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## Fixed Base Year vs. Chain Linking in National Accounts: Experience of Sub-Saharan African Countries

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# Fixed Base Year vs. Chain Linking in National Accounts: Experience of Sub-Saharan African Countries

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## Abstract

There are two approaches for producing volume estimates of GDP, fixed base year and annual chaining. While most advanced economies have adopted the chain-linked approach in the past twenty years, some African countries are hesitant to do so, in part because of the computation and data requirements, and resource constraints. What difference does this make for the accuracy of the growth rates? From detailed data provided by three Sub-Saharan African countries we run simulations and conclude that the differences of GDP growth using the two approaches are small and do not behave in the consistent way found in advanced countries. We also show that weak deflation techniques and overly aggregated classifications used to derive volume measures can lead to large distortions. We conclude that improved deflation techniques and detailed classification should be addressed before adopting chain linking.

JEL Classification Numbers: B40, C10, E20

Keywords: System of National Accounts, chain linking, volume measures, fixed base year

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## I. INTRODUCTION[1]

This paper investigates whether chain-linked volume measures of GDP yield superior results than a fixed-base year method in three Sub-Saharan African (SSA) countries. While similar assessments have been conducted for advanced countries, this is the first such study for SSA countries. This study has become possible with detailed source data and compilation worksheets on GDP volume measures provided by three SSA countries with the understanding that only the results will be published without disclosing the countries. The IMF's statistics advisors in African Regional Technical Assistance Centers coordinated with country authorities to facilitate the collection of required data. These detailed data also allowed us to undertake simulations to assess the impact of deflation techniques and level of classification on volume growth from fixed-base and chain-linked approaches. The simulations involved a complete recalculation of the data, using the most detailed components.

Periodic changes in the values of macroeconomic aggregates such as output, investment, consumption expenditure, and gross domestic product (GDP), reflect a combination of price and volume changes of the underlying products (goods and services). Volume changes refer to changes in quantity and quality of products over time. Macroeconomic analysis requires information on both of these components and the *System of National Accounts 2008* (2008 SNA) refers to two alternative methods for separating volume and price changes. The traditional method is to determine a fixed base year. Volume changes in subsequent periods are aggregated using the price structures and weights of that year. Annual chain linking was introduced in the 1993 edition of the *SNA* and it requires updating of the base year annually and linking the year-on-year changes. If the linked series are expressed in index number form with reference year t=100, the index is called chained volume index with reference year "t."

To obtain accurate estimates of volume changes, the above approaches need to be applied at a detailed level of goods and services that make up these aggregates. Detailed level means that the volume estimates of GDP by production should be obtained from volume estimates ofeconomic activitieswith at least 2-digit level of International Standard Industrial Classification (ISIC). The *2008 SNA* suggests that the ideal way of producing volume estimates of macroeconomic aggregates is to work at a very detailed level, preferably using the supply and use tables (SUT) framework, and deflating each component by a strictly appropriate price index. For example, typically diversified advanced economy would use 50

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different price indices to produce a volume measure. Without high quality price indices at the detailed level of expenditures and/or outputs, no overall measure of economic growth will be of high quality.

The pros and cons of the two methods have been well researched for advanced economies and the general consensus is that chain linking produces superior results when economies are characterized by significant structural changes and movements of relative prices with a relatively consistent trend. For example, this is the case in countries where new technologies play an important role. The *SNA* also recognizes that chain linking may not be suitable in all circumstances. If prices and quantities of underlying products fluctuate and relative price and quantity changes of earlier periods are reversed in later periods, chain linking will produce inferior estimates of growth compared to the fixed-base approach. Therefore, it is essential to assess whether the economic structure of a particular country over time is favorable for implementation of chain-linked volume measures or not.

Many advanced economies introduced chain-linked volume measures in their national accounts during the 1990s following in-depth testing. In recent years, other countries have adopted chain linking including about a third of the SSA countries.[2] This paper considers whether the intended goal of improving the estimates of GDP growth rates has been achieved. Our comparison of the fixed-base and the chain-linked approaches was carried out with recent fixed bases, compatible with a revised base at five-year intervals.[3]

The paper is structured as follows: Section II provides an overview of the theoretical background of chain-linked and fixed-base approaches and experiences of some advanced countries. Section III looks at the prevailing practices of volume measures of SSA countries. Section IV provides a detailed comparison of growth using the fixed-base and chain-linked approaches for three selected countries, and a simulation analysis to assess the impact of deflation techniques and level of classification details on volume growth from fixed-base and chain-linked approaches. Section V concludes.

## II. Experience of Advanced Countries

In the fixed-base approach, weights are derived from a specific year (fixed-base year). The often-used Laspeyres fixed-base index allocates higher weights to products whose relative prices have decreased and volumes increased faster (e.g., electronic devices). Over time, this approach produces higher growth rates which have upward bias as weights become outdated. In contrast, the chain-linked approach uses more up-to-date weights and, therefore, eliminates the bias in growth rates for such items. Therefore, in countries with large portions

[2] Table 3 provides a list of 15 SSA countries that use chain linking. The majority of developing countries and some G-20 countries continue to derive their volume measure estimates of GDP using the fixed-base approach. GDP volume measures of the following six G-20 countries are derived using the fixed base method: Argentina (2004), China (2010), India (2011/12), Indonesia (2010), Saudi Arabia (2010), South Africa (2010) and Turkey (1998). Figures in the brackets indicate the fixed-base year used by these countries.

[3] While five-yearly rebasing avoids volatility, very old base years fail to capture long term trends and could be misleading.

of their economies influenced by products with systematic trends in relative prices and quantities, chain linking is the preferred approach. As noted in the SNA, "if individual prices and quantities fluctuate so that the relative price and quantity changes occurring in earlier periods are reversed in later periods, chaining will produce worse results than a simple index[4]" (*2008 SNA* para 15.43).

Even though the *2008 SNA* cautioned that chain linking could lead to distortions when product prices and volumes oscillate, it is generally interpreted as favoring chain linking. "On balance, situations favorable to the use of chain Laspeyres over time seem more likely than those that are unfavorable. The underlying economic forces that are responsible for the observed long-term changes in relative prices and quantities, technological progress and increasing incomes, do not often go into reverse. Hence, it is generally recommended that annual indices be chained" (*2008 SNA* para 15.44). The recommendation was mainly tested using data from advanced countries.

Chain-linked indices are computationally difficult and demand additional resources. The *2008 SNA* notes that the computing requirements of deriving annual chain indices are greater than those for fixed-weighted indices and should not be attempted without adequate, tailored software. This highlights that implementation of chain linking is more complex and needs additional resources for development of suitable price deflators and software which could be important factors to consider in developing Africa. Another known disadvantage of chain-linked growth estimates is non-additivity.[5] The non-additivity associated with chain linking needs to be suitably explained to the user community, which also requires additional resources.

Most of the advanced countries introduced chain-linked volume measures during 1990s. The Netherlands was one of the first in the early 1980s. Other advanced economies including Australia, Canada, Japan, New Zealand, and the United States implemented chain linking during late 1990s or early 2000s. Most European Union member states adopted the chain-linked approach around 2005.[6]

Volume measures are compiled at a very detailed level of classifications in advanced countries. For example, in Canada, volume measures of expenditure GDP are based on 435 series of expenditure components (out of which 130 for household final expenditure, 24 for

[4] In the present context, simple index refers to Laspeyres fixed-base volume index.

[5] Non-additivity means that when the current price values in the reference year are extrapolated backwards or forwards using a chain-index, the extrapolated values of the components of an aggregate do not, in general, sum exactly to the extrapolated value of the aggregate. For further details, please refer to Chapter 15 ("Price and Volume Measures") of the *2008 SNA*.

[6] Implementation of chain-linked volume measures in European Union member states derives from the European Union Commission decision of November 1998 clarifying annex to Council Regulation (EC) No. 2223/96 on the European system of national and regional accounts in the Community as concerns the principles for measuring prices and volumes (notified under document number C (1998) 3685).

government final consumption expenditure, 69 for exports, and 68 for imports). In the Dutch national accounts, the estimates of volume measures are compiled with 250 industries, 850 commodities, and 10 final demand categories. The value at current prices, the value in prices of the previous year, the volume index and the deflator are available for every cell of the supply and use table (SUT). For European Union countries, volume measures must be implemented at least as detailed as the P60 level (which approximates the two- digit industry level), for output as well as intermediate and final use categories. The UK implemented chain linking at the four-digit level of the ISIC which required additional resources relative to the fixed base year method. In the UK the results for the study period (1995–99) showed some significant growth differences with the four-digit level implementation producing the lowest estimates of growth (lower by 0.5 percentage points) for the year (1999) farthest from the fixed base year (Tuke, 2001). More than 300 input series at broadly four-digit level were used, compared to less than 60 series at broadly two-digit level. Other advanced countries also follow detailed levels of classification for their chain volume measures. Implementation of GDP volume measures at such detailed levels of classification require availability of detailed price deflators and these countries have supporting statistical systems and resources in place.

Studies from France, Netherlands, UK, and the United States showed that the use of chain-linked indices provided GDP growth rates with improved accuracy compared to growth rates based on the fixed-base method.[7] For the United States, the estimates of GDP volume growth from the chain-linked approach are consistently lower than the fixed-base growth estimates around the mid-nineties. For the year (1995) farthest from the fixed base year 1987, the difference is around one percentage point, mostly driven by changes in prices of computer equipment relative to prices of other goods and services during the study period. The computer industry valued at fixed-base year prices provides a higher share in total output than the output estimate valued under the chain-weighted approach. In addition, larger growth contributions from other industries could not compensate for the drastically reduced contribution of computers to growth (Steindel, 1995).

For other countries, the differences are significant, but less pronounced. For France, GDP growth rates are also generally lower from chain linking compared to the fixed-base approach (over the period 1980–1997). The difference is generally small, less than 0.2 percentage points. Overall, the analysis shows that chain linking yields better results for all industries. This is less true for agriculture where high fluctuation in quantities and prices makes this method not desirable (Berthier, 2002). Dutch results also underscore that chain linking provided a significantly higher growth for agriculture, especially for the years farthest from the fixed-base year (0.7 and 0.9 percentage points for the last two years respectively). The Dutch and French studies emphasize that the impact of chain linking on agriculture significantly differ from other industries given the fluctuating nature of agriculture prices and quantities. Dutch results also underline that the impact of chain linking on output and value

[7] Most of these studies are available for the periods of 1990s / early 2000s. See Table 1 for details.

added could be considerably different, which signifies the importance of deflation techniques.[8] Table 1 provides a summary of differences in overall GDP growth rates for four advanced countries showing growth rates from chain linking minus growth rate for fixed-base for the last year of the study period when fixed weights are likely to be out of date.

**Table 1: Differences in Growth Rates of Selected Advanced Countries**
(Chain Linking minus Fixed Base)

| Country | Fixed Base Year | Study Period | Difference in GDP Growth Rate* (Year) |
|---|---|---|---|
| Australia | 1989/90 | 1989/90-1996/97 | 0.2 (1996/97) |
| Netherlands | 1986 | 1986-93 | -0.5 (1993) |
| United Kingdom | 1994 | 1994-99 | -0.5 (1999) |
| United States | 1987 | 1987-95 | -1.0 (1995) |

* Difference in growth rate = Growth rate from chain-linked – Growth rate from fixed-base approach, for the last year of the study period

Source: Australian Bureau of Statistics, 1998; Boer, Dalen, Verbiest, 1997; Tuke, Reed, 2001; Steindel, 1995

However, there are some exceptions. Australian GDP growth rates obtained from the chain-linked approach showed higher growth rates than fixed-base approach growth rates (Australian Bureau of Statistics, 1998). The cumulative growth for the period (1989–90 to 1996–97) following the fixed-base approach is 0.4 percentage points lower than chain indices. Annual GDP growth rates from the fixed-base approach are consistently lower or equal to the growth rates based on the chain-linked approach. Australian output has a relatively larger share of commodities, both minerals and farm output. This result is relevant for many SSA countries that are mainly commodity producers and have larger shares of commodities in their output than Australia. Even though empirical results showed that chain linking offered gains only for some components and not for total GDP, Australia implemented chain-linked volume measures of GDP. The decision is based on index number theory and it is argued that constant price estimates may get worse as new technologies appear and ensuing price and volume relatives continue.

## III. GDP VOLUME MEASURES IN SUB-SAHARAN AFRICAN COUNTRIES

About a third of SSA countries apply an annual chain-linked approach starting in the early 2000s. Most Francophone countries and some others in the SSA implemented chain-linked volume measures in the overall context of harmonization of national accounts compilation

[8] For example, for agriculture, growth rates of output from fixed-base and chain-linked approach for the year 1993 (the year farthest from the fixed-base year 1986) are 0.5 percent and 0.8 percent respectively. However, value added growth rates using fixed-base and chain-linked approach for the same year (1993) are 1.6 percent and 2.5 percent respectively.

methods in their regions.[9] Most of these are either low-income or fragile countries. Out of the eight oil- exporting SSA countries, Cameroon and Gabon use chain linking.

SSA countries are typically commodity producers of agricultural and mining products with the characteristics that tend to make chain linking a less suitable approach for volume measures. For about one-third of the SSA countries, more than 40 percent of GDP comes from agriculture and mining products, and for more than two-thirds of countries, more than one quarter of GDP is contributed by agricultural and mining.[10] Table 2 provides shares of agriculture and mining value added in GDP of selected SSA countries.

**Table 2: Share of Agriculture and Mining in GDP for Selected SSA Countries (2013)**

| Country | Share of agriculture and mining in GDP (percent) | Country | Share of agriculture and mining in GDP (percent) |
|---|---|---|---|
| Equatorial Guinea | 89 | Ethiopia | 46 |
| Congo | 68 | Togo | 45 |
| Liberia | 67 | Mali | 42 |
| Sierra Leone | 65 | Chad | 42 |
| Angola | 65 | Burkina Faso | 40 |
| Central African Republic | 53 | Nigeria | 36 |
| Niger | 47 | Ghana | 27 |
| Guinea-Bissau | 47 | Mauritius | 3 |
| Gabon | 46 | Seychelles | 2 |

Source: African Development Bank - Statistical Yearbook 2014

As discussed earlier, availability of proper price and volume indices is fundamental for producing good quality volume measures. Most SSA countries lack appropriate price and volume indicators. In terms of price deflators, while most of the SSA countries compile CPIs with monthly frequency, producer price indices (PPI) are compiled by only eight countries. In the absence of PPIs, reliance on CPIs as a deflator for goods and services outside the scope of consumers is a major weakness of GDP volume measures. However, the quality of CPIs is also a concern for many countries. Only five countries update the CPI weights in five years or less.

Table 3 shows the status of CPI and PPI data in the SSA countries that implemented chain linking. Annex I provides details of the GDP base / reference years and weights vintage and coverage of CPI and PPI for all SSA countries. For the countries that implemented chain linking the coverage of CPI is complete in only five countries and weights vintage is less than five years old in two countries and PPI is not compiled in most of the countries. The use

[9] Benin, Burkina Faso, Burundi, Cameroon, Côte d'Ivoire, Gabon, Guinea, Mali, Mauritania, and Togo. Cabo Verde also introduced annual chain-linked approach during the recent base year revision in 2013.

[10] 31 SSA countries derive more than 25 percent of their GDP from agriculture and mining.

of such CPI data could lead to biased GDP volume measures, irrespective of the approach used for GDP volume measures.

**Table 3: Sub-Saharan African Countries: CPI and PPI: Weights Vintage and Coverage**
(As of April 2016)

| Country | CPI | | PPI |
|---|---|---|---|
| | Weights vintage(years) | Coverage | Weights vintage |
| Benin | Older than 5 | Main cities | X (not compiled) |
| Burkina Faso | Older than 5 | Capital city | |
| Burundi | Older than 5 | Main cities | |
| Cape Verde | Older than 5 | Nation-wide | |
| Cameroon | 3–5 | Nation-wide | |
| Central African Republic | Older than 5 | Capital city | |
| Chad | Older than 5 | Capital city | |
| Congo DRC | Older than 5 | Nation-wide | |
| Côte d'Ivoire | Older than 5 | Main cities | |
| Gabon | Older than 5 | Capital city | |
| Guinea | Older than 5 | Capital city | |
| Malawi | 3–5 | Nation-wide | |
| Mali | Older than 5 | Capital city | |
| Mauritius | 3–5 | Nation-wide | Older than 5 |
| Togo | Older than 5 | Capital city | X |

Source: IMF Data Dissemination Bulletin Board (http://dsbb.imf.org); International Labor Organization (http://laborsta.ilo.org/apple8/data/SSM1_NEW/E/SSM1.html)

## IV. Data Analysis of Chain Linking in Three Sub-Saharan African Countries

Three SSA countries (referred to as country **A**, **B**, and **C**) with different economic structures and income levels are investigated to assess the impact of chain linking on volume GDP growth rates. Country A is mainly a commodity producer, whereas country C has a higher proportion of services. Country B's structure is somewhere in between these two. In addition, these countries are characterized by varied levels of statistical standards measured in terms of statistical capacity indicators.[11] Two of these countries apply chain linking, and the third follows the fixed-base approach for measuring the GDP volume measures.

We compare volume growth rates from the fixed-base and chain-linked approaches at the overall GDP level. We compiled volume estimates of GDP from both approaches at a detailed level, specifically the level at which deflation is carried out by countries under the existing compilation systems. The number of years and the periods for which this assessment is undertaken differs given data availability. For Country A, the assessment is based on data for eight years (2006–13), Country B six years (2005–10), and Country C seven years (2007–13). Our compilations are based on detailed source data from these countries, and cover production GDP and components. We did not undertake our analysis for expenditure GDP

[11] Available through internet (http://databank.worldbank.org/data/reports.aspx?source=Statistical-capacity-indicators)

and components because in most of the SSA countries the estimates of GDP are compiled using the production approach. The quality of GDP expenditure data at current prices and volumes are considered weak as most of the countries derive their household final consumption expenditure as a residual, and estimates for private capital formation are not reliable.[12]

**Country A**

The primary sector accounts for about half of GDP for most of the years of the study period. This country has highly volatile GDP growth rates driven by volatile agricultural production resulting from climatic shocks. This underscores the dominance of primary products, particularly crops and animal farming activities, in overall GDP. Such volatility in agricultural production highlights that chain linking may not be suitable for measuring the volume growth of GDP. As expected, the chain-linked approach shows a significantly higher volume growth than the fixed-base growth rate for agriculture. The difference in agriculture growth is most pronounced (about 1 percentage point) for the year farthest from the fixed base year.[13] The difference in the growth for agriculture for the year 2013 is the highest compared to any of the activities. In addition, for manufacturing and total services, the fixed base reduces growth by 0.5 and 0.1 percentage points respectively for the year 2013.

However, for the overall GDP, chain linking reduces growth in the last two years (2012 and 2013) by about 0.7 and 0.2 percentage points respectively, mostly driven by a surge in production of primary products. Such upward effect is also observed in advanced economies. The difference in GDP growth rates for different years is higher for Country A than the two countries. In addition, the differences are highly volatile. This suggests that changes in signs cancel out. This is evident from the same volume index for the year 2013 from both approaches (taking volume index for 2007=100). In general, results show that chain linking is not essential for important components such as agriculture, manufacturing, and services. For GDP, the difference in the last year is small. Additionally, for the whole period 2006–13, cumulative growth is almost the same from both the approaches (Figure 1).

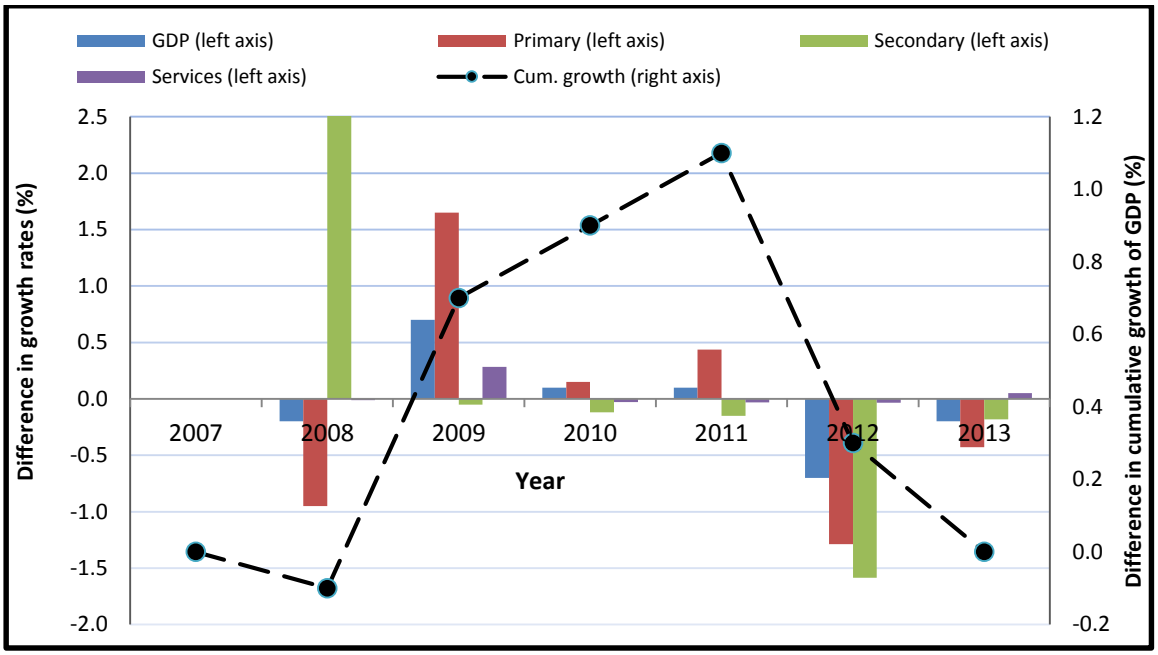
We examine whether the differences in growth rates truly reflect the underlying economic structure or are perhaps outcomes of statistical techniques used? As noted above, for agriculture, manufacturing, and services, chain-linked growth rates show an upward drift compared to fixed base. There are differences in the compilation of volume measures for these sectors. In Country A agriculture estimates are largely compiled at a detailed product

[12] In most of the SSA countries, a direct estimate of household final consumption expenditure (HHFCE) is available for the benchmark year only. For other years, HHFCE is calculated as a residual taking the GDP by production as the firm figure or extrapolating the base year estimates using the growth rate of population and CPI.

[13] In this paper, difference in growth rates for year **t** = growth rate from annual chain-linked approach for year **t** – growth rate from fixed-base approach for year **t**. In this paper, we present differences and not actual growth rates to maintain confidentiality of the data.

level using single deflation, whereas estimates for manufacturing are compiled at two-digit level of ISIC through extrapolation.

**Figure 1: Country A: Differences in Growth Rates of GDP and Components**
(Chain Linking minus Fixed Base)




Source: Staff calculations

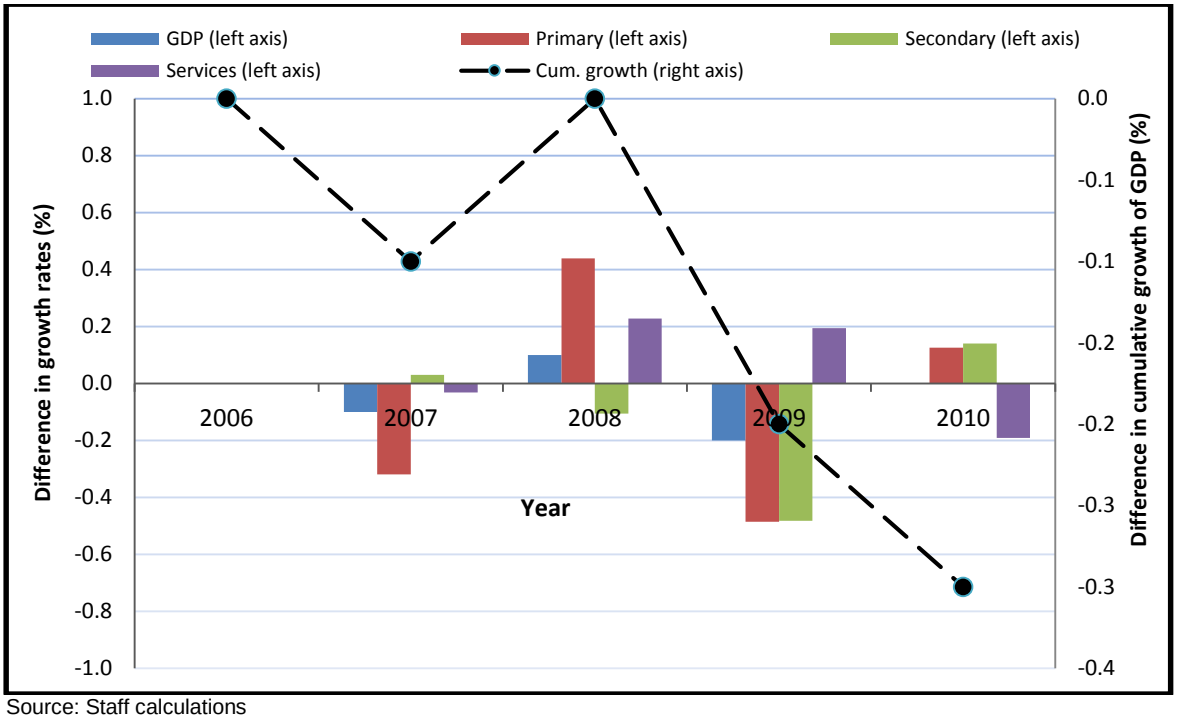
About 75 percent of the volume measures of services are based on single indicator methods (extrapolation or deflation) generally at a higher level of ISIC. The CPI covers only the capital city and uses outdated weights. Empirically, single indicator methods (deflation and extrapolation of value added) provide the same growth rates from the fixed-base and the chain-linked approaches at the level of their application. As a result, use of single indicator methods tends to reduce the differences in growth rates at the aggregate level. In addition, improper deflators and higher classification levels of implementation of deflation techniques have the potential to introduce bias in the volume growth estimates of underlying economic activities from both the approaches. This highlights that the insignificant difference in growth rate for 2013 with minor upward drift for chain-linked services estimates may not reflect the changes in underlying economic structure. For manufacturing, there are no differences in growth rates at two-digit level, however, differences are observed at the aggregate level. It is likely that improvements through double deflation at two-digit level may improve the growth estimates from both the approaches and bring out an accurate picture of difference in growth rates. We will investigate the potential impact of improper deflation techniques and classification level of implementation on chain linking in Section V.

**Country B**

This country has a relatively high proportion of services. For Country B, the differences in annual GDP growth rates are very small for all years and, for the year farthest from the fixed base year, there is no difference at all. Even though chain linking reduced the growth for total

services in the last year, the combined effect of all other activities appear to counteract this growth. The estimates of cumulative growth for the six year period (2005–10) shows that chain linking produces only a slightly smaller cumulative growth rate (Figure 2).

**Figure 2: Country B: Differences in Growth Rates of GDP and Components**
(Chain Linking minus Fixed Base)




Source: Staff calculations

The volume estimates of GDP for this country are compiled at a very detailed level using double indicator method in the Supply and Use Tables (SUT) framework.[14] For activities where detailed intermediate consumption data are available at current prices, double deflation is used to get value added at previous year prices. Each item (product) of intermediate consumption in the production account is deflated by the relevant price index from the SUTs related to that product. Activities where intermediate consumption is known at current prices are the formal sector (retrieved from detailed financial statements) and the general government. For activities where detailed data are not known at current prices, single extrapolation is used, using the volume index of the output. These activities are related to the informal sector, and some activities performed by nonprofit institutions serving households.

As the estimates of volume measures are compiled in the SUT framework, we consider that the differences in growth rates could be largely attributed to underlying economic reality. In view of this, nil difference in the growth rate for 2010 (invisible blue bar), and an

[14] In this method, a volume measure of value added is obtained as the difference between volume measures of output and intermediate consumption (each of which derived by direct revaluation, deflation, or volume extrapolation). This method is often referred to as double deflation.

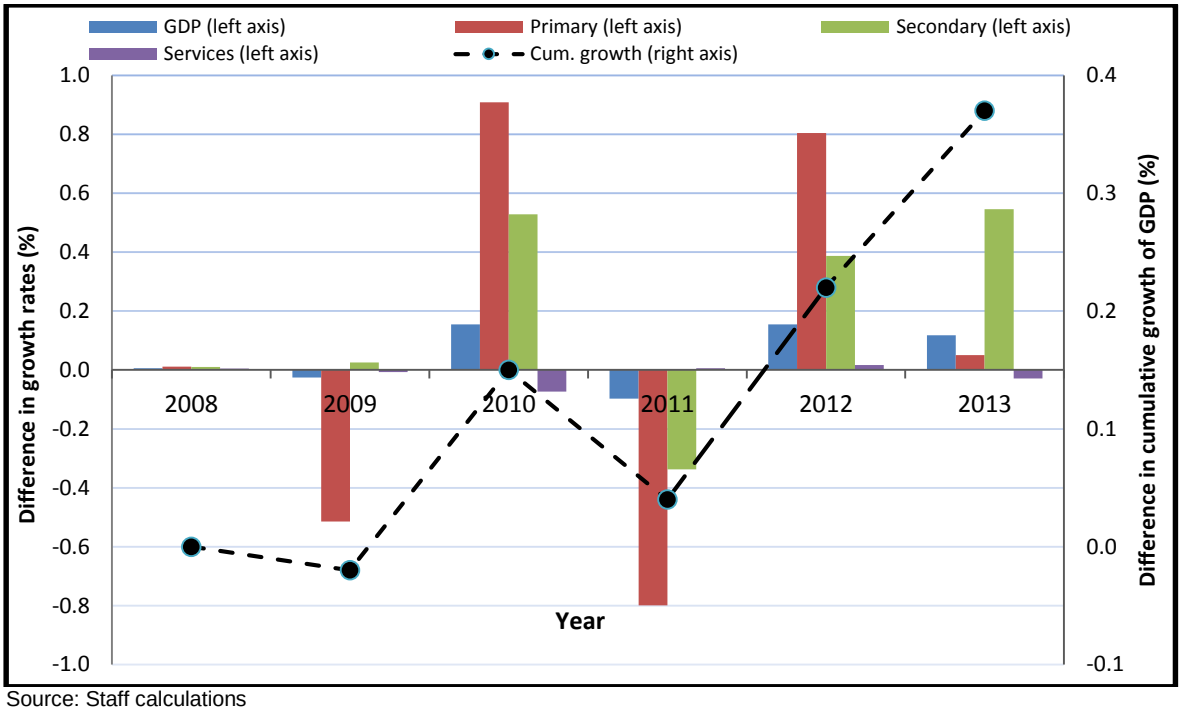
insignificant difference in the cumulative growth rate up to 2010 bring out an important point regarding the impact of chain linking. In general, growth rates for this country are not impacted by the approach used for volume measures estimation.

**Country C**

This country is a relatively services dominant economy among the three countries. The differences in GDP growth rates are rather small for all the years and mostly positive. The highest difference is 0.2 percentage points observed in two years (2010 and 2012). For the year farthest from the fixed base year, the difference is 0.1. Except for transportation and storage, all other activities showed either positive differences or no difference for 2013. We see higher cumulative growth from chain linking than the fixed-base approach for the period 2006–13 (Figure 3).

Manufacturing is a major contributor to the GDP in this country. As the estimates are obtained through extrapolation at two-digit level of manufacturing, no differences in growth rates are observed at that level. However, there are significant differences at aggregate level. This significant upward drift in volume growth estimates of value added from chain linking could be partly attributed to volatility in sub-sectors of manufacturing. For services, empirical considerations influenced the growth estimates from both the approaches. First, use of single indicator methods at higher classification levels mean that there is almost no difference for most of the services. Second, the lower growth estimates for transportation and storage from chain linking were offset by the combined effect of other services and resulted in no difference to the services growth. Overall, it appears that the differences in growth estimates for services largely depict the statistical method rather than economic structure.

**Figure 3: Country C: Differences in Growth Rates of GDP and Components**
(Chain Linking minus Fixed Base)




Source: Staff calculations

## Results of Data Analysis

Overall, our study shows insignificant difference in growth rates for the farthest year, volatile differences in growth rates, and negligible or even zero difference in cumulative growth for the respective study periods. Our results are in contrast with results for advanced economies. As seen in our analysis, the cumulative growth over a period of five to six years, which is normally an ideal period between two base years, is not significantly affected by the approach for producing volume measures of GDP in these countries. Our results also indicate that deflation techniques and classification levels of implementation may have an impact on the growth rates. We conclude that an assessment of the potential impact of deflation techniques and level of classification details need to be investigated further. These may significantly affect the impact of chain linking.

## V. SIMULATION ANALYSIS OF DEFLATION TECHNIQUES AND DETAILED LEVEL OF CLASSIFICATIONS

As noted in Section II, the *2008 SNA* recommends that the volume estimates of GDP be obtained at a very detailed level preferably using the SUT framework, deflating each

component by a strictly appropriate price index.[15] This implies that compilation of volume measures obtained at a detailed classification level would improve the accuracy of growth rates irrespective of the approach (fixed-base or chain-linked).

The detailed data obtained for this project allowed us to undertake two different simulations. The first simulation uses single deflation rather than double deflation. The second simulation uses overly-aggregated classification levels instead of detailed classification levels. These simulations provide useful insights to understand how deflation techniques and classification levels affect the volume measures of GDP when chain linking is used.

The simulation on the impact of single deflation was carried out using the data for Country B and overly-aggregated classification levels using Country C's data.

The results of the simulation analysis provide the following key conclusions:

- Use of improper deflation techniques and overly-aggregated classifications can lead to significant distortions in growth rates and provide wrong conclusions regarding the efficacy of the approach (fixed-base or chain- linked) appropriate for obtaining GDP volume measures; and

- Chain linking has limited influence in correcting the bias that improper deflation techniques and overly-aggregated classifications can introduce.

The impact of single deflation using data for Country B is presented first followed by the results on overly-aggregated classifications for Country C.

**Impact of Deflation Technique**

For Country B, in the existing compilation system, a large portion of volume measures of GDP is compiled through double deflation. To assess the impact that single deflation would have had on Country B, volume measures were obtained through single deflation in the place of double deflation. The results indicate significant differences in the growth rates obtained from using double deflation rather than single deflation.

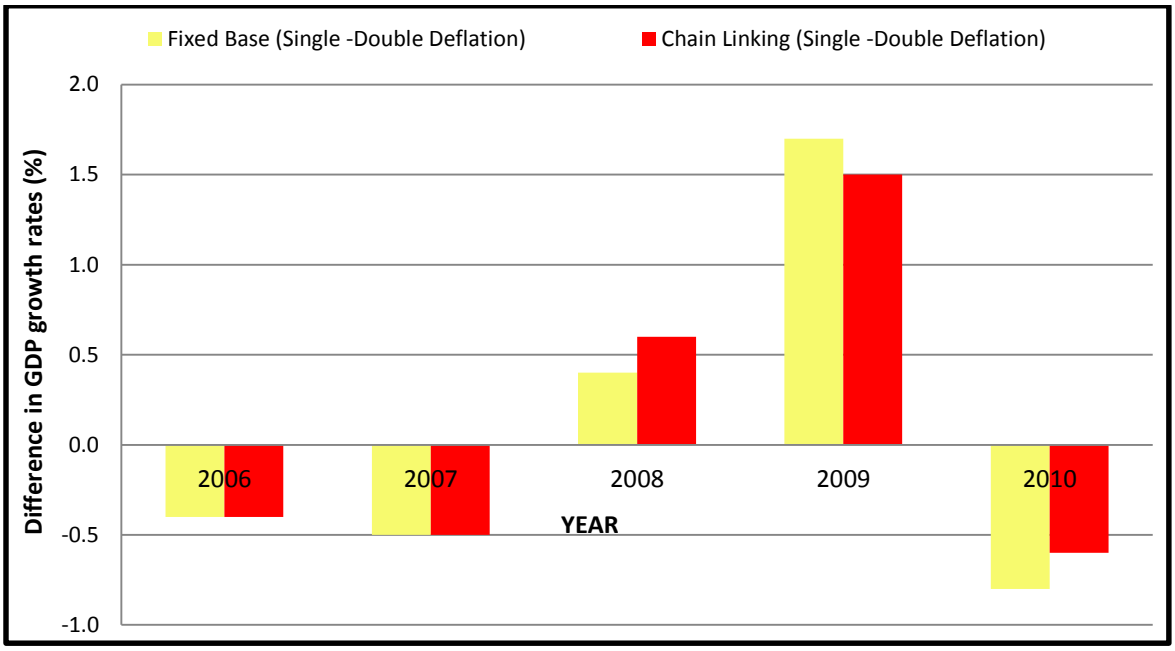
In Figure 4, 'yellow bars' represent differences in GDP growth rates for Country B obtained from single and double deflation using the fixed-base approach. Positive yellow bars indicate that growth rate from single deflation is higher and negative yellow bars convey that growth rate using single deflation is lower in the respective years. We note that the use of single deflation reduces the growth rate for three years, and increases it for two years. While the differences are large (around 0.5 percent in four of the five years and by 1.5 percent for

[15] In the absence of suitable price deflators, volume extrapolation is the second best alternative. For an introduction to these techniques, please see the *Eurostat's Handbook on Price and Volume Measures in National Accounts.*

2009), no consistent pattern is observed. Single deflation produced a much higher growth rate for 2009.

These results for Country B suggest that the failure of single deflation to take into account changes in the relative prices of inputs and output is not just a theoretical weakness, but are significant in practice. Therefore, compilers may consider replacement of single deflation as a relatively high priority.

**Figure 4: Difference in Growth Rates for Country B**
(Single minus Double Deflation)




Source: Staff calculations

**Interaction Between Deflation Technique and Chain Linking**

Looking at the combined effect of the deflation technique (single deflation or double deflation) with the fixed-base or chained approach, the difference in the growth rates between chain-linked and fixed-base approaches did not change significantly. In Figure 4, 'red bars' present differences in GDP growth rates obtained from single and double deflation using the chain linking.

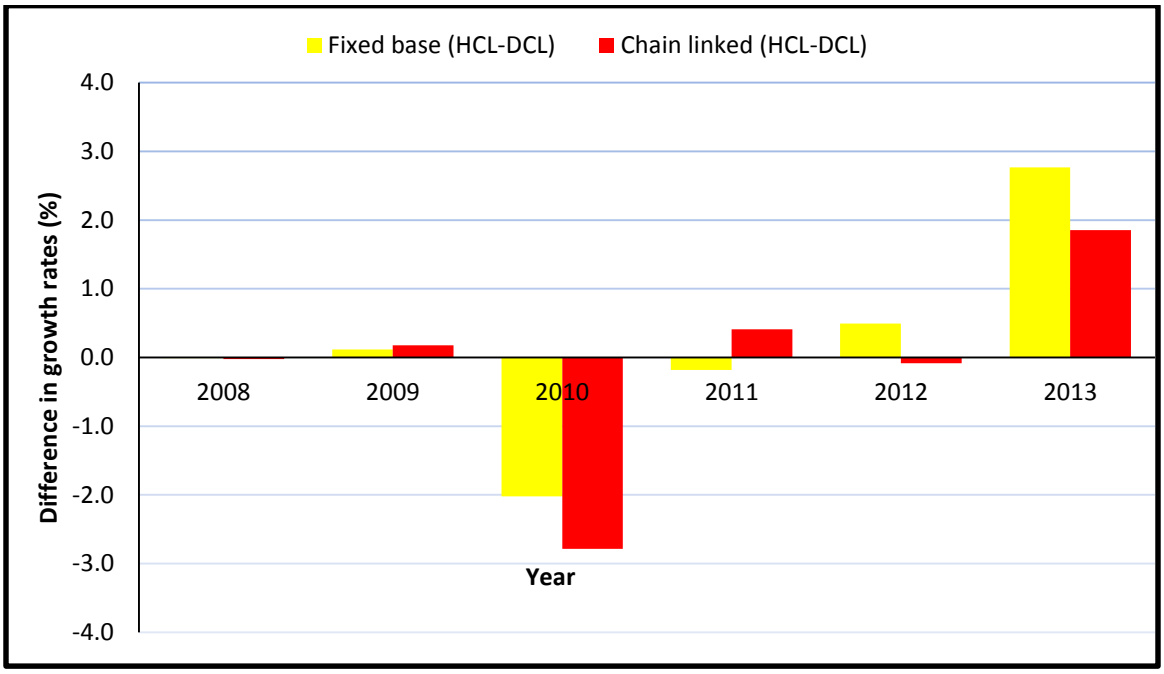
**Impact of Overly Aggregated Classifications**

For Country C, in the existing compilation system, volume estimates of manufacturing are compiled at sub-activity levels (which are referred to as divisions in the ISIC) and aggregated to obtain volume measure of manufacturing. The sub-activity level value added estimates are extrapolated using the index of industrial production (IIP) sub-components to obtain volume

measures. [16] To understand the impact of overly aggregated classifications on the volume estimates, we undertook a simulation using the volume measures of manufacturing value added at the highest classification level.

In Figure 5, 'yellow bars' represent the difference in growth rates for manufacturing value added using a higher classification level and a detailed classification level following the fixed-base approach. Similarly, 'red bars' represent the difference in growth rates for manufacturing value added using a higher classification level and a detailed classification level following the chain-linked approach.

**Figure 5: Country C: Comparison of Growth Rates for Manufacturing**
(HCL–Higher Classification Level minus DCL-–Detailed Classification level)




Source: Staff calculations

The classification level made significant differences to manufacturing growth rates in two out of six years. For the year 2013, the difference is 2.8 percentage points using fixed-base approach (yellow bar) and 1.9 percentage points (red bar) using chain-linked approach. In 2010, the use of higher classification level reduces the manufacturing growth rates by 2.8 percentage points from chain-linked and 2 percentage points for fixed-base approach.

[16] Empirically, extrapolation and single deflation of GVA create no differences in growth rates from the fixed base and chain-linked approaches. Difference in growth rates comes only at the level of aggregation.

### Interaction Between Classification Levels and Chain Linking

The interaction between chain linking and classification levels are examined using the simulation results for Country C. From Figure 5, we note that the fixed-base approach provides higher growth rates in two years (2012 and 2013) and chain linking in two years (2010 and 2011). Overall, there is no consistent pattern. This signifies that implementation of overly aggregated classification has significant impact on growth rates and chain linking apparently has no influence in correcting this.

The above results underscore the importance of obtaining volume measures at a very detailed classification level using appropriate deflation techniques. Therefore, we suggest that the implementation of a good system of double deflation at a very detailed classification level be given priority over chain linking. We noted in Section III that most of the SSA countries lack appropriate price and volume indicators. We suggest that the SSA countries should improve price and volume indices and to develop new indices such as the PPI which are more appropriate for output GDP activities. This will lead to substantial improvements in the volume measures of these countries in the first instance. Once suitable price and volume indices are available for all the activities (at least at two-digit level of ISIC) and the resources are in place for their regular update, the suitability of chain linking can be assessed.

## VI. CONCLUSIONS

There is a perception among national accounts compilers that implementation of chain linking provides superior estimates of volume measures of GDP under all conditions. However, this paper concludes that chain linking provides no substantial gains vis-à-vis the fixed-base approach in terms of providing accurate growth rates for the three SSA countries. Implementation of fixed-base approach at a detailed level (at least two-digit level of ISIC) using appropriate deflation techniques, and regular base year revisions yield more significant improvements in volume measures of GDP for SSA countries. The paper suggests that the quality of price and volume indices and the classification level of implementation should be given priority in countries with limited resources. They lead to major improvements in growth estimates irrespective of the approach used for aggregation. Also, chain linking should be undertaken following assessment as highlighted in this paper.

The results from this paper may provide useful guidance to national accounts compilers and managers. Implementation of chain linking should be driven by the economic structure of a particular county and the availability and timeliness of the required underlying detailed data. Conversely, countries that are not applying chain-linked volume measures should not be judged as lagging in implementation of an important recommendation of the *2008 SNA*. Finally, we suggest further research and assessments for developing countries from other regions of the world to see if these results can be generalized for other countries.

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**Appendix 1: GDP Base / Reference Year, and Weights Vintage and Coverage of CPI and PPI for SSA Countries (As of April 2016)**

| Country | National Accounts | | CPI | | PPI |
|---|---|---|---|---|---|
| | Fixed Base (FB) / Chain Linking (CL) | Base / Reference Year* | Weights vintage(years) | Coverage | Weights vintage |
| Angola | FB | 2002 | 3–5 | Capital city | X |
| Benin | CL | 2007 | Older than 5 | Main cities | X |
| Botswana | FB | 2006 | Older than 5 | Nation-wide | X |
| Burkina Faso | CL | 1999 | Older than 5 | Capital city | X |
| Burundi | CL | 2005 | 3–5 | Capital city | X |
| Cabo Verde | CL | 2007 | Older than 5 | Nation-wide | X |
| Cameroon | CL | 2000 | 3–5 | Nation-wide | X |
| Central African Republic | CL | 1985 | Older than 5 | Capital city | X |
| Chad | CL | 2005 | Older than 5 | Capital city | X |
| Comoros | FB | 2007 | Older than 5 | Capital city | X |
| Congo DRC | CL | 2005 | Older than 5 | Nation-wide | X |
| Congo Republic | FB | 1990 | Older than 5 | Capital city | X |
| Côte d'Ivoire | CL | 2008 | Older than 5 | Main cities | X |
| Equatorial Guinea | FB | 1992/93 | Older than 5 | Nation-wide | X |
| Ethiopia | FB | 2011 | Older than 5 | Nation-wide | X |
| Gabon | CL | 2001 | Older than 5 | Capital city | X |
| Gambia | FB | 2004 | Older than 5 | Nation-wide | X |
| Ghana | FB | 2006 | Older than 5 | Nation-wide | Older than 5 |
| Guinea | CL | 2010 | Older than 5 | Capital city | X |
| Guinea-Bissau | FB | 2005 | Older than 5 | Capital city | X |
| Kenya | FB | 2009 | Older than 5 | Nation-wide | X |
| Lesotho | FB | 2004 | Older than 5 | Nation-wide | X |
| Liberia | FB | ** | Older than 5 | Capital city | X |
| Madagascar | FB | 1984 | Older than 5 | Nation-wide | X |
| Malawi | CL | 2010 | 3–5 | Nation-wide | X |
| Mali | CL | 1999 | Older than 5 | Capital city | X |
| Mauritius | CL | 2007 | 3–5 | Nation-wide | Older than 5 |
| Mozambique | FB | 2009 | 3–5 | Urban areas | X |
| Namibia | FB | 2010 | 3–5 | Nation-wide | X |
| Niger | FB | 2006 | Older than 5 | Capital city | X |
| Nigeria | FB | 2010 | Older than 5 | Nation-wide | X |
| Rwanda | FB | 2011 | 3–5 | Urban areas | 3–5 |
| Sao Tome and Principe | FB | 2001 | Older than 5 | Capital city | X |
| Senegal | FB | 1999 | Older than 5 | Capital city | X |
| Seychelles | FB | 2006 | Older than 5 | Nation-wide | 3–5 |
| Sierra Leone | FB | 2006 | Older than 5 | Nation-wide | X |
| South Africa | FB | 2010 | 3–5 | Nation-wide | 3–5 |
| South Sudan | FB | 2010 | Older than 5 | Nation-wide | X |
| Swaziland | FB | 1985 | Older than 5 | Urban areas | X |
| Tanzania | FB | 2007 | 3–5 | Urban areas | Older than 5 |
| Togo | CL | 2007 | Older than 5 | Capital city | X |

| | | | | | |
|---|---|---|---|---|---|
| Uganda | FB | 2009/10 | Older than 5 | Urban areas | Older than 5 |
| Zambia | FB | 2010 | Older than 5 | Nation-wide | X |
| Zimbabwe | FB | 2009 | 3–5 | Nation-wide | Older than 5 |

Source: Websites of statistical offices, GDDS, SDDS, ILO, WEO database, etc.; X- indicates that PPI is not compiled for this country;

* Base year applies to countries using fixed base approach and reference year for countries using chain linking.

** Liberia has no official GDP data