Forecasting Tanzania GDP per Capita, 2013 – 2021

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This study forecasts standard of living in Tanzania over the next ten years as measured by the ratio of two rates: (1) economic growth, using real gross domestic product (GDP), to (2) population growth. GDP alone is an insufficient measure of a nation's well-being. China and India, for example, have high levels of GDP, but the pie is sliced very thin to be shared among the billions of people who live in those two countries. Real GDP per capita measures not only the level of economic activity but also the number of people who must share in the results of that activity. This study uses historical data for Tanzania's real GDP (i.e., adjusted for inflation) and population to observe the ratio over time (from 1960 to 2011). One discovery is that of a point of inflection at the end of the 20th century, such that GDP per capita rose at an annual rate of just one percent "pre-inflection" and four times that rate "post-inflection." The study uses standard statistical methods to forecast the variables over the next ten years. Results of the forecast indicate that GDP will continue to grow at a faster rate than will population, with a consequent steady rise in the average standard of living. How the increased prosperity will be distributed, so as to reduce the level of poverty and the disparity of income, remains to be seen.

JEL Classifications:

C53: Forecasting and Other Model Applications

E17: Forecasting and Simulation: Models and Applications

O11: Macroeconomic Analyses of Economic Development

O40: Economic Growth and Aggregate Productivity

O55: Economywide Country Studies – Africa

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This study forecasts standard of living in Tanzania over the next ten years as measured by the ratio of two rates: (1) *economic growth*, using *real gross domestic product* (GDP), to (2) *population growth*. GDP alone is an insufficient measure of a nation's well-being. China and India, for example, have high levels of GDP, but the pie is sliced very thin to be shared among the billions of people who live in those two countries. (While the combined population of China and India comprises nearly 37 percent of the world's population, their combined GDP accounts for only 14 percent of the gross world product (Wikipedia, 2013a and b)).

Real GDP per capita measures not only the *level* of economic activity but also the number of people who must share in the results of that activity. This study uses historical data for Tanzania's *real GDP* (i.e., adjusted for inflation) and *population* to observe the ratio over time (from 1960 to 2011).

This study re-visits the perennial question asked by development economists: Why is it that some nations grow rich while others remain poor? By all economic measures, Tanzania is a poor country (e.g., CIA, 2013; Feenstra, Inklaar, & Timmer, 2013; Global Finance, 2013; IMF, 2013). Will it remain poor, or are there signs of improvement in the standard of living of the average Tanzanian person? Such signs are already evident in the data. However, this study is limited to analyzing macroeconomic data and does not address the distribution of income and wealth among the nation's families and

regions; this is a most important area, embracing the reduction of the rates of poverty, that must be examined in future studies.

Method and Sources

The study employs two variables: (1) real gross domestic product (GDP, or *Y*) and (2) population (*N*). (See Appendix D for mathematical notation.) Specifically, the study is concerned not just with the *levels* of GDP and population, but more importantly, with their *rates of growth* (g_Y and g_N). An operating premise of the study is that improvement in *standard of living* is determined in general by the ratio of GDP growth rate to population growth rate. A consequence of the premise is that if GDP grows at a faster rate than population, then the standard of living will rise.

Historical data for both variables are found in a number of resources, including, *inter alia,* the Bank of Tanzania (2013), *The World Factbook* of the United States Central Intelligence Agency (CIA, 2013), the International Monetary Fund (IMF, 2013), Infoplease (2013), Tanzania National Bureau of Statistics (NBS, 2013), USAID (2013), Theodora (2013), and the World Bank Group (2013). This study, however, uses as its primary source the recently released, highly regarded, and most comprehensive longitudinal database, Penn World Table PWT 8.0 (Feenstra, Inklaar, & Timmer, 2013a & b). Historical economic and population data comprise the base for a 10-year forecast using Forecast Pro, the powerful statistical forecasting program employed by businesses, governments, academics, and others around the world (Stellwagen & Goodrich, 2010b). Interpretations of results are aided by the *Forecast Pro Statistical Reference Manual* (Stellwagen & Goodrich, 2010a). (A list of abbreviations and acronyms is at Appendix C.)

Results

Gross Domestic Product Level and Growth Rate

Figure 1 shows the historical data for Tanzania GDP from 1960 to 2011, the latest year for which PWT 8.0 has such data. Using 2005 as the base year, real GDP (adjusted for inflation) in 1960 was about $5.5 billion in constant US dollars. By 2011, real GDP had increased 10-fold to $54.7 billion.

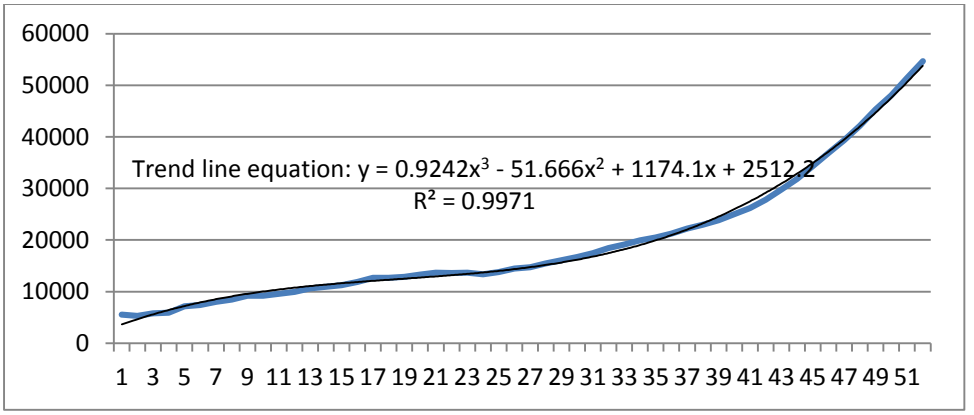

Figure 1. Real GDP, Tanzania, 1960-2011 (2005 constant US Dollars, millions) with well fitted 3rd-order polynomial trend line. (The thinner trend line is so close to the actual data that it may be difficult to see.)

A 3rd-order polynomial trend line fits the data very well, with an R^2 of 0.9971. The curve, however, reveals a most interesting fact: there is a noticeable point of inflection between years 37 and 41. This would be calendar years 1997-2001. The curve reveals an inflection point at this time. Further study is needed in order to discern the reasons for the increase in the rate of growth of GDP. It is, however, especially notable that the steeper rate of growth has continued from that time to the present.

The following six figures (1.1, 1.2, 1.3, 1.4, 1.5, and 1.6) show the "pre-inflection" growth rate compared to the "post-inflection" rate. Figure 1.1 shows the entire series, from 1960 to 2011. The linear trend line replaces the polynomial trend line in Figure 1 in order more readily to compare and contrast the slopes of the two periods. For the entire period, the slope of the linear trend line, as shown in the equation, is 1058; i.e., the average increase is $1,058 million per year.

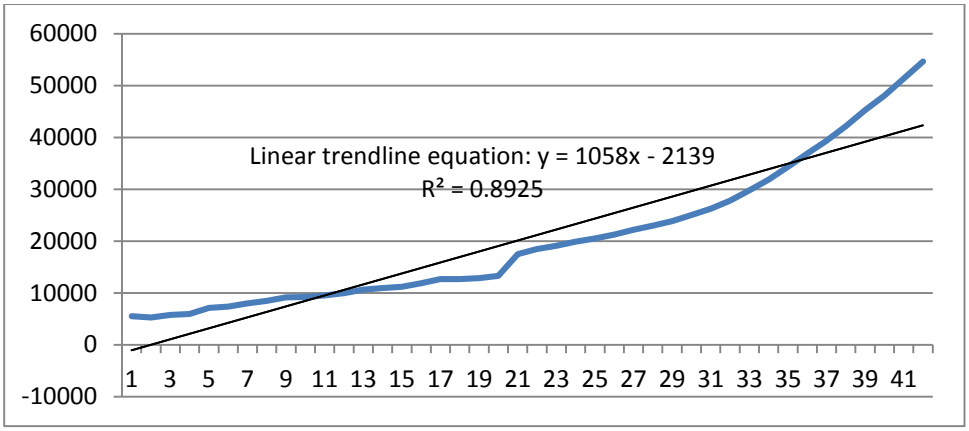

Figure 1.1. Real GDP, Tanzania, 1960-2011 (2005 constant US Dollars, millions) with linear trend line. Slope of the linear trend line is 1058; average annual increase is $1,058 million.

The "pre-inflection" period, 1960 to 1999, in Figure 1.2, shows that the slope of the linear trend line is 681, or about 64 percent of the slope of the full period of 1960 to 2011.

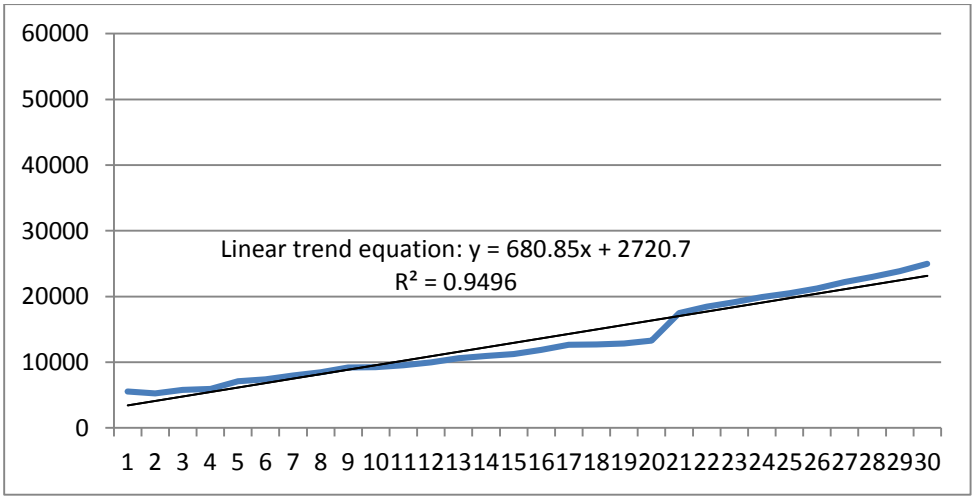

Figure 1.2. Real GDP, Tanzania, 1960-1999 (2005 constant US Dollars) with linear trend line. Slope of the linear trend line is 681; average annual increase is $681 million.

The "post-inflection" period, 2000 to 2011, shown in Figure 1.3 reveals a growth rate nearly four times that of the "pre-inflection" period, with a slope of 2610.

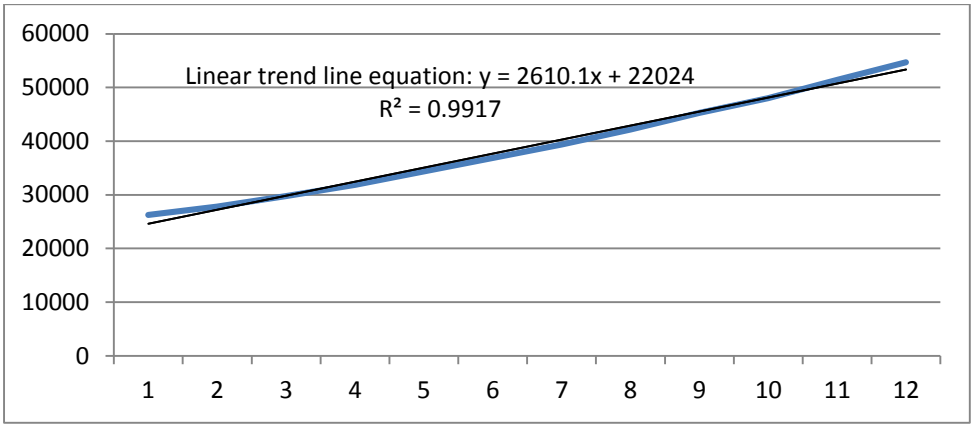

Figure 1.3. Real GDP, Tanzania, 2000-2011 (2005 constant US Dollars, millions) with linear trend line. The slope of the linear trend line is 2610, nearly four times that of the "pre-inflection" period of 1960-1999.

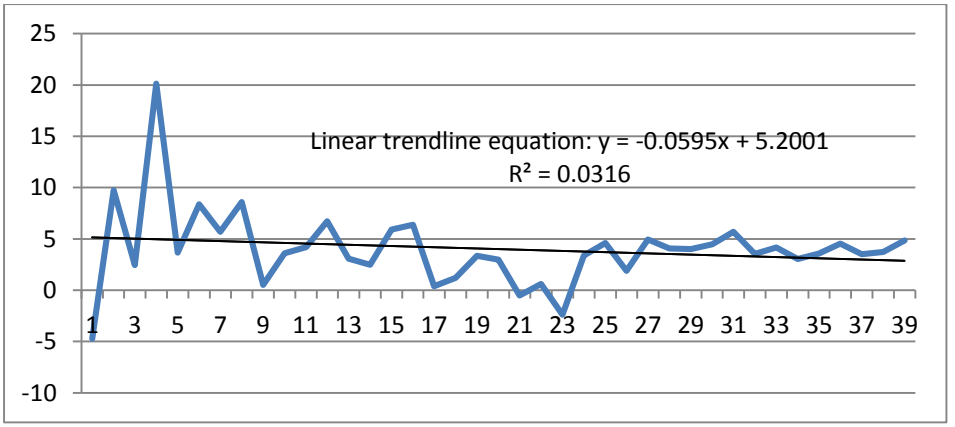

Figure 1.4. Real GDP growth rate, Tanzania, 1961-1999 (2005 constant US Dollars, millions) with linear trend line.

Figure 1.4 shows, for 1961-1999, that the slope of the linear trend line is almost level, even slightly negative. At several points, the growth rate is zero

or negative during this period. In most years, the growth rates have been below five percent.

By contrast, Figure 1.5 shows that the slope of the linear trend line is positive for the growth rates from 2000 to 2011. The growth rates were consistently above five percent during this period.

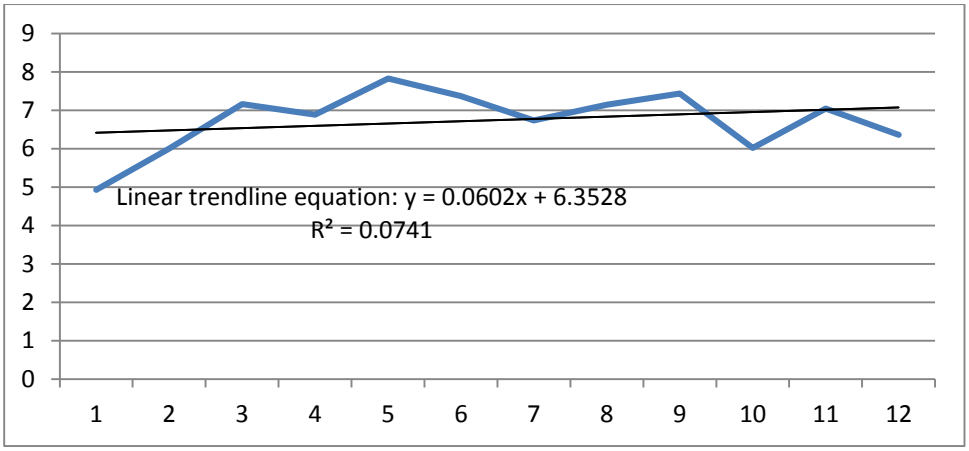

Figure 1.5. Real GDP growth rate, Tanzania, 2000-2011 (2005 constant US Dollars, millions) with linear trend line.

The geometric mean of the real GDP growth rates for the period 1961 to 1999, as shown in Figure 1.4, is 3.9 percent per year. For the period 2000 to 2011, the geometric mean is 6.7 percent, or 1.7 times the value for the earlier period. Geometric means are considered to be more accurate than arithmetic means for compounded growth rates (Spizman & Weinstein, 2008).

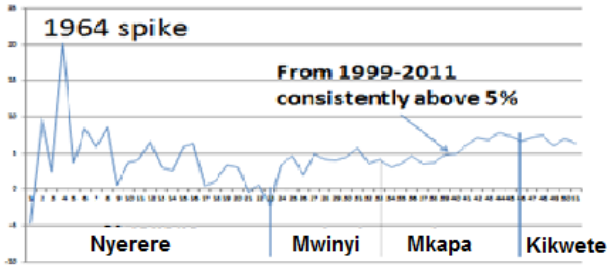

Figure 1.6. Real GDP growth rate, Tanzania, 1961-2011 (percent per year), with presidential tenures.

A detailed examination of the causes of the "inflection" noted above is beyond the scope of this study. It is, however, apparent that the rates of growth vary during the tenures of the four national presidencies, as shown in Figure 1.6.

During the presidency of Julius Nyerere, RGDP spiked in 1964 and thereafter declined steadily. The rate rose during the presidency of Ali Hassan Mwinyi and continued to rise under Benjamin Mkapa. It has held steady under Jakaya Kikwete (JK). It may help in forecasting future rates of growth if we were able to discern reasons for these differences.

Using the 1960-2011 real GDP data (Appendix A, Table A1) as the historical base, Forecast Pro generates a 10-year forecast, as shown in Figure 2. The line in the center is the forecast; the lines above and below the forecast are the 95 percent confidence limits. From a base in 2011 of about $54.7 billion, the forecast for 2021 is $87 billion, about 60 percent higher, or about 6 percent per year on average. Statistical results of the forecast are at Table A2 in Appendix A. There is reason to be cautious regarding such a continued robust growth rate. Nevertheless, the signs are positive.

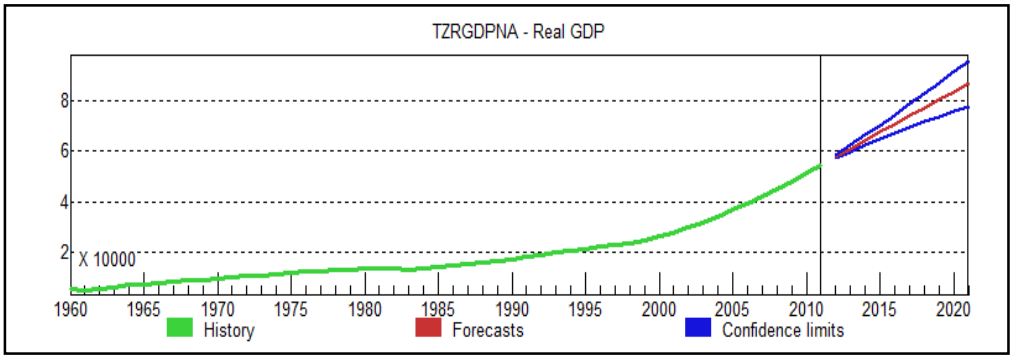

Figure 2. Historical real GDP 1960-2011 and Forecast Pro 10-year forecast with 95 percent confidence intervals.

Population Level and Growth Rate

The population of Tanzania in 1960 was just over 10 million. By 2011, population had reached nearly 45 million. Unlike the growth rate of GDP, which saw a marked increase in the rate of growth at the end of the last century, the population growth rate has been fairly stable, even declining

slightly. The arithmetic mean from 1960 to 1999 was 2.97 (geometric mean 2.93). From 2000 to 2011, the arithmetic mean was 2.79 (geometric mean 2.91). Of course, a zero population growth rate might be desirable, but the decline is encouraging – that is, it is not rising. The data are reflected in Figure 3. A quadratic (2nd-order) polynomial trend line fits the data well, with an R^2 of 0.9996.

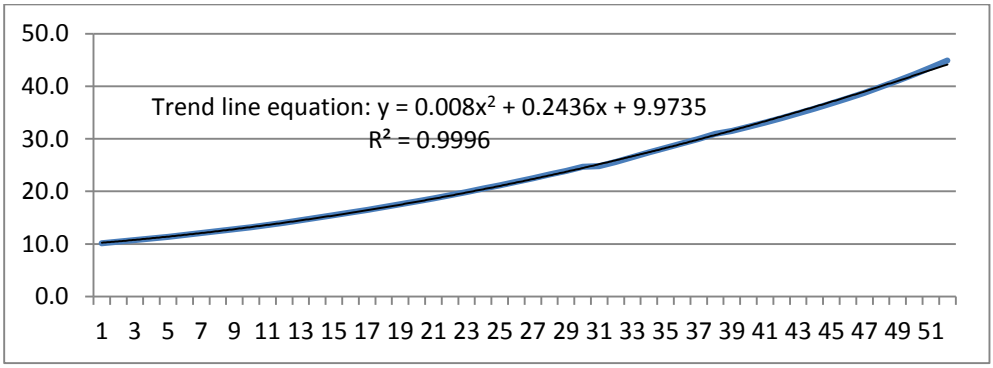

Figure 3. Population, Tanzania, 1960-2011 (Millions). Source: PWT 8.0. Horizontal axis shows years, with 1960=1. There is a well fitted 2nd-order polynomial trend line.

Using 1960-2011 population data as a base (see Appendix A, Table A1), Forecast Pro generates a 10-year forecast (Figure 4). Statistical results of the forecast are at Table A3 in Appendix A. (Technical notes on the forecast results are at Appendix B.) As with Figure 2, the line in the center is the forecast; the lines above and below the forecast are the 95 percent confidence limits. From a base in 2011 of about 44.9 million, the forecast for 2021 is 60 million, an increase of about 15 million, or 33 percent higher, or about 3.3 percent per year on average, slightly higher than the 2.8-2.9 rate of the most recent 12-year period. Studies have shown that, as women reach higher education levels, they tend to have fewer children, with the result that the community becomes more prosperous (Martin, 1995; Reading, 2011).

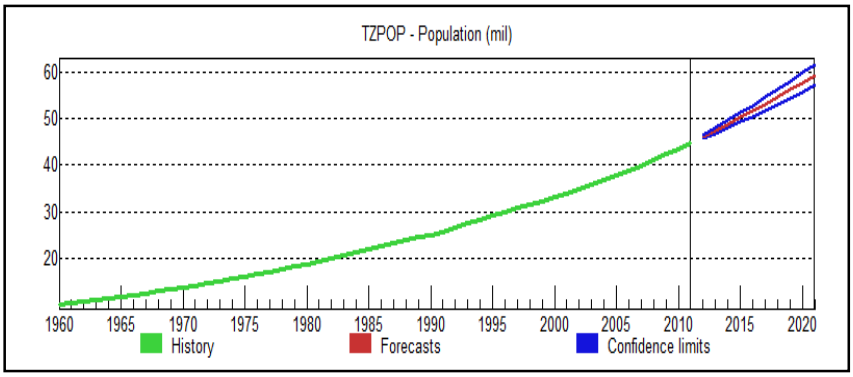

Figure 4. Historical population 1960-2011 and Forecast Pro 10-year forecast with 95 percent confidence intervals.

GDP per Capita Level and Growth Rate

As noted, standard of living is measured more effectively by GDP per capita than by GDP alone. Moreover, it is not so much the *level* of GDP per capita that is of most interest to scholars and practitioners alike, including government and non-government policy makers, as is the *rate of growth* of that measure. In short, one would like to know the answer to the question, "Are we getting any better? And if so, by how much?" People in all countries want to know if their children will have a better standard of living than their parents and grandparents.

Consistent with the calculation that the rate of GDP growth has, for most years, exceeded the rate of population growth, it is logical to expect that the ratio would be increasing, as well. Figure 5 shows the ratio from 1960 to 2011. In 1960, GDP per capita in Tanzania was 547 US dollars. Maintaining constant 2005 dollars as the base for real GDP growth, that figure had risen to $1,217 in 2011, or 122 percent, an average of 2.4 percent per year. Breaking the period into "pre-inflection" and "post-inflection" leads to the following analysis: From 1960 to 1999, GDP per capita rose at a rate of just 1.0 percent per year. From 2000 to 2011, that most important ratio increased at a rate of 3.9 percent per year, four times the rate of the previous period.

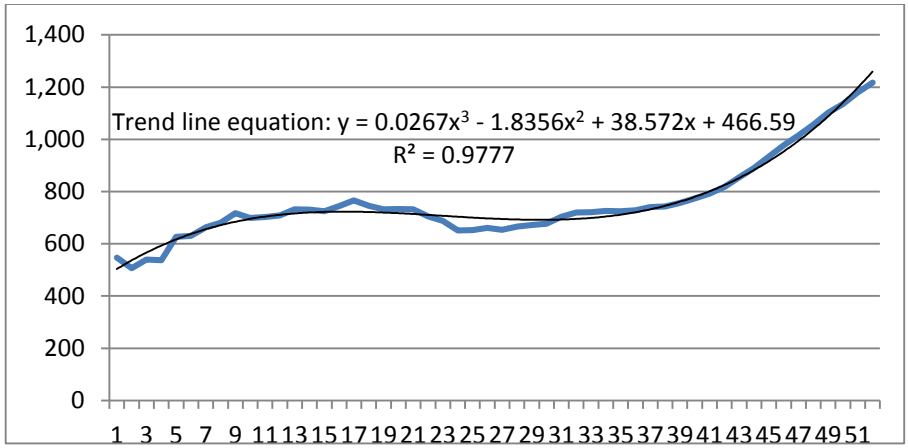

Figure 5. Real GDP per capita, Tanzania, 1960-2011 (2005 US Dollars) with well fitted 3rd-order polynomial trend line. Source: PWT 8.0.

Using the 1960-2011 RGDP and population data as a base, Forecast Pro generates a 10-year forecast for real GDP per capita, as shown in Figure 6. Statistical results of the forecast are at Table A4 in Appendix A. As with Figures 2 and 4, the line in the center is the forecast; the lines above and below the forecast are the 95 percent confidence limits. From a base in 2011 of $1,217, the forecast for 2021 is $1,615, an increase of about 32.7 percent, or about 3.3 percent per year on average, slightly lower than the 3.9 rate of the most recent 12-year period, yet significantly greater than the "pre-inflection" period of 1.0 percent.

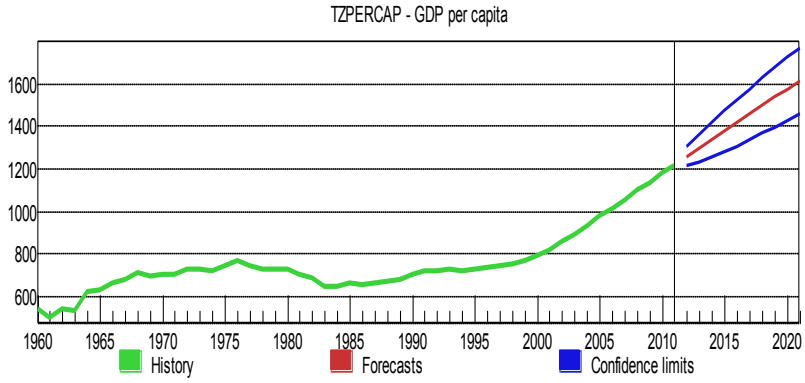

Figure 6. Historical GDP per capita 1960-2011 and Forecast Pro 10-year forecast with 95 percent confidence intervals.

Conclusions and Further Research

The current study concludes that the standard of living in Tanzania, as measured by real gross domestic product per capita, is growing at a robust rate and is likely to continue to rise at a healthy rate. A rising real GDP is the consequence of an increase in aggregate demand, which implies the creation of new jobs. Given that the new jobs are being increased at a higher rate than the rate of population growth, this means a decline in the unemployment rate. In general, then, the conclusion of the current study is, *on average*, Tanzanians are becoming better off year-by-year.

Another conclusion is that the advanced statistical forecasting measures that were used in this study are generally applicable to other situations where decision-makers may gain insights into future scenarios. It does not, however, get into the darker side of the economy, the matter of the equitable distribution of income and wealth and the reduction of the rate of poverty.

Further Research

Forecasts of GDP per capita are a necessary but insufficient condition for informed policy-making decisions. More study, for example, is clearly indicated as to the causes of the "inflection" noted here, and while more research is indicated in this field, there are related areas in which further research can add to the base of evidence to guide decision-makers.

Reasons for changes of economic growth rates

A more detailed examination of the events of the past, events that appear to coincide with economic growth rates, might better inform forecasts under similar or different conditions. This is an area of special interest to historians and political scientists, as well as to development economists.

Distribution of income and wealth.

This study shows a trend of increasing prosperity for Tanzania, but questions remain: "Where is the money going? Who is benefitting from the increased GDP per capita? Why do poverty rates remain high?" To be consistent with the spirit and teachings of the "Father of the Nation," Julius Nyerere, scholars would be well advised to address the issues surrounding disparities of income and wealth, in general, and poverty specifically. Nyerere continues to inform

the nation on this chronic problem. He "had an impeccable desire and commitment to reducing the level of poverty" (Kamuzora, 2010, p. 93). More research is also needed on the sources of slow growth (Sachs & Warner, 1997) in sub-Saharan Africa, as well as the causes of both rural and urban poverty.

Studies of success and best practices.

There are also areas of research potential with a focus on the success stories, such as the 17 countries Radelet (2010) notes in his studies of emerging African economies.

Quality and reliability of data.

The quality of data from countries in sub-Saharan Africa has been questioned (Jerven 2013), with the conclusion that policies and programs based on such data are deeply flawed. However, in his comparison of "GDP from country" and "GDP from WDI" Jerven shows a difference of less than one percent for Tanzania (p. 25). If Jerven's findings are generally applicable across the continent, research might help policy makers to improve the collection, storage, retrieval, and analysis of data related to the economies of the continent.

Studies of individual markets and economic sectors in Tanzania.

There are opportunities at the microeconomic level of research as well as the macroeconomic issues studied in this current work. For example, Carmody (2013) notes, "The value of Tanzania's timber exports increased by 1,400 percent from 1997 to 2005, and sometimes a single tree may be worth tens of thousands of dollars" (p. 12). And "China's consumption of fish may treble by 2025." Carmody details the interest of China in various locations in Africa, forecasting that one of "a series of industrial hubs with tax incentives that will be linked by rail, road and shipping lanes to the rest of the world…will probably be in the Tanzanian capital (sic), Dar es Salaam" (p. 73).

Research on land use policies in Tanzania.

One of Tanzania's most valuable economic resources is land, much of which is unused or underused. Carmody (2013) notes, "In some cases, African governments are actually – somewhat unbelievably – giving land away for free to promote biofuel production" (p. 142). Knaup (2008) reports the

government of Tanzania granted the British firm Sun Biofuels a 99-year lease on an area equivalent to 12,000 soccer pitches to grow jatropha, a biofuel tree, for free. In return, the company will spend US$20 million to build roads and schools. Carmody reports that, "Prokon, a German company, has plans to cultivate with *Jatropha* an area the size of Luxembourg in Tanzania" (p. 143). While biofuels may offer substantial export potential, Habib-Mintz (2010) argues "that without strong regulatory frameworks for land, investment management, and rural development, biofuel industrialization could further exacerbate poverty and food insecurity in Tanzania" (p. 3985).

Research on the impact of globalization on the Tanzanian people.

In the summer of 1995, visitors to the Fishpack facility in Musoma, on the eastern shore of Lake Victoria, learned that the entire output of the plant was exported to places like Japan and Israel, where buyers would pay a higher price than would families in Mara, one of the poorest regions of Tanzania. In 1997, the operation was incorporated as Musoma Fish Processors Ltd (MFPL) still "with the objective of processing and exporting Nile Perch Fillets" (Alpha Group, 2013).

Writing about the paradox of places that have food and famine at the same time, Sen (1981) notes when a nation produces food that can be exported at a higher price than local people can afford, the food is sent away to the markets that offer the higher price. Producers earn a higher income, but people are denied the food that is produced in their region. As Sen puts it, "Starvation is the characteristic of some people not having enough food to eat. It is not the characteristic of there being not enough food to eat" (p. 1). Steele (2001) writes about Sen, "His work on the causes of famine changed public perceptions by showing why thousands might starve even when a country's food production has not diminished."

Standing (2009) reports, "The EU pays annual lump sums to African countries for fishing agreements, so that its boats can fish in their waters. For example, in the Tanzania case the EU pays around €600,000 a year for seventy-nine fishing boats to be able to catch 8,000 tonnes of tuna (p. 349)." Fish taken from Tanzanian waters do not nourish the people of Tanzania but the people of nations who can afford the higher international market price.

Research on business and economic forecasting in Tanzania.

Finally, the people of Tanzania would benefit from research on the policy of economic forecasting. Such research might result in more accurate forecasts and, consequently, better policies regarding the allocation of resources to achieve key national objectives. As Morlidge (2013) concludes, "While it may never be possible to determine the best accuracy one can hope to achieve in forecasting any particular item, we can demonstrate what level of forecast error is *unavoidable* – a significant step toward being able to make objective statements about forecast quality" (p. 6).

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Appendix A

Data for Forecasts

Table A1. Data for Tanzania Gross Domestic Product (GDP), Population, and GDP per Capita

Year	RGDP ($US Mil)	POP (Mil)	GDP per Cap ($US)	Year	RGDP ($US Mil)	POP (Mil)	GDP per Cap ($US)
1960	5531	10.1	547	1986	14721	22.5	654
1961	5269	10.4	507	1987	15447	23.2	665
1962	5783	10.7	540	1988	16074	23.9	672
1963	5925	11.0	538	1989	16716	24.7	677
1964	7117	11.4	627	1990	17462	24.8	704
1965	7377	11.7	631	1991	18458	25.6	720
1966	7995	12.1	663	1992	19109	26.5	721
1967	8449	12.4	680	1993	19905	27.4	726
1968	9176	12.8	717	1994	20509	28.3	725
1969	9222	13.2	699	1995	21241	29.2	729
1970	9554	13.6	702	1996	22207	30.0	741
1971	9954	14.0	709	1997	22989	31.0	743
1972	10623	14.5	732	1998	23844	31.5	756
1973	10948	15.0	731	1999	24998	32.3	774
1974	11221	15.5	725	2000	26231	33.1	792
1975	11885	16.0	744	2001	27805	34.0	818
1976	12643	16.5	767	2002	29796	34.9	855
1977	12694	17.0	746	2003	31848	35.8	890
1978	12848	17.6	732	2004	34342	36.7	935
1979	13278	18.1	733	2005	36872	37.8	977
1980	13675	18.7	732	2006	39357	38.8	1,015
1981	13606	19.3	706	2007	42170	39.9	1,056
1982	13687	19.9	688	2008	45306	41.1	1,103
1983	13362	20.5	651	2009	48034	42.3	1,135
1984	13814	21.2	652	2010	51417	43.6	1,180
1985	14448	21.8	661	2011	54689	44.9	1,217

Note. GDP and population from PWT 8.0. GDP per capita calculated by author.

Table A2. Forecast Pro Expert Analysis and Statistics for Forecast of Tanzania GDP, 2012-2021

Very low irregularity suggests Box-Jenkins.

Expert selection				
Box-Jenkins ARIMA(0, 2, 1)				
Term	**Coefficient**	**Std. Error**	**t-Statistic**	**Significance**
b[1]	0.3843	0.1287	2.986	0.9957

Sample size	52	No. parameters	1
Mean	19454.48	Std. deviation	12569.04
Adj. R-square	1	Durbin-Watson	2.14
Ljung-Box(18)	22.8 P=0.80	Forecast error	348.34
BIC	358.33	MAPE	2.01
RMSE	344.98	MAD	270.45

Date	**2.5 Lower**	**Forecast**	**Annual**	**97.5 Upper**
2012	57231	57920	57920	58610
2013	59841	61151	61151	62462
2014	62362	64383	64383	66403
2015	64796	67614	67614	70431
2016	67152	70845	70845	74538
2017	69434	74076	74076	78718
2018	71648	77307	77307	82966
2019	73798	80538	80538	87278
2020	75887	83769	83769	91651
2021	77919	87000	87000	96082
Total		724603		
Average		72460		
Minimum		57920		
Maximum		87000		

Table A3. Forecast Pro Expert Analysis and Statistics for Forecast of Tanzania Population, 2012-2021

Expert Analysis

Very low irregularity suggests Box-Jenkins.

Model Details

Expert selection	**Box-Jenkins with log transform ARIMA(0, 2, 1)**			
Term	**Coefficient**	**Std. Error**	**t-Statistic**	**Significance**
b[1]	0.9161	0.05981	15.32	1

Within-Sample Statistics

Sample size	52	No. parameters	1
Mean	3.08	Std. deviation	0.45
Adj. R-square	1	Durbin-Watson	1.96
Ljung-Box(18)	6.9 P=0.01	Forecast error	0
BIC	0.1	MAPE	0.2
RMSE	0.12	MAD	0.05

Forecast Data

Date	**2.5 Lower**	**Forecast**	**Annual**	**97.5 Upper**
2012	46	46	46	47
2013	47	48	48	48
2014	48	49	49	50
2015	49	50	50	51
2016	51	52	52	53
2017	52	53	53	55
2018	53	55	55	56
2019	55	56	56	58
2020	56	58	58	60
2021	57	60	60	62

Total	526
Average	53
Minimum	46
Maximum	60

Table A4. Forecast Pro Expert Analysis and Statistics for Forecast of Tanzania GDP per Capita, 2012-2021

Expert Analysis

Using rule-based logic I have narrowed down the choice to exponential smoothing or Box-Jenkins.
I will perform an out-of-sample test to select between these two approaches.

The cumulative MAD for Exponential smoothing was 83.45 and for Box-Jenkins was 136.06.
The rolling out-of-sample test used a maximum horizon of 8 and generated 36 forecasts for each method.

Based on the lower MAD, I will use Exponential Smoothing.

Model Details

Expert selection

Holt exponential smoothing: Linear trend, No seasonality

LN(0.758, 0.530)

Component	Smoothing Wgt	Final Value
Level	0.7583	1218
Trend	0.5302	39.69

Within-Sample Statistics

Sample size	52	No. parameters	2
Mean	760.34	Std. deviation	157.52
Adj. R-square	0.98	Durbin-Watson	2.04
Ljung-Box(18)	23.5 P=0.83	Forecast error	20.69
BIC	21.89	MAPE	2.1
RMSE	20.29	MAD	14.37

Forecast Data

Date	2.5 Lower	Forecast	Annual	97.5 Upper
2012	1215	1258	1258	1300
2013	1232	1297	1297	1363
2014	1255	1337	1337	1419

2015	1280	1377	1377	1473
2016	1308	1416	1416	1525
2017	1337	1456	1456	1575
2018	1366	1496	1496	1625
2019	1397	1535	1535	1674
2020	1428	1575	1575	1722
2021	1459	1615	1615	1770

Total	14362
Average	1436
Minimum	1258
Maximum	1615

Appendix B

Notes on Forecast Statistics

Durbin-Watson Test

Analyzing the three time series in this study (GDP, population, and GDP per capita) Forecast Pro uses the Durbin-Watson test for the presence of autocorrelation (Stellwagen & Goodrich, 2010a, p. 37). The Durbin-Watson statistic tests the null hypothesis that the residuals from an ordinary least-squares regression are not autocorrelated against the alternative that the residuals follow an AR1 process. The Durbin-Watson statistic ranges in value from 0 to 4. A value near 2 indicates non-autocorrelation; a value toward 0 indicates positive autocorrelation; a value toward 4 indicates negative autocorrelation. The Durbin-Watson tests for the historical data for 1960 to 2011 for Tanzania GDP, population, and GDP per capita are 2.14, 1.96, and 2.04, respectively, providing strong evidence of non-autocorrelation of the data.

Ljung-Box Test

The Ljung-Box Q-statistic "is a weighted sum of squared autocorrelations, so it is zero only when every autocorrelation is zero" (Stellwagen & Goodrich, 2010a, p. 37). Forecast Pro calculates low values for the Ljung-Box Q-statistic for the three time series in this study: 0.80, 0.01, and 0.83, respectively, showing low over-all autocorrelation.

Mean Absolute Percentage Error (MAPE)

The forecasts noted in the results above show quite small values of the Mean Absolute Percentage Error (MAPE): 2.01, 0.20, and 2.10, respectively. This may be interpreted as strong evidence of a robust forecast model for each of the forecasted variables, with only about a two percent error between the forecast and the actual value. The calculation is:

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}\frac{|Y_t - F_t|}{|Y_t|}$$

Appendix C

Abbreviations and Acronyms
ARIMA – Autoregressive Integrated Moving Average
BIC – Bayesian Information Criterion
CIA – Central Intelligence Agency of the United States Government
GDP – Gross Domestic Product
IMF – International Monetary Fund
MAD – Mean Absolute Deviation
MAPE – Mean Absolute Percentage Error
PWT – Penn World Table, produced by the University of Pennsylvania
R^2 – Proportion of variation in *Y* explained by its linear relationship with *X*
RGDP – Real Gross Domestic Product (adjusted for inflation)
RMSE – Root Mean Square Error
TZPERCAP – Data set for Tanzania GDP per capita
TZPOP – Data set for Tanzania population
TZRGDPNA – Data set for Tanzania real GDP using national accounts in USD
USD – United States dollars
WB – World Bank
WDI – World Development Indicators of the World Bank Group

Appendix D

Mathematical Notation

(Adapted from Yevdokimov, 2013, pp. 193-194)
Economic growth rate: The rate of change of real GDP (RGDP) expressed as a percentage per period (usually a year or quarter).

$$g_Y = \frac{(Y_t - Y_{t-1})}{Y_{t-1}} x100\%$$

where g_Y is the growth rate of real GDP, Y_t is real GDP in the current period, and Y_{t-1} is the real GDP in the prior period.
Real GDP per person: Real GDP (RGDP) divided by the population.

$$y_t = \frac{Y_t}{N_t}$$

where N_t is the population in period *t.*
Growth rate of real GDP per person: The rate of change in RGDP.

$$g_P = g_Y - g_N$$

where g_P is growth rate of RGDP per person, g_Y is growth rate of RGDP, and g_N is the population growth rate.