term with South Sudan included.” The idea of constructing the second scenarios is to analyse GDP per capita inequality for a short to medium term when data were available for all EAC countries, including South Sudan.

Remarkably, the results of analysis the window period 2007–2014 indicated converging GDP per capita amongst EAC countries for both CV and weighted beta tests when a linear regression model was assumed (Fig 7C and 7D). However, this assumption can be valid only when significant short run changes occur in the economy such as the increase in saving rate which in turn affects the level of income per capita in the positive way decreasing income inequality and making the standard of living increase [79]. Thus, there are some sceptical to this effect. First, the effect is essentially a short run effect (happening within a span of only 7 years from 2007–2014) and it does not necessarily affect the rate of growth in long run (Fig 7A and 7B). Second, the change in GDP per capita which derives from the convergence presented in Fig 7A and 7B is quite small which implies existence of several impacts on the rate of growth resulting into different levels of income. It is therefore hard to ascertain if the resultant effect (GDP per capita convergence) will be a short or long term event.

Table 3. Results of trend analysis of GDP per capita amongst EAC member countries (South Sudan inclusive).

<table>
<thead>
<tr>
<th>Country</th>
<th>Period</th>
<th>Trend of GDP per capita</th>
<th>Average GDP per capita</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Equation</td>
<td>Type</td>
</tr>
<tr>
<td>Kenya</td>
<td>2000–2019</td>
<td>y = 76.862x + 159.20</td>
<td>increasing (+)</td>
</tr>
<tr>
<td>Tanzania</td>
<td>2000–2019</td>
<td>y = 42.106x + 284.34</td>
<td>increasing (+)</td>
</tr>
<tr>
<td>Uganda</td>
<td>2000–2019</td>
<td>y = 37.623x + 188.21</td>
<td>increasing (+)</td>
</tr>
<tr>
<td>Rwanda</td>
<td>2000–2019</td>
<td>y = 35.869x + 166.50</td>
<td>increasing (+)</td>
</tr>
<tr>
<td>South Sudan</td>
<td>2007–2014</td>
<td>y = -42.019x + 1,621.70</td>
<td>decreasing (-)</td>
</tr>
<tr>
<td>Burundi</td>
<td>2000–2019</td>
<td>y = 10.306x + 102.77</td>
<td>increasing (+)</td>
</tr>
</tbody>
</table>

3.5. Decomposition of GDP per capita inequality by value adding activities

The results of decomposition of GDP per capita inequality using the data reported by the EAC Secretariat [35] for the period 2015–2018 are shown in Table 4. Out of 22 categories of GDP value adding activities, only six were found to be increasing GDP per capita inequality amongst the EAC countries. These activities include agriculture (CV = 1.16); electricity and gas (CV = 1.22); transport and storage (CV = 1.27); real estate activities (CV = 1.11); public administration (CV = 1.01); and education (CV = 1.06). The remaining 16 activities had CV values of less than 1, implying to be decreasing GDP per capita inequality amongst the EAC countries. It is important to reiterate here that CV ranges between 0 (0%) and 1 (100%), with 0 representing perfect equality and 1 representing perfect inequality [80]. Values over 1 are possible due to high variability in income between the rich and the poor or middle classes, directly influencing the short- and long-term economic growth [81].

<table>
<thead>
<tr>
<th>Value adding activity</th>
<th>Coefficient of variation*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>1.16</td>
</tr>
<tr>
<td>Forestry</td>
<td>0.54</td>
</tr>
<tr>
<td>Fishing</td>
<td>0.67</td>
</tr>
<tr>
<td>Mining and quarrying</td>
<td>0.80</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>0.92</td>
</tr>
<tr>
<td>Electricity and gas</td>
<td>1.22</td>
</tr>
<tr>
<td>Water supply and sewerage</td>
<td>0.60</td>
</tr>
<tr>
<td>Construction</td>
<td>0.93</td>
</tr>
<tr>
<td>Trade and repairs</td>
<td>0.96</td>
</tr>
<tr>
<td>Transport and storage</td>
<td>1.27</td>
</tr>
<tr>
<td>Accommodation and food services</td>
<td>0.32</td>
</tr>
<tr>
<td>Information and communication</td>
<td>0.87</td>
</tr>
<tr>
<td>Financial and insurance activities</td>
<td>1.36</td>
</tr>
<tr>
<td>Real estate activities</td>
<td>1.11</td>
</tr>
<tr>
<td>Professional, scientific and technical</td>
<td>0.57</td>
</tr>
<tr>
<td>Administrative and support services</td>
<td>0.65</td>
</tr>
<tr>
<td>Public administration</td>
<td>1.01</td>
</tr>
<tr>
<td>Education</td>
<td>1.06</td>
</tr>
<tr>
<td>Human health and social work</td>
<td>0.79</td>
</tr>
<tr>
<td>Arts, entertainment and recreation</td>
<td>0.70</td>
</tr>
<tr>
<td>Other service activities</td>
<td>0.28</td>
</tr>
<tr>
<td>Domestic services</td>
<td>0.88</td>
</tr>
</tbody>
</table>

* South Sudan excluded

Source: Computed using GDP values at market and purchaser prices reported by the EAC Secretariat [35]

https://doi.org/10.1371/journal.pstr.0000036.t004

3.6. Results of simple linear regression models

The test results for twenty four individual simple linear regression models specified in the current study are provided as a S1 Table. Based on the DW test statistics, the presence of negative autocorrelation was confirmed in five models (i.e. manufacturing, trade & repair, education, human health & social work, and information and communication models). It should be noted that out of these five models three (i.e. trade & repair, education, and information & communication) yielded statistically significant results. However, the three models are...
disqualified for having the syndrome of negative autocorrelation which changes the direction of the influence. Negative autocorrelation implies that if a particular value is above an average, then the next value (or for that matter the previous value) is more likely to be below average. If a particular value is below average, the next value is likely to be above average.

Negative autocorrelation is a violation of independence but is generally less worrisome because it produces greater precision in the average than an independent series would be [82]. Though it represents a lost opportunity to model the correlation and get better estimate of confidence limits, the alternating pattern in a negative autocorrelation insures that a series will be more likely to bracket the true mean [82]. Positive autocorrelation was diagnosed in four models (mining & quarrying, accommodation & food services, other service activities, and fishing). The remaining models yielded values of $DW \geq 2.0$ implying absence of autocorrelation in the data.

Two models (i.e. accommodation & food services; and other service activities) also yielded negative adjusted $R^2$ which means insignificance of explanatory variable. The negative adjusted $R^2$ appears when residual sum of squares approaches to the total sum of square which means the explanation towards response is very low or negligible. The results in this case may be improved by increasing the sample size which was not possible in this study. The removal of all models which did not pass the tests and those which indicated non-significant $p$-values gives a summary of results presented in Table 5.

The results in Table 5 indicate that GDP per capita among EAC countries was positively and statistically significantly influenced by five value adding activities, namely agriculture, transport & storage, real estate activities, financial & insurance activities, and public administration (all at $p \leq 0.05$) and export concentration was found to be negatively related with GDP per capita ($p \leq 0.05$). Of the six models in Table 5, export concentration model yielded
relatively the smallest AIC value (48.766) indicating that it was the best-fit model, followed by agriculture model (AIC = 50.464), transport & storage model (AIC = 50.495), public administration model (AIC = 50.750), and real estate activities model (AIC = 51.542). The financial & insurance model ranked the least with AIC value of 51.709.

4. Discussion

This section discusses the key findings which emanated from the study. Specifically, the discussion reflects back to the flow of activities and methods applied in the study as summarized in Fig 8.

![Fig 8. A schematic presentation of flow of research activities and methods.](https://doi.org/10.1371/journal.pstr.000036.g008)
The findings indicate negative trends of net trade for EAC countries. However, negative trends of net trade or current trade deficits cannot necessarily imply deteriorating economies as it can also be an indicative of a strong economy. Trade deficit can also lead to stronger economic growth in the future, especially when coupled with prudent investment decisions [83]. When the economy of a country grows and strengthens, consumers have more wealth to purchase goods from producing countries, which will increase the trade deficit. A strong economy also attracts foreign investment, further enlarging the trade deficit. Thus, a large trade deficit can also indicate economic growth. Even though the changing trend from substantially higher to relatively lower deficits for Tanzania that has occurred between 2013 to 2019 deserves noting. One may associate it with the key milestone that the country has achieved in July 2020, when it formally graduated from low-income country to lower-middle-income country status.

Yet, further analysis indicated that in the long term the EAC economies were generally growing in terms of GDP per capita, except for South Sudan which showed a declining trend based on the 2007–2014 data. However, inequality in GDP per capita was increasing in the long term (when South Sudan was excluded) but decreasing in the short to medium term (when South Sudan was included). These results in turn support the argument of Ejones et al. [16] who affirm that RTA or regionalism has heterogeneous effects on economic growth in the EAC. Their findings seem to recognize the on-going efforts to leverage integrated economic development through EAF. Based on the results of analysis, the current study underscores the need to address the issue of huge disparity in GDP per capita which can be quite challenging but as Amogne and Hagiwara [84], argue RTAs can result into positive distributional effects. Of course this will depend on the pre-existing trade share between member countries: the larger the share is, the larger the net trade creation and the smaller the trade diversion effect.

Agriculture and manufacturing were the major GDP value adding activities during the period 2015–2018. Their role in economic development is broadly recognised in the literature. Agriculture, for example, has already significant contribution to the economic prosperity of both developed and developing countries and its role in economic development is widely acknowledged in the literature [84–88]. There is also clear evidence that a thriving manufacturing sector increases productivity and thereby enhancing economic growth. According to Yong [89] the advent of manufacturing has been driving economic development in both developed and developing countries because it offers several productive advantages. First, it enables mass production which entails economies of scale: the more units produced, the lower the per-unit cost, and thereby increasing the value of outputs per input. Second, manufacturing tends to have strong linkages to other parts of the economy, creating demand for skills, inputs, manufacturing components, transportation and storage. This means that growth in manufacturing boosts growth throughout a broader set of activities, including in the service sector. Third, most innovation and technological advances originate in the manufacturing sector, which can then feed into other economic sectors, making them more productive as well.

The negative relationship between export concentration and GDP per capita (model 23) revealed in the current study supports the proposition that exports of EAC member countries are highly concentrated in a few industrial sectors and a few destination markets, implying limited diversification of products and markets. Lack of diversification is considered as one of the barriers that impede growth and create multiple macro-economic challenges [90]. The current study shows that GDP per capita amongst EAC member countries have decreased with export concentration between 2000 and 2019. It is important to note at this point that though the positive relationship between export diversification and economic growth is extensively reported in the literature [91–93] there also exist contradicting arguments. For example,
Önder and Yılmazkuday [94] and the World Bank [95] found contrasting evidence with respect to trade or export diversification.

The study by the World Bank [95] which covers a period between the mid-1960s and the late 1990s showed that while most Latin American countries diversified their export structures, they were yet unable to achieve considerable levels of GDP expansion. Thus, it should not be taken for granted that increasing levels of export diversification guarantees higher levels of economic growth. Countries should choose right mixes of export goods and services keeping in view of prevailing market factors, including the changing taste in importing countries. Agreeing to waive tariff barriers and selecting the right set of products for each EAC partner to trade can considerably enhance market competitiveness for these countries. Leyaro [96] denoted that the effects which arise from the removal of border measures (tariff barriers to trade) and behind-the-border measures (non-tariff barriers to trade) are based on imperfect competitive trade theory, where firms derive profits from exploiting market dominance, through economies of scale, increased competition, improved technology, and/or greater specialization.

The correlation between GDP growth, in some sectors like agriculture, and increasing GDP per capita inequality is not new in the literature. It is a common phenomenon, particularly in agrarian economies or economies that rely mainly on crop and livestock farming [97–99]. In smallholder agro-based economies, income inequality results from the disproportion in productivity of the production factors and from the influence of many other variables, such as, the level and structure of the production factors, its scale and intensity, the quality of agricultural production space and the ability to manage farm resources [99]. In Poland, Kata & Wosiek [99] reported the problem of excessive and growing income inequalities in agriculture as an important barrier to the sustainable development in the country. In EAC, agriculture is one of the most important sectors employing about 80 percent of the region’s population and is dominated by smallholder mixed farming of crops and livestock [100].

Thus, the problem of income polarization or inequality is not likely to be uncommon in the region. The problem is further exacerbated by factors such as the sudden breaks or interruptions in local or global supply chains which are quite common in post 2010 periods, globally, due to recessions and social inequalities which are triggered and aggravated by disaster-like situations caused by climate change [31] and epidemic outbreaks [101]. As in many other regions [102], these disruptions have in turn impacted trade and commodity prices widening the income inequality in the region [101]. For example, Mulwa [31] projected a depression in the welfare of EAC member countries to US$ 4.86 per person by 2045, indicating that the impact of climate change in this region will have adverse effects on production. In Uganda, Babyenda et al. [103] also found climate variability to have a significant nonlinear impact on household welfare outcomes. Just as important, Kassegn & Endris [101] showed that the socio-economic impacts of the COVID-19 pandemic, desert locust and flooding are considerable and have resulted in devastating implications on livelihood and food security in EAC.

5. Conclusions

The study demonstrated that the EAC member countries have continued to register trade deficits overtime, registering mean annual rates of increase in trade deficits ranging from the lowest of 6.26 percent for Rwanda, to the highest of 15.34 percent for Kenya. Substantial improvement was observed for Tanzania between 2013 and 2019 when the country registered a decrease of trade deficits from 5.057 Billion US$ to 0.70351 Billion US$ for that window period. The smallest trade deficit for Tanzania was registered in 2002 (0.244 Billion US$). Burundi also slightly improved her trade deficits from 0.692.69 Billion US$ in 2013 to 0.62019 Billion US$ in 2018. Kenya registered not only the highest mean annual rates of increase in

The top five GDP value adding activities in region were agriculture, manufacturing, trade and repair, construction, and transport and storage, altogether contributing about 38 percent to total annual GDP. The GDP per capita for the region has increased overtime. Yet, GDP per capita amongst member states has been diverging in the long run, but converging in the short to medium term. Of all value adding activities covered in the study, six significantly increased GDP per capita inequality in the region namely; agriculture, electricity and gas, transport and storage, real estate activities, public administration, and education. GDP per capita also decreased with export concentration, implying that when the EAC countries leverage to widen and deepen co-operation among them, they should choose the right mixes of export goods and services keeping in view of prevailing market factors, including the changing taste in importing countries.

**Supporting information**

S1 Table. Supplementary table showing the results of regression models.
(DOCX)

S1 File. Data used in the analysis of export trends for EAC countries.
(XLSX)

S2 File. Data used in the analysis of import trends for EAC countries.
(XLSX)

S3 File. Data used in the analysis of trends of net trade for EAC countries.
(XLSX)

S4 File. Data used in the analysis of GDP value added by activities.
(XLSX)

S5 File. Data used in the analysis of average annual GDP (at purchaser prices).
(XLSX)

S6 File. Data used in the analysis of trends of GDP per capita for EAC countries.
(XLSX)

S7 File. Data used in the analysis of GDP per capita inequality using Coefficient of Variation (CV).
(XLSX)

S8 File. Data used in the analysis of GDP per capita inequality using weighted beta (WB).
(XLSX)

S9 File. Data used in decomposition of GDP per capita inequality by value adding activities.
(XLSX)

**Author Contributions**

**Conceptualization:** Reuben M. J. Kadigi.

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Investigation: Reuben M. J. Kadigi.
Methodology: Reuben M. J. Kadigi.
Visualization: Reuben M. J. Kadigi.
Writing – original draft: Reuben M. J. Kadigi.
Writing – review & editing: Reuben M. J. Kadigi.

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