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Sub-Annual Change Detection in Eritrea Gross Domestic Product (GDP) Using Innovative Breed Technique.

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Abstract

The main objective of this study is to examine the phenomenon, Structural change in the gross domestic product of Eritrea, forecast and recommend for future adjustment. Gross fixed capital formation (% of GDP). Eritrea Gross Domestic Product (GDP) data was obtained from the data stream of Universiti Utara Malaysia library. In the methodology, BFAST (Break for additive, Season and trend) and BFTSC (Break for time series components) was used to examine the structural change, time series components present in the data (Eritrea GDP) using R and Python software. BFTSC was created to capture the trend, seasonal, cyclical and irregular components as a combined image and to present them in a single plot. The result obtained, model acquired from the components (pattern) extracted using BFTSC was subsequently process for forecasting purposes and recommendation follows.

Keywords: Eritrea, Gross Domestic Product, Break for Time Series Components, Forecast, Control, Trend change.

1. INTRODUCTION

(HISTORICAL BACKGROUND)

This study uses BFTSC (Break for time series components) to identify the components of time series present in the empirical data which is the GDP yearly data of Colombia GDP gross domestic product. BFTSC is considered to be more efficient in identifying all the components of time series statistics better than manual approach and BFAST. Verbesselt, Hyndman,

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Newnham, & Culvenor, 2010, p106-115 . recommended an approach of basic swing identification to spot time series component. This approach was also used by Verbesselt, Zeileis, Hyndman, & Verbesselt, 2012, p106-115, as the latest time series component recognition approach which is a technique that was first described and utilized by (Verbesselt, Hyndman, Newnham, & Culvenor, 2010, p106-115).

The technique BFAST was for recognizing breaking points with the help of seasonal and trend decomposition using loess (STL), it facilitates the detection of trend change in a given information. The elementary standard of the BFAST technique is the splitting of time series into seasonal, trend and also remnants element by the approach for breaks detecting software in R studio core 2012 **(**10).

The economy of Eritrea has undergone extreme changes after the War of Independence. It experienced considerable growth in recent years, indicated by an improvement in gross domestic product in 2011 of 8.7 percent and in 2012 of 7.5% over 2011, and has a total of $8.090 billion as of 2020. However, worker remittances from abroad are estimated to account for 32 percent of gross domestic product (World Bank, 2020: World Economic Outlook 2024:Wikipedia, 2023). Eritrea has an extensive amount of resources such as copper, gold, granite, marble, and potash. As of 2012, 20 mining companies had obtained licenses to prospect and exploit mines. Eritrea's recent growth performance has been marked by significant volatility in part due to its dependence on a predominantly rain-fed agriculture sector, accounting for about one-third of the economy and which has a significant impact on distribution services which account for around 20% of gross domestic product (GDP), and on a narrow mining sector which also accounts for 20% of the economy. Real GDP growth is estimated to have recovered to around 12% in 2018, while averaging -2.7% during 2015–18 on account of frequent droughts and a decline in mining production (World Bank, 2020: World Economic Outlook 2024:Wikipedia, 2023: CIA World Fact Book history, 2019, p1019).

Reported inflation has been negative during 2016–18, following the exchange of currency in circulation in November 2015 that resulted in a monetary contraction. Deflation continued in 2018 as increased trade with Ethiopia resulted in further put downward pressure on prices (2,40). In recent years, Eritrea has significantly tightened fiscal policy to reverse the chronic deficits it suffered after the increase in regional insecurity in 1998. In 2018, the fiscal surplus widened to around 11% of GDP. This was largely achieved by a sharp drop in capital spending as well as some revenue measures. However, fiscal pressures, both recurrent and wage-related are likely to mount (CIA World Fact Book history, 2019, p1019).

Short-term growth prospects remain challenging given fiscal constraints and limited opportunities under existing restrictions. The recovery in agriculture is expected to slow. The country remains in a difficult macroeconomic situation with an unsustainable debt burden (including arrears to the World Bank) and vulnerable financial and external sectors (CIA World Fact Book history, 2019, p1019).

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Eritrea's GDP, estimated at $4.037 billion in 2011, was 8.7 percent above the GDP in 2010. The growth was due to increased agricultural output and the expansion of the mining industry along with increasing gold prices. Breakdowns of the Eritrean economy by sector have not been readily available; however, according to some estimates, in 2011 services accounted for 55 percent of the GDP, industry for 34 percent, and agriculture for the remaining 11 percent. The growth of the GDP, however, is compromised by the ongoing and tensions with the country's borders (World Bank, 2020: World Economic Outlook 2024:Wikipedia, 2023).

In 2004, agriculture employed nearly 80 percent of the population but accounted for only 12.4 percent of gross domestic product (GDP) in Eritrea. The agricultural sector has improved with the use of modern farming equipment and techniques, and dams. Nevertheless, it is compromised by a lack of financial services and investment. Major agricultural products are sorghum, barley, beans, dairy products, lentils, meat, millet, leather, teff, and wheat. The displacement of 1 million Eritreans as a result of the war with Ethiopia, and the widespread presence of land mines have played a role in the declining productivity of the agricultural sector. Almost a quarter of the country's most productive land remains unoccupied because of the lingering effects of the 1998–2000 war with Ethiopia (CIA World Fact Book history, 2019, p1019).

Forestry is not a significant economic activity in Eritrea. As of 2011, the government encouraged large-scale cultivation of cactus to help alleviate the human suffering and, in the future, increase export revenues. Cactus plants are said to have been introduced in 1839 by a French catholic missionary who planted the cactus in Digsa, Akrur and Hebo, Southern region. The second generation cactus plants were introduced by the Italians, who planted them at Arberebu while they were building the Asmara rail lines. Reliable figures on the extent and value of the fishing industry in Eritrea are difficult to obtain. However, Eritrea's long coastline offers the opportunity for significant expansion of the fishing industry from its current, largely artisanal, stage. Eritrea exports fish and sea cucumbers from the Red Sea to markets in Europe and Asia, and there is hope that the construction of a new, jet-capable airport in Massawa, as well as rehabilitation of the port there, may support increased exports of high-value seafood. In 2002, exports were about 14,000 tons, but the maximum stable yield is thought to be nearly 80,000 tons. A fish processing plant was built in 1998 that now exports 150 tons of frozen fish every month to markets in Britain, Germany, and the Netherlands. Tensions with Yemen over fishing rights in the Red Sea flared up in 1995 and again in 2002, and Eritrea's difficult relations with other nations could hamper further development of the industry (World Bank, 2020: World Economic Outlook 2024:Wikipedia, 2023).

As of 2001, Eritrea's substantial mineral deposits were largely unexplored. According to the Eritrean government, artisanal mining in 1998 collected 573.4 kilograms of gold, however the number of gold reserves was unknown. International observers also have noted Eritrea's potential for quarrying ornamental marble and granite. As of 2001, some 10 mining companies had obtained licenses to prospect for different minerals in Eritrea. The government of Eritrea

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reportedly was in the process of conducting a geological survey for use by potential investors in the mining sector. The presence of hundreds of thousands of land mines in Eritrea, particularly along the border with Ethiopia, has presented a serious impediment to future development of the mining sector. In 2011, AngloGold Ashanti moved into Eritrea to explore the Arabian-Nubian Shield for gold through a 50/50 joint venture set up in 2009 with Thani Dubai Mining (CIA World Fact Book history, 2019, p1019).

In 2011, the Australian Chalice mining company applied through a 60/40 joint venture for a mining license for 18 years. Also in 2011, Nevsun Resources completed construction of its Bisha gold mining project. Estimated production was to be 350,000 ounces of gold per year until the gold ore is exhausted, at which point the mine would produce copper and zinc (World Bank, 2020: World Economic Outlook 2024:Wikipedia, 2023).

As of 2012, nine explorer companies operated in Eritrea from Canada (NGEx Resources), Australia (Chalice Gold Mines, South Boulder Mines, Sunridge Gold Corp), China (Sichuan Road and Bridge Group, Zhong Chang Mining Co, China Africa Huakan Investment Co.,Land Energy Group (China) Ltd, Beijing Donia Resources Co.) , UK (London Africa Ltd, Andiamo Exploration Ltd.), UAE and Barbados. During the period of federation, industrial capacity largely shifted to Ethiopia, leaving the Eritrean industrial sector with outmoded capital equipment. In 2003 industry accounted for 25.3 percent of gross domestic product. Major products include processed food and dairy products, alcoholic beverages, glass, leather goods, marble, textiles, and salt (CIA World Fact Book history, 2019, p1019).

Energy in Eritrea (World Bank, 2020: World Economic Outlook 2024:Wikipedia, 2023). Households consume more than 80 percent of total energy production. Electricity production in 2001 was estimated at 220.5 million kilowatt-hours. Consumption for that year was estimated at 205.1-kilowatt hours. An 88-megawatt electricity plant funded by Saudi Arabia, Kuwait, and Abu Dhabi was completed just south of Massawa in 2003, its completion delayed nearly three years by the war with Ethiopia. Annual consumption of petroleum in 2001 was estimated at 370,000 tons. Eritrea has no domestic petroleum production; the Eritrean Petroleum Corporation conducts purchases through international competitive tender. According to the U.S. Department of Commerce, opportunities exist for both on- and offshore oil and natural gas exploration; however, these prospects have yet to come to fruition. The use of Wind energy and solar power have slightly increased, due to the growth of solar power manufacturing companies in the country. The Eritrean government has expressed interest in developing alternative energy sources, including geothermal, solar, and wind power (World Bank, 2020: World Economic Outlook 2024:Wikipedia, 2023).

Harnet Avenue in Asmara. In 2011, services accounted for 55 percent of gross domestic product. Financial services, the bulk of the services sector, are principally rendered by the National Bank of Eritrea (the nation's central bank), the Commercial Bank of Eritrea, the Housing and

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Commerce Bank of Eritrea, the Agricultural and Industrial Bank of Eritrea, the Eritrean Investment and Development Bank, and the National Insurance Corporation of Eritrea.

Tourism in Eritrea. Eritrea's lack of access to funds, the presence of large numbers of land mines, and the continued tensions that flare up between Eritrea and Ethiopia have deterred the development of a tourist industry in Eritrea. According to the World Tourism Organization, international tourism receipts in 2002 were only US$73 million. Banking in Eritrea. According to the International Monetary Fund, commercial banks in Eritrea—all government owned and operated—appear to be in compliance with prudent regulations. Although the commercial banking sector is largely profitable, mostly owing to income from foreign exchange transactions, the sector is burdened by a high proportion of non-performing loans. Core lending activities do not generate sufficient income to cover operating costs at most commercial banks (World Bank, 2020: World Economic Outlook 2024:Wikipedia, 2023).

Agriculture employs about 80 percent of the population in Eritrea, and the remaining 20 percent are employed in industry and services. The GDP per capita at nominal value was $475 in 2011. The official currency is the Eritrean nakfa (ERN), introduced in November 1997. In early 2005, likely in an effort to increase foreign capital reserves, the Eritrean government decreed that all transactions in Eritrea must be conducted in nakfa. It soon became illegal for individuals to hold and exchange foreign currency. As of January 1, 2005, the government set the foreign exchange rate at US$1=ERN15 (CIA World Fact Book history, 2019, p1019).

Inflation continues to be a problem in Eritrea, particularly as years of drought push grain prices higher and defense expenditures remain high. The International Monetary Fund estimates that in 2003 (the most recent year for which figures are available) average inflation reached 23 percent. The Massawa-Asmara Highway, built as part of the Wefri Warsay Yika'alo program (World Bank, 2020: World Economic Outlook 2024:Wikipedia, 2023). Eritrea does not publish a budget, making its fiscal condition difficult to assess. According to the International Monetary Fund, the overall fiscal deficit in 2003 was 17 percent of gross domestic product (GDP). Government expenditures for that year were estimated to be US$375 million, with revenues of only US$235.7 million. In 2002 the fiscal deficit was 32 percent of GDP. Current expenditures continue to exceed budgeted spending, particularly in defense and other discretionary expenditures. Monetary policy remains subservient to the financing demands of the government, and debt is unsustainably high. This situation is not likely to change until demobilization of the military occurs. According to the CIA World Factbook, the Eritrean Government has revenues of $715.2 million, and outlays of $1.021 billion (CIA World Fact Book history, 2019, p1019).

China, India, South Korea, Italy, South Africa, and Germany are aggressively pursuing market opportunities in Eritrea. There is growing interest in U.S. products and services in Eritrea, although U.S. investment in Eritrea is still small (World Bank, 2020: World Economic Outlook 2024:Wikipedia, 2023). In 2011, Eritrea imported goods worth US$899.9 million, including machinery, petroleum products, food, and manufactured goods. Eritrea's main suppliers were

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Brazil, China, Egypt, India, Italy, Germany, Saudi Arabia, and South Africa. In 2011 exports from Eritrea were valued at US$415.4 million, and the bulk were food, livestock, small manufactures, sorghum, and textiles. The major markets for Eritrean goods were China, Egypt, Italy, Saudi Arabia, Sudan, and the UK. More recently, fish, flowers, and salt have joined the list of exports. Foreign investment is hindered by government regulations that seek to protect domestic industries from foreign competition and by a generally unfavorable investment climate. Major foreign investors in Eritrea include China, South Korea, Italy, South Africa, and Germany, as well as the World Bank (CIA World Fact Book history, 2019, p1019).

The government prefers private-sector investment to official aid programs and declines foreign aid; therefore its relations with aid-dispensing nations and international institutions have often been difficult (World Bank, 2020: World Economic Outlook 2024:Wikipedia, 2023).

On 16 September 2018, Eritrean President Isaias Afwerki and Ethiopian Prime Minister Abiy Ahmed signed a peace agreement in Jeddah, Saudi Arabia between the two countries after a bitter war that lasted 20 years (from 1998 to 2018). The two neighboring countries ceased hostilities and restored trade and diplomatic ties, and planned joint projects.

The technique BFAST was for recognizing breaking points with the help of seasonal and trend decomposition using loess (STL), it facilitates the detection of trend change in a given information. The elementary standard of the BFAST technique is the splitting of time series into seasonal, trend and also remnants element by the approach for breaks detecting software in R studio core 2012 (Verbesselt, Hyndman, Newnham, & Culvenor, 2010, p106-115).

2. Material and Methods

BFAST is the technique used in analyzing the generality of time series data by extracting the trend and seasonal pattern during time series decomposition. Given the general time series additive model of the form of equation 1.1 (Ajare & Ismail 2019, p995: Ajare & Ismail, 2019, p1005: Ajare & Ismail, 2019, p2826) From equation (1.2) BFAST takes all other components relatively trend and seasonal component to be randomized (R_p) and the equation was expressed as

$$Y_p = T_p + S_p + R_p \quad (1.2)$$

The residual random consist of cyclical and irregular component (Ajare & Adefabi, 2023: Ajare, Adefabi & Adeyemo, 2023: Abbes & Farah, 2017).

To generate trend components using BFAST, we need a piecewise linear model approach (DeVries, Pratihast, Verbesselt, Kooistra, de Bruin, & Herold, 2013), Suppose T_p is a piecewise linear model with an actual slope and intercept on q+1 segments broken with q breakpoints and P period; $p_1^{\neq}$,……., $p_q^{\neq}$ then T_p can takes the form as follows

$T_p = \alpha_k + \beta_k P$

where $p_{k-1}^{\mp} < p \leq p_k^{\mp}$

and If k = 1,…..,q then $p_0^{\mp} = 0$ and $p_{q+1}^{\mp} = n$.

The slope of the change before the breakpoints while β_{k-1} and the slope of the breaks after the change breakpoints are β_k. The intercept and the slop of the linear model α_k and β_k with time period p and it will be used to derive the magnitude and direction of change . (Adewoye & Chapman, 2018: Box, Jenkins, Reinsel, & Ljung, 2015: Bai, & Perron, 2003)

To generate seasonal components using BFAST, we need a simple harmonic model (Ewing, & Malik, 2013: Flicek, & Birney, 2009: Jain, Duin, & Mao, 2000 p108).
Thus, S_p can be represented by a simple harmonic model with j terms; j = 12….J and time t.

$$S_p = \sum_{j=1}^{J} \omega_{k,j} \text{ Sin } (\frac{2\pi jt}{F} + \sigma_{K,j}) \quad (1.3)$$

where k = 1… q, $p_{k-1}^{\mp} < p \leq p_k^{\mp}$ and also $\omega_{k,j}$, $\sigma_{K,j}$ are the segment amplitude and F is the frequency .(Mok, Wu, Ahn, Garassino, Kim, Ramalingam & Lee, 2017, p629-640.:Maus, Câmara, Appel, & Pebesma, 2017).
To generate random components, any data that does not belong to trend nor seasonal is classified random R_p (Gorelick, Hancher, Dixon, Ilyushchenko, Thau, & Moore, 2017, p202).

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$$Y_p = \underbrace{\{\alpha_k + \beta_k P\}} + \underbrace{\left\{\sum_{j=1}^{J} \omega_{k,j} \; Sin \left(\frac{2\pi jt}{F} + \sigma_{K,j} \right)\right\}} + \underbrace{R_p} \quad (1.4)$$

$$Y_p = \quad T_p \quad + \quad S_p \quad + \quad R_p$$

The new technique called GFTSC considered splitting the random into cyclical components and irregular components which is an extension of BFAST (Bohn, 1995: Cipra, & Romera, 1997: Caiado, 2009). This was done through the inclusion of two new components (Bornhorst, Dobrescu, Fedelino, Gottschalk, & Nakata, 2011)
To calculate cyclical components, center moving average is involved (Ajare & Ismail 2019, p995: Ajare & Ismail, 2019, p1005: Ajare & Ismail, 2019, p2826)
Derivation of cyclical code, let CMA be the center moving average of t objects, then CMA can be computed as follow

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$$\text{CMA} = \sum_t^n \frac{Yt}{nt} \quad (1.5)$$

$$C_p = \frac{CMA}{\hat{CMA}} \quad (1.7)$$

After extracting the trend, seasonal and cyclical components, the left out components is called irregular components, the new equation becomes

$$Y_p = \underbrace{\{\alpha_k + \beta_k P\}} + \underbrace{\{\sum_{j=1}^{J} \omega_{k,j} \quad Sin\left(\frac{2\pi jt}{F} + \sigma_{K,j}\right)\}} + \underbrace{\{\frac{CMA}{\hat{CMA}}\}} + \{\underbrace{I_p}\} \quad (1.8)$$

$$Y_p = \quad T_p \quad + \quad S_p \quad + \quad C_p \quad + \quad I_p$$

For identification of Y_p , S_p , C_p , and I_p (See the paper: 4,5, 33,34,35).

The first stage in forecasting is to view the data and to examine all the components of time series present in that data in order to select the most appropriate forecasting technique (Box & Jenkins, 1976: Cleveland & Tiao, 1976).

The UK yearly quarterly GDP data components identification was carried out with the help of the new technique called BFTSC. This new technique helps to have a clear image of the entire variations presents in the time series data (Jamali, Jönsson, Eklundh, Ardö, & Seaquist, 2015 p156 :Porter & Zhang, 2018: Tolsheden, 2018: Maggi, 2018, pp. 1-29)

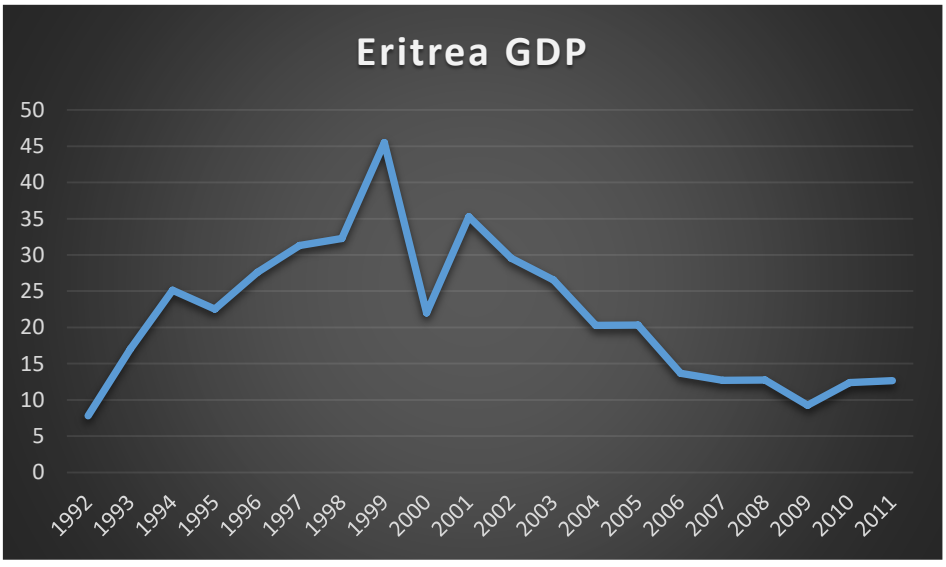

Figure 1. Original Manual Eritrea Gross Domestic Product (GDP) plot.
Figure 2. The free fitted value and the real data of the Eritrea Gross Domestic Product (GDP).

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This reveal that for the next two years period, the Eritrea Gross Domestic Product (GDP show evidence of sharp decline and the fitted value fit well and match intact to the original Gross Domestic Product (GDP) data so the model can be applied for prediction of more years GDP of Eritrea.

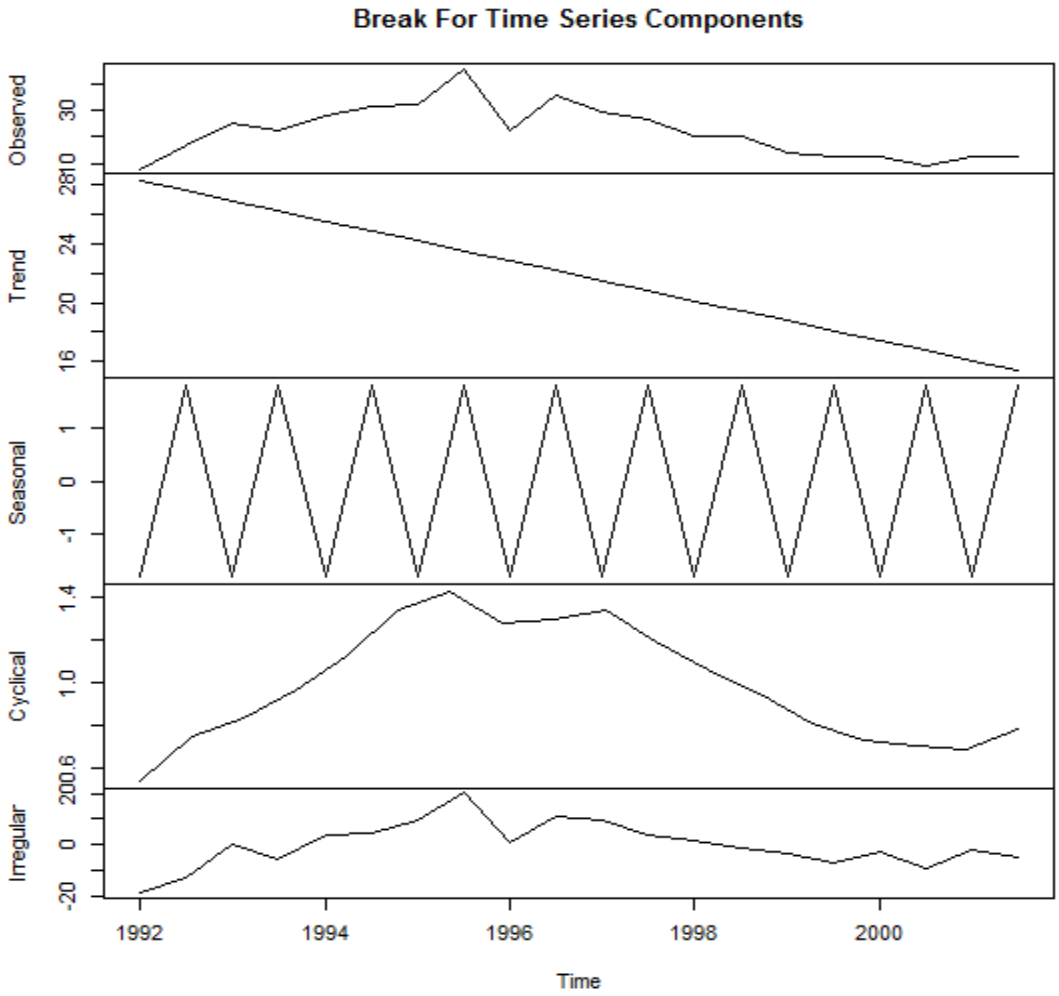

Figure 1 reveals all the time series components hidden in the Eritrea Gross Domestic Product (GDP) data for 63 Years, the image in the figure above indicate the presence of trend, seasonal components, Hence the most appropriate techniques for analyzing such data is ARIMA.

Ten ARIMA models were fitted and the best model was selected based on the ARIMA with the smallest AIC (Akaike's Information Criterion). Based on the AIC models, the ARIMA (Zdravevski, Lameski, Mingov, Kulakov & Gjorgjevikj, 2015, pp. 381-388 : Zhao, Li, Mu, Wen, Rayburg, & Tian, 2015 p1331-1343) is the best model to be used in fitting the Eritrea quarterly GDP . ARIMA (Zhu, Park, Isola, & Efros, 2017: Zewdie, Csaplovics & Inostroza, 2017, p167-178) is selected and used for fitting the model .

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3. RESULTS

The results scientifically shows that Eritrea GDPis declining gradually and need to be improved els would go into borrowing to sustain the economy of the country.

The basic recommendation of this paper is that Eritrea government need to improve on its economy, improve on local production, local processing and also increase in export or else the economy may suffer set back tremendously. Though from the forecast, the economy gradually pick up at 2026 but never the less the government should not rest and relax on the forecast but put more effort on implementing programs that would help yield better economy for the country.
Note: The data used for this paper can be gotten freely from the authors Dr Ajare Emmanuel (ajareoloruntoba@gmail.com) also the BFAST technique can be acquired from same author freely. But the forecast values can be acquired from the author likewise but not free, $1000/year forecast. If Eritrea government want further details they can purchase the forecast data for 10 years it would be very beneficial and advantageous for domestic GPD growth (ajare_emmanuel@ahsgs.uum.edu.my).

This paper serve as forecasting guide and it makes it easier for anyone that wants to venture into forecasting GDP or els otherwise both the technique used and the forecast values can be acquired per-year with a little money to support the authors academic development.

4. Discussion/Conclusion

The technique BFAST was for recognizing Breaks for Additive Seasonal and Trend (BFAST). This technique helps to recognize trend breaks enclosed by the series. The essential guide of the BFAST technique is the decomposition of time series component into seasonal, trends and miscellany elements with the technique for recognizing structural similarity and difference. Rikus, 2018, p2285-2310 recommended that the technique of BFAST is for identifying topographical pattern and also for improvement to be applied in other related disciplines Zeileis, Kleiber, Krämer, & Hornik 2003, p109-123.

Chen (2006) describe BFAST as not being capable of identifying topographical vegetation basic component perfectly, though satellite sensor image have made topographical vegetation data available for so many years but yet the detection of topographic trend and variation is not yet clearly defined. Chen (2006) suggested that, this may be due to the limited number of available trend and change detection techniques accessible, algorithm suitable in identifying and characterizing abrupt changes without sacrificing accuracy and efficiency Cesta, Cortellessa, Pecora & Rasconi, 2005: Chen, 2006

Based on previous studies, BFAST is used for topographical green forest picture data at certain specific time. Introducing BFAST to time series data and how to implement BFAST on time series data which contain only one variable for each time is another form of challenge. BFAST is a technique that take in data and processed to extract each component point of the data, it would

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be reasonable to use BFAST for time series components identifications Jong, Verbesselt, Schaepman, & Bruin, 2012 . BFAST approach give a very considerable outcome and was recommend as a modern instrument for statistics information decomposition and detections but could not separate random noise and is a customized additive decomposition method, from all indication observed so far, it reveal that BFAST need to be extended for the purpose of coping with other varieties of uses Jong, Verbesselt, Schaepman, & Bruin, 2012 . Based on the result in figure 1 and figure 2, there are no evidence of decline in Eritrea GDP. The forecast data reveal smooth and steady drop in trend Eritrea GDP. Hence no scientific evidence of GDP sharp or sudden crash or ruin in the next five good years provided every other normal conditions id not obstructed. Never the less this should not be taken for levity but with all seriousness to make the GDP grow beyond prediction and beyond expectation. The forecast should encourage Eritrea in improving and investing on the country GDP so as to have blossom reserve. They should employ all other possible means of generating revenue (both internally and externally) for the country utilization.

BFTSC is the most appropriate for time series components identification. BFTSC is recommended as a good alternative to BFAST. This is because BFTSC identifies the four components of time series statistics which is one of the basic limitations of BFAST. Based on the forecast value for 2019 and 2020 , it reveal scientific evidence of drop in Eritrea GDP so improvement is needed to be establish to improve on the yearly quarterly GDP. The contribution of this study to the scientific community is that the BFTSC gives good results that improve the weaknesses of the existing BFAST. BFTSC forecast output is more reasonable for effective policy making.

Note: The data, BFTSC and GFTSC can be made available based on request from the original author of this paper Dr. Ajare Emmanuel. The data utilized in this study is available freely if the author is contacted. The BFTSC and GFTSC can be acquired with $10,000 from Dr Ajare Emmanuel. The forecast in this Eritrea GDP can likewise be acquired with $1000 per year per forecast. This forecast is very good for economic development.
(ajareoloruntoba@gmail.com and ajare_emmanuel@ahsgs.uum.edu.my).

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6. Authors Contributions

Ajare Emmanuel Oloruntoba and all other co-authors listed on the introduction log: Analyzing, producing the results and writing the paper.

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7. Ethics

This is the original manuscript; there will be no expectation of any ethical problems.

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