# An Examination of Subnational Growth in Nigeria: 1999 – 2012

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**ERSA working paper 438**

**June 2014**

Economic Research Southern Africa (ERSA) is a research programme funded by the National Treasury of South Africa.

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June 24, 2014

**Abstract**

I use satellite imagery on night time lights to measure growth across states and local government areas in Nigeria since the return of democracy in 1999. I show that states in Southern Nigeria have grown faster on average than states in the North. I also evaluate the effects of violence on growth in Plateau, Yobe and Borno states. I find that the crisis in Plateau state has resulted in slower growth compared to other states in the region. I also show that Yobe and Borno states had performed worse than other states in the North even before the outbreak of violence related to the Boko Haram sect. Finally using OLS I estimate a relationship between change in night lights and real GDP growth in Africa. I then use the coefficients to estimate GDP growth for states and local government areas in Nigeria over the period.

Keywords: Measurement of Economic Growth, Africa

JEL Classification Numbers: O47, O55

## 1 Introduction

Africa in general, and Nigeria in particular, suffer from a lack of quality data on national and subnational economic activities (Jerven, 2013). Estimates of gross domestic product and other officially published data on national accounts are often characterized as not very accurate. The situation is even worse when considering subnational economic activity with data virtually non-existent for states and local governments in Nigeria and across Africa. The unavailability of data and poor quality where it exists poses a challenge in properly measuring economic activity and understanding the factors that drive its growth. Examining economic activity at a sub-national level is also important in understanding the factors that drive economic growth in that country.

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In this paper I propose an alternative way to measure economic activity. I use a technique proposed by Henderson, Storeygard, and Weil (2012) to measure the change in economic activity across states and local government areas (here on referred to as LGAs) in Nigeria since the return of democracy in 1999. They argue that the amount of light observed from outer space at night serves as good proxy for economic activity. I use changes in these "night lights" as measured from outer space as a proxy for the growth of economic activity across states and local government areas in Nigeria. The night lights allow me to estimate data for economic growth between 1999 and 2012.

Using this data I show that there is indeed variation in growth across states and LGAs in Nigeria. I also show that the night lights data captures some of the expected trends in economic growth within Nigeria. Firstly I show the effect of the Jos crisis, which started in 2001, on economic growth in Plateau state relative to other similar states. I find that since 2001 growth in Plateau state has been slower than other states in the Middle Belt region. Secondly I examine the effect of the Boko Haram crisis on economic activity in Borno and Yobe states. The data suggests that growth in Yobe and Borno states had already been much slower than other states in Northern Nigeria before the onset of the Boko Haram crisis. Thirdly I compare growth in the largest states in Northern Nigeria to counterparts in the south to explore the argument that growth in the north has lagged behind the south. Finally I use the data to estimate a more conventional measure of growth of GDP for states and LGA's in Nigeria.

This paper builds on the work of Henderson, Storeygard and Weil (2012) in using night lights to measure economic activity of national and subnational administrative units. The rest of the paper is organized as follows. Section 2 provides a brief discussion on the importance of measuring subnational economic activity and understanding the drivers of economic activity below the level of the nation state. Section 3 discusses the sources and construction of the proxy measure of economic activity. Section 4 discusses trends in the data as well as the effects of the Jos and Boko Haram crises on economic activity in the affected areas. In section 5 I estimate GDP growth rates for states and LGAs in Nigeria. Section V concludes.

## 2 Background – Variation in growth across Africa

Economic growth and development in sub-Saharan Africa has lagged behind much of the rest of the world, at least since the $19^{th}$ century. According to data from the World Bank, 19 of the 20 poorest countries in the world in 2012 as measured by GDP per capita are in Africa[1]. Africa also seems to lag behind the rest of the world in many other measures of development. Comparing GDP per capita across continents, as shown in Figure 1, shows a divergence in economic

[1] GDP per Capita data accessed from World Bank data archive at http://data.worldbank.org/

growth between sub-Saharan Africa and much of the rest of the world. Whereas other parts of the world have shown increasing economic growth and an increase in incomes, Africa appears stuck in a relatively low growth equilibrium.

However there are dangers with proposing such a blanket view of growth in Africa. Such a view masks the fact that even within Africa there is a lot of variation in growth. Some countries have shown periods of strong economic growth, some countries have fit the no-growth scenario while some have shown a collapse in growth. For example GDP per capita in constant 2005 dollars in Botswana has risen from a low of $334 in 1960, below the African average, to almost $7000 in 2012. On the other hand GDP per capita in Liberia shrunk from about $552 to about $278 over the same period, way below the African average as shown in Figure 2. These two examples are not just outliers as there is a lot of variation in growth across African counties. Looking at economic performance for Africa as a whole therefore masks the fact that different countries have reacted in different ways to the challenges of sustained economic growth.

The same scenario can also be used to describe within country growth in Africa. Nigeria, for example, appears to have grown much slower than expected since independence in 1960. Compared to countries of a similar size at the time, Nigeria has exhibited the same low growth patterns that fit much of sub-Saharan Africa grouped as a whole. Comparing growth in Nigeria since 1960, when Nigeria gained independence, to Tunisia, Malaysia and Indonesia shows a similar pattern. As seen in Figure 3, Tunisia and Malaysia although already with a higher GDP per capita than Nigeria have shown much higher growth compared to Nigeria. Even Indonesia which had almost half the GDP per capita of Nigeria in 1960 has grown to almost double that of Nigeria as at 2012. The major point is that the Nigerian economy when viewed as whole has underperformed since the 1960's compared to some of its peers.

However, as is the case with Africa, looking at growth in the Nigerian economy as a whole might obscure some of the within-country variation of growth in Nigeria. Is it possible that there are areas within Nigeria which have performed much better than the average? Nigeria is a country made up of a multitude of ethnic groups with different customary practices and traditions on everything from rural land tenure systems to inheritance practices. Nigeria also has a lot of variation in geographical factors which have been thought of as important for growth, such as agricultural suitability, the incidence of malaria and so on. All these suggest that even within Nigeria there may be a decent amount of variation in economic activity across the different regions. It is possible that some areas have performed relatively well and above average while other areas might have performed poorly.

In this paper I use a new way of measuring economic activity to uncover the variation in economic growth across states and LGAs in Nigeria since the return of democracy in 1999. I use satellite data on night lights as proxy for economic activity as used by Henderson, Storeygard and Weil (2012) and Michalopoulos and Papaioannou (2013). The use of satellite data on night lights allows me to construct and measure changes in economic activity for both states and LGAs between 1999 and 2012. I use this data to show that there has been variation in

economic growth across different states and local government areas in Nigeria.

# 3 Data

## 3.1 Night time lights

Satellites from the United States Air Force Defense Meteorological Satellite Program (DMSP) have been circling the earth 14 times per day recording the intensity of Earth-based lights with their Operational Linescan System (OLS) sensors since the 1970's, with a digital archive beginning in 1992. Although the program was originally intended to collect low-light imaging data for the purpose of detecting moonlit clouds, it also captures lights produced by human settlements. The satellites capture these lights all over the globe sometime between 8:30pm and 10:00pm local time, i.e. the time at the location being captured. This information is then processed by scientists at the National Oceanic and Atmospheric Administration's (NOAA) National geophysical Data Center (NGDC). The processing of these images involve removing some natural anomalies such as the effect of the lunar cycle and auroral activity, and as a result removes sources of natural light, leaving mostly man-made light. Observations where cloud cover obscures the earth's surface are also removed. Finally, data from all orbits of a given satellite in a given year are averaged over all valid nights to produce a satellite-year dataset.

The satellite-year dataset reports the intensity of lights as a six-bit digital number, for every 30 arc-second output pixel (approximately 0.86 square kilometres at the equator) between 65 degrees south and 75 degree north latitude. The digital number is an integer between 0 (no light) and 63. The high resolution of this data makes it extremely useful for spatial analysis of economic activity across small geographical areas. This use of night lights as a proxy for economic activity has been used by Henderson, Storeygard and Weil (2012), Elvidge, Baugh, Kihn, Kroehl and Davis (1997), Doll, Muller, and Morley (2006), Sutton, Elvidge, and Ghosh (2007), and Michalopoulos and Papaioannou (2013). Although Chen and Nordhaus (2010) argue that there are problems with the satellite image data, they concede that night lights can be useful for analysis of economic activity in areas where good quality data does not exist.

The Intensity of night light reflects outdoor and some indoor use of lights. In general, nearly every economic activity at night requires lights. It is likely that an increase in economic activity, which should correspond to an increase in both consumption and investment goods at night, should be correlated with lights usage per person. Although the use of night lights does not capture any daytime economic activity, examining the change in night lights should provide guidance on the relative size of economic activity and its change over time. Provided there is no bias towards night time economic activity in some particular areas, use of only night time lights should be adequate.

The night lights allow for measures of economic activity to be calculated across any geographical area. For this paper it allows me to measure economic

activity for states and LGAs. Nigeria is divided into thirty six sub-national units called states excluding the Federal Capital Territory (FCT) which is under the direct control of the federal government. Each state has its own state government and house of assembly. States are free to pass specific laws as long as they do not contravene national laws. States are further subdivided into LGAs. Each LGA has its own elected official as well. I calculate the average night lights for all thirty six states and the Federal Capital Territory each year from 1999, following the return of democratic rule, and 2012, the latest year for which the night lights image is available. This results in a panel data of economic activity for 36 states plus the FCT over 14 years. I start from 1999 because the democratic nature of administration implies that economic growth for states and LGAs is more likely to be as a result of policies implemented by state governors and local government chairmen. Growth before 1999, when the country was under military rule, may be attributed to the decisions by the federal government and not necessarily because of anything attributable to the states or local governments themselves. I also calculate the average night lights for all 774 LGAs over the same period, 1999 to 2012. This results in a panel data of economic activity in local government areas for 14 years. Maps for states and local government areas were downloaded from DIVA-GIS[2].

Other papers have established a correlation between night lights and various measures of economic activity and development across countries (e.g., Doll et al. 2006, Sutton et al. 2007, Ghosh et al. 2010, and Henderson et al. 2012). However it is useful to perform a cross validation exercise to further investigate the relationship between night lights and development. Since the focus of this paper is not only to analyse growth across Nigeria as a whole, but to examine growth across states and local government areas within Nigeria, it is useful to compare the night lights data to other data on measures of economic development which are available for these states and local government areas.

I start by examining the correlation between log of average night lights and GDP per capita across African countries in 1999 and in 2012. Data on GDP per capita for both years is taken from the World Bank data archive. As figures 4 and 5 show, there is a clear positive correlation between the two with a correlation coefficient of 0.63 and 0.52 respectively. One potential problem with using night lights is the probable correlation with population density. Areas with a high population density will probably emit more light at night than areas with low population density, not because there is more economic activity per person but because there are more people. Urban areas, for example, may emit more light than rural areas not because of income differences but because of the dense population. To deal with this problem I use the log of night lights partialling out the effects of log population density. Data on population is also taken from the World Bank data archive. As shown in figures 6 and 7 the correlation between night lights and GDP per capita remains and is even stronger with a correlation coefficient of 0.89 and 0.87 which is relatively high.

Since this paper is focused on growth it is useful to compare the change in

[2] Downloaded at http://www.diva-gis.org/

night lights across countries to the change in GDP per capita over the same period. Examining correlation between growth of GDP between 1999 and 2012 and the change in night lights also shows that night lights can serve as a good proxy for growth of economic activity as shown in figure 8. The relationship between growth in GDP and growth in night lights in 1999 and 2012 is clearly present.

Of course GDP per capita is only one measure of economic activity and doesn't entirely capture the level of economic development in different countries. The case of Equatorial Guinea which has a GDP per capita in 2012 as high as $20,000 but perhaps due to extreme income inequality has very poor development statistics serves as a good example. To get around the idea that GDP per capita may not completely measure relative development I use infant mortality as an alternative. Infant mortality is often used a proxy for the quality of life across countries (e.g. Michalopoulos & Papaioannou, 2013). As shown in figures 9 and 10 the correlation between the log of night lights and infant mortality in 1999 and 2012 is clear with a correlation coefficient of -0.65 and -0.49 respectively. This implies that night light serves as a good measure not only for economic activity, but for relative development as well.

The point of using night lights as a measure of economic activity and relative development is partially due to the unavailability of quality data at the subnational level. There are no officially reported GDP number for state and LGAs in Nigeria. However since night lights can also be used as a proxy for other measures of relative development it is useful to compare with other data which measure relative development and which are available for states and LGAs. Literacy, for example is used as an alternative measure of relative development. The assumption is that areas with a higher literacy rate are presumed to be better off than areas with lower literacy (Lucas, 1988; Mankiw, Romer and Weil, 1992; Hall and Jones, 1999). In fact the United Nations uses the adult literacy rate as one of the components in the calculation of the Human Development Index. Adult literacy rates are reported for states and local government areas in Nigeria. It is therefore possible to compare night lights to literacy rates to see how well it performs at a subnational level. Figure 11 plots the log of night lights for each state in 2010 against the adult literacy rate in any language for the same year as reported by the Nigerian Bureau of Statistics[3]. A positive correlation is clear with a correlation coefficient of 0.69. Again this suggests that just as was the case across countries, night lights do measure relative development, as proxied by literacy rates, across states in Nigeria. The Nigerian Bureau of Statistics also reports numbers on absolute poverty across states in Nigeria. Areas with a higher incidence of poverty are thought of as less developed than areas with a lower incidence of poverty. Comparing the log of night lights in 2004 and 2010 to absolute poverty rates in both years again shows the correlation between night lights and poverty rates for both years as shown in figures 12 and 13.

One advantage of using night lights as a measure of economic activity is that

[3] Accessed from http://www.nigerianstat.gov.ng/

it includes the informal sector. One criticism of official national accounts is that it does not take into account activities in the informal sector, the part of the economy that is not taxed or monitored by the government in any way. The informal sector is relatively large across most African countries and failure to include these informal activities in national accounts is often cited as a problem preventing proper measurement of economic activities (Schneider and Enste, 2000). The night light data however captures all economic activity across the geographical space being measured and therefore includes the informal sector as well.

The apparent robust association between night lights and the various measures of economic activity and relative development across countries, states and LGAs in Nigeria show that night lights are a good proxy for measuring economic activity in the absence of alternatives.

## 3.2 Evaluating relative growth

As discussed in the previous section, night lights allow me to construct estimates of growth in economic activity each year. In this paper I focus on growth after the return of democracy in 1999. As stated earlier this allows me to capture growth that is supposedly driven by local actions as opposed to growth driven by federal government policies. The assumption is that controlling for allocations disbursed by the federal government, policy both at the state and local government level is driven by state and local administration.

There are two ways to measure growth using night lights. The first is to measure the absolute increase in the brightness of each pixels. In this case I subtract the sum of pixels in each state and local government in 1999 from the sum of pixels in each state and local government in 2012. This method captures growth regardless of the size of the state or local government being measured. Unfortunately because of the two dimensional nature of the night lights maps, this method may be biased against states and local governments with smaller land sizes. States with a large expanse of land, Sokoto state for example, might grow horizontally simple because there is enough space to grow. States like Lagos state for instance, with its relatively small land size, might be forced to grow vertically. Although vertical growth should in theory result brighter lights per square kilometre, it might be useful to measure average night lights for each state and LGA, i.e. the sum of lights divided by the land size of the state or local government area. This is the same technique used in Henderson et al, 2012.

Table 1 reports the statistics for all thirty six states and the FCT using the average sum of lights. The data shows that there is a lot of variation in growth across states between 1999 and 2012. Some states such as Taraba and Lagos have grown much faster than others. However it is important to note that the data for some states are influenced by the presence of gas flaring. As discussed in Henderson et al, gas flaring emits bright lights that might obscure lights from other economic activities. The presence of gas flaring and changes in gas flaring imply that the data captured in the states influenced may not

be due to changes in economic activity but due to changes in gas flaring. The bright lights from gas flaring may also obscure any changes in economic activity since it would not show up as night light. Delta and Edo states, in the top five, and Rivers and Bayelsa, in the bottom five are affected by gas flaring. It is also unlikely that a change in night lights are simply representing change in electricity production and distribution as suggested by Elvidge et al (2001). Nigeria's poor formal electricity generating capacity has been well documented. Data from the International Energy Agency[4] shows that Nigeria's formal electricity generated per capita grew from 141 KWh in 1999 to 149 Kwh in 2011. To put that in context South Africa generated 4,604 KWh per person in 2011. It is therefore unlikely that a change in night lights is simply capturing a change in electricity production.

For states not affected by gas flaring the data confirms what is expected; fast growth in the urban centres of Lagos, Ogun and the FCT and slower growth in the northern states of Yobe and Borno. A benefit of the night lights data is that it allows for comparison of economic activity across small geographical units such as local government areas. An abridged version of data from LGAs is reported in Table 4. Growth in non-oil producing states is led by Isa in Sokoto state followed by Ibeju/Lekki in Lagos State and Nkanu East in Enugu state. At the other end Roni and Garki LGA in Jigawa state recorded the slowest growth over the period, followed by Maiyama LGA in Kebbi state and Miga LGA in Jigawa state. The patterns are as expected with relatively higher growth centred around the South West and relatively slower growth in the North.

It is important to note that the statistics do not necessarily imply that the slower growing states of Borno and Yobe are not growing. It simply shows that they are the slowest growing compared to the rest of the country. However it is also possible that economic activity in these states are shrinking although that may also be true for the relatively faster growing states of Lagos, Ogun and the FCT.

# 4 The impact of the Jos and Boko Haram crisis on economic activity in affected local government areas

The night lights data provides alternative estimates to growth in economic activity for areas that typically have no official data available, such as states and LGAs. One benefit is that the data allows researchers to examine the effects of events across these smaller areas without being limited to national-level data. In this section I examine the effects of various incidents in Nigeria since the return of democracy on economic growth. Specifically I focus on three events, the effect of the Jos crisis on economic activity in Plateau state, the effect of the Boko Haram insurgency on growth in Borno and Yobe states and the relatively poor economic performance of many Northern states.

[4]Data accessed from the International Energy Agencyhttp://www.iea.org/statistics/

## 4.1 Conflict in Plateau State

Although there had been occasional outbreaks of violence in Plateau state, things to a turn for the worse in 2001. From September $7^{th}$ to $17^{th}$, Jos became the scene of mass killing and destruction. The 10 day riots resulted in many casualties and over 3000 dead (Danfulani and Fwatshak, 2002). Initially starting in Jos North Local Government Area, the crisis spread to other parts of the state. Similar riots erupted in November 2008 and January 2010 resulting in an estimated 381 and 200 dead respectively. The recurrent crisis has resulted in an atmosphere of instability in Jos and the surrounding areas. Some studies have argued for the impact of political instability and violence on economic growth across countries (e.g Gupta and Gupta, 1990, Alesina et al, 1996, Bodea and Elbadawi, 2008). The night lights data allows for a more detailed examination of the direct impact on the areas involved compared to other areas that did not experience such outbreaks of violence.

In Figure 14 I compare average night lights in Plateau state, where the crisis took place to the average night lights in Kogi state where the same kind of violence did not take place at scale. The graph shows a reversal of fortunes at least as far as both states are concerned. Although Plateau state initially had higher average night lights, the distance between the two states starts to shrink from around 2001. Kogi state overtakes Plateau by 2005 and remains permanently better off until the end of the series in 2012. The same pattern can be observed in figures 15 and 16 where I compare average night lights in Plateau to Benue and Kwara states. In all cases Plateau state appears to lose momentum from around 2001 with Kwara and Benue states closing the gap. Although this does not technically imply that the crises caused the relative slowdown in Plateau state it does provide evidence of such a slowdown. Given that one of the major events occurring in Plateau and not in other states compared is the crisis, it does suggest that the crisis might be responsible for the poor performance.

## 4.2 Boko Haram Crisis

The Boko Haram uprising also provides another opportunity to examine the relationship between violence, instability and economic activities in the areas directly affected compared to other areas not directly affected. The Jamâ?at Ahl as-Sunnah lid-da?wa wal-Jihâd, popularly known as Boko Haram, is an Islamic sect based in North Eastern Nigeria. Although the sect has been in existence since 2001 it started its campaign against the Nigerian state sometime in 2009 with a prison break in Bauchi state. Since then the sect has launched a campaign against the government. The bulk of its attacks occur in the north eastern states of Borno and Yobe although attacks have occurred across a large part of Northern Nigeria including a few attacks in Abuja (Adesoji, 2010 and Onuoha, 2010).

The night lights data once again allows us to explore on a basic level the relationship between the uprising and economic activity in areas where the sect is most active, specifically Borno and Yobe states. Figures 17 and 18 plot the

average night lights for both Borno and Yobe states compared with Sokoto and Kebbi states respectively, two similar states in the North West not directly affected by the Boko Haram crisis. This time around the effect of the Boko Haram crisis is not very obvious. There already seems to be a divergence in economic activity between the North East states of Borno and Yobe compared to the North West states of Sokoto and Kebbi. Sokoto and Kebbi start growing faster than Yobe and Borno states from as far back as 1999. One possible implication of this is that the poor performance may be in some way responsible for the uprising in the North East. Many commentators, most notably former US President Bill Clinton, have argued for a link between poor economic performance and the rise of Boko Haram[5]. The data provides some evidence that this idea may not be too farfetched. The effect of the crisis on growth itself however is not clearly visible. This may be because according to Onuoha (2010), the crisis only really started in 2009 and therefore the effects might not yet show up clearly in the data.

## 4.3 Economic performance of the north

As a final example, I examine the idea that states in Northern Nigeria have grown slower that states in the south since the return of democracy in 1999. Most parts of northern Nigeria have been relatively poorer than the south but the situation seems to be getting worse. A couple of authors (e.g. Garbe, 2006, Watts, 2013, and Ngbea, 2014) have argued that economic activity in the north continues to lag behind the rest of the country with the governor of the Central Bank of Nigeria once stating that "some states in the North are poorer than Niger, Cameroon and Chad"[6]. Niger republic and Chad rank as two of the poorest countries in the world. This idea is partly backed by numbers released by the National Bureau of Statistics which show poverty rates at almost 90% in some states in the North.

The night lights data once again allows me to compare the growth in economic activity between states in the North compared to other southern states. We already know that Borno, Yobe, and Plateau states have performed relatively badly but what about the other states? I start by examining growth in two of the most populated states in the country, Lagos and Kano states. Both states were reported in the Nigeria census of 2008 as having populations above 9 million. Figure 19 compares the growth in average night lights for both states. Although Lagos starts off at a much higher level than Kano, the divergence in growth is very clear. Lagos has grown at a much faster rate than Kano. Comparing Kano with Ogun and Enugu states, two other relatively large states in the south, also shows a similar pattern. Kano appears to be growing at a much slower rate than both Ogun and Enugu states as shown in figures 20 and 21. The same pattern is apparent for both Kaduna and Katsina states, the second and third most populous states in the north according to the 2008 census. As

[5] Reported in local newspapers on Nigeria on the $27^{th}$ of February, 2013 http://www.punchng.com/news/poverty-fuelling-boko-haram-insurgency-clinton/

[6] Published at http://odili.net/news/source/2011/mar/25/838.html

shown in figures 22 and 23, both states have grown much slower than Ogun state, and by virtue Lagos and Enugu states.

Overall the night lights data confirm the argument that economic growth in parts of the north has been much slower than the south although the specific reason for this is unclear. The data however provides the opportunity for further research on the issue.

# 5 Estimating growth rates

The discussion in the previous section focuses on relative growth in economic activity across states and local government areas. However the night lights data does not say anything about the size of growth itself. As mentioned earlier, the scaling factor applied when converting lights to digital numbers each year makes direct comparison for different years difficult. Henderson, Storeygard and Weil (2012) however argue that actual GDP numbers can be used to estimate growth in subnational units. Following Henderson et Al (2012) I use the reported values of real GDP for countries in Africa reported in 1999 and 2012 to estimate the relationship between the change in reported real GDP and the change in night lights over the period. It is possible that the relationship between GDP and night lights varies across continents. For instance the relationship between real GDP and night lights in Western Europe may be different from the relation in Africa. As a result I use only countries in Africa to estimate the relationship. Data on real GDP is taken from the World Bank data archive. As in Henderson et al (2012) I suggest a relation of the form:

$$Y_j = BX_j + E_j \tag{1}$$

where Y is the change in real GDP between 1999 and 2012 in country j and X is the change in night lights over the same period in country j. $E_j$ includes year fixed effects and country fixed effects. I estimate the model using OLS. Although the night lights are comparable across geographic areas, they are not directly comparable across time. The specifications used when capturing images of the night lights change frequently. This implies that the relationship between night lights and GDP, and as a result change in night lights and change in GDP, depend on the year or range being compared. As a result of this panel estimation techniques are not applicable when estimating the relation between change in GDP and change in night lights. The OLS results are reported in Table 2. Comparing the change in real GDP for African countries to the change in night lights yields an estimate of 1.384 for the parameter B. I then use this parameter to estimate the growth numbers for the states and LGAs as predicted by their change in night lights. Although the estimate for B uses data for real GDP which may not be very accurate, Henderson et Al (2012) show that it could still be used to get unbiased estimates of B. Intuitively, as long as the quality of data is the same in both years it should not affect the estimate of B.

Estimation of the parameter B allows me to construct estimates of growth of GDP for states and LGAs in Nigeria using their change in night lights and the functional form as in equation (1). Table 3 reports the estimated change in GDP for states between 1999 and 2012.
The parameter for B implies that Lagos state, the commercial centre, grew by about 114% between 1999 to 2012. This is an average of 6.5% per year. Kano, the commercial centre in the North, grew by 24% over the period, an average of 1.7% per year. Growth overall was led by Taraba state which grew by 528% over the period, an average of 17.8% per year. At the other end the data suggests that economic activity in Yobe state actually shrunk by 0.21%, 0.02% per year, over the period. Growth rates for all states are reported in Table 3. Growth rates for the fastest and slowest growing LGAs are reported in Table 4.

Overall the statistics suggest robust long term growth in some parts of Nigeria with economic activity contracting or showing no signs of growth in other parts. This fits the argument made earlier about the dangers of measuring growth in Nigeria as a whole without understanding the internal variations in economic growth.

# 6 Conclusions

In this paper I have argued that using only national-level statistics to measure economic activity might not tell the entire story of economic performance within countries. Just as in Africa, where some countries are growing relatively fast despite the slow average, it is possible that sections of poor countries have areas that are performing relatively well. Understanding the factors which influence faster than average growth within sections of specific countries might help create a better understanding of these countries. To examine this possibility I use the average night time lights as a proxy for economic activity and show that night lights is correlated with various measures of economic activity and development both at the national and subnational level. I use this proxy for economic activity to examine economic growth across states and LGAs in Nigeria since the return of democracy in 1999. I show that there is indeed variation in growth within Nigeria. Specifically I show that some states, e.g. Lagos and Ogun states, have grown much faster than the average. I also show that some states in the Northern part of the country have lagged behind.

The use of night lights as a proxy for economic activity makes it possible to examine growth over time across small geographic areas. I exploit this by examining the effects of the Jos crisis on growth in Plateau state compared to growth in other similar states in Nigeria. I also explore the relationship between poor economic performance in the North Eastern states of Borno and Yobe and the rise of Boko Haram. The data suggests that Plateau state has suffered since start of the crisis in 2001 with growth slower than in neighbouring Kogi and Benue states. The data also suggest that the North Eastern states of Borno and Yobe have performed worse than other northern states and that this relatively poor performance precedes the emergence of violence associated with

Boko Haram.

This paper opens up the opportunity for further research exploring the factors which influence variation in growth within poor countries. The paper also promotes a means to measure sub-regional economic growth for countries where such data is not available.

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**Table 1: Change in Night Lights - States**

| State | Average Lights 1999 | Average Lights 2012 | Growth of Lights (%) |
|---|---|---|---|
| Abia* | 2.33 | 4.74 | 103.77 |
| Adamawa | 0.13 | 0.18 | 35.20 |
| Akwa Ibom* | 3.57 | 6.92 | 93.96 |
| Anambra | 3.64 | 5.65 | 55.33 |
| Bauchi | 0.10 | 0.16 | 61.18 |
| Bayelsa* | 12.58 | 11.54 | -8.28 |
| Benue | 0.11 | 0.42 | 279.98 |
| Borno | 0.09 | 0.10 | 3.67 |
| Cross River | 0.12 | 0.52 | 321.24 |
| Delta* | 9.68 | 11.77 | 21.56 |
| Ebonyi | 0.16 | 0.75 | 362.91 |
| Edo* | 2.52 | 4.04 | 60.48 |
| Ekiti | 0.16 | 0.67 | 310.14 |
| Enugu | 0.98 | 2.65 | 169.43 |
| FCT | 2.39 | 5.99 | 150.56 |
| Gombe | 0.18 | 0.34 | 85.79 |
| Imo* | 11.02 | 11.12 | 0.87 |
| Jigawa | 0.22 | 0.36 | 69.15 |
| Kaduna | 0.50 | 0.80 | 61.25 |
| Kano | 1.11 | 1.31 | 17.41 |
| Katsina | 0.49 | 0.55 | 12.97 |
| Kebbi | 0.13 | 0.17 | 33.84 |
| Kogi | 0.15 | 0.45 | 200.37 |
| Kwara | 0.14 | 0.35 | 153.11 |
| Lagos | 10.63 | 19.36 | 82.10 |
| Nassarawa | 0.13 | 0.54 | 306.66 |
| Niger | 0.16 | 0.28 | 81.81 |
| Ogun | 1.16 | 3.43 | 197.12 |
| Ondo | 0.73 | 1.31 | 81.11 |
| Osun | 0.65 | 1.89 | 190.57 |
| Oyo | 0.43 | 0.99 | 127.87 |
| Plateau | 0.27 | 0.41 | 50.76 |
| Rivers* | 20.90 | 17.68 | -15.42 |
| Sokoto | 0.23 | 0.45 | 95.24 |
| Taraba | 0.02 | 0.12 | 381.78 |
| Yobe | 0.07 | 0.07 | -0.15 |
| Zamfara | 0.09 | 0.31 | 239.31 |

*Oil Producing States: Results are affected by presence of gas flaring

**Table 2: Relationship between Change in GDP and Change in Night lights**

| | Coef. | $R^2$ | No. Obs |
|---|---|---|---|
| Growth of Lights | 1.384*** | 0.418 | 48 |
| | (0.234) | | |

Notes: Standard Errors are reported in brackets. ***, ** and * indicate significance at the 1%, 5%, and 10% levels.

**Table 3: Estimated GDP growth - States**

| State | Growth of Lights (%) | Estimated GDP growth | Average Annual Growth Rate |
|---|---|---|---|
| Abia* | 103.77 | 143.62 | 7.79 |
| Adamawa | 35.20 | 48.72 | 3.25 |
| Akwa Ibom* | 93.96 | 130.04 | 7.23 |
| Anambra | 55.33 | 76.57 | 4.77 |
| Bauchi | 61.18 | 84.67 | 5.18 |
| Bayelsa* | -8.28 | -11.46 | -0.92 |
| Benue | 279.98 | 387.49 | 14.97 |
| Borno | 3.67 | 5.08 | 0.38 |
| Cross River | 321.24 | 444.60 | 16.19 |
| Delta* | 21.56 | 29.84 | 2.09 |
| Ebonyi | 362.91 | 502.27 | 17.31 |
| Edo* | 60.48 | 83.71 | 5.12 |
| Ekiti | 310.14 | 429.23 | 15.87 |
| Enugu | 169.43 | 234.49 | 10.96 |
| FCT | 150.56 | 208.37 | 10.13 |
| Gombe | 85.79 | 118.73 | 6.75 |
| Imo* | 0.87 | 1.21 | 0.09 |
| Jigawa | 69.15 | 95.70 | 5.71 |
| Kaduna | 61.25 | 84.77 | 5.18 |
| Kano | 17.41 | 24.10 | 1.72 |
| Katsina | 12.97 | 17.95 | 1.30 |
| Kebbi | 33.84 | 46.83 | 3.14 |
| Kogi | 200.37 | 277.31 | 12.22 |
| Kwara | 153.11 | 211.91 | 10.25 |
| Lagos | 82.10 | 113.63 | 6.53 |
| Nassarawa | 306.66 | 424.41 | 15.77 |
| Niger | 81.81 | 113.23 | 6.51 |
| Ogun | 197.12 | 272.81 | 12.09 |
| Ondo | 81.11 | 112.26 | 6.50 |
| Osun | 190.57 | 263.75 | 11.83 |
| Oyo | 127.87 | 176.97 | 9.05 |
| Plateau | 50.76 | 70.25 | 4.44 |
| Rivers* | -15.42 | -21.34 | -1.72 |

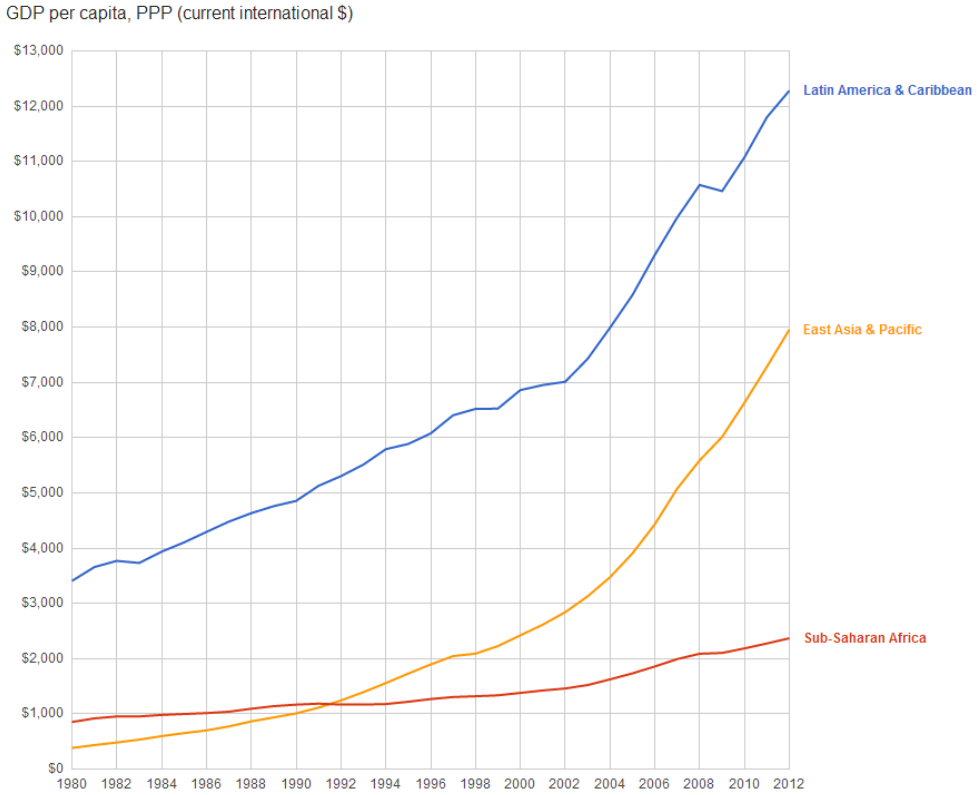
| | | | |
|---|---|---|---|
| Sokoto | 95.24 | 131.81 | 7.31 |
| Taraba | 381.78 | 528.38 | 17.79 |
| Yobe | -0.15 | -0.21 | -0.02 |
| Zamfara | 239.31 | 331.21 | 13.64 |

*Oil Producing States: Results are affected by presence of gas flaring

**Table 4: Estimated Growth Rates - LGAs (Abridged)**

| LGA (State) | Growth of Lights (%) | Estimated GDP growth | Average Annual Growth Rate |
|---|---|---|---|
| Top 15 | | | |
| Uruan (Akwa Ibom) | 9076.14 | 12561.38 | 57.53 |
| Isa (Sokoto) | 6874.98 | 9514.98 | 53.44 |
| Ibeju/Lekki (Lagos) | 6740.16 | 9328.37 | 53.16 |
| Ibiono Ibom (Akwa Ibom) | 6431.36 | 8901.01 | 52.48 |
| Nkanu East (Enugu) | 5073.98 | 7022.39 | 49.09 |
| Mariga (Niger) | 5033.56 | 6966.45 | 48.97 |
| Ofu (Kogi) | 4619.90 | 6393.94 | 47.77 |
| Obanliku (Cross River) | 4377.84 | 6058.92 | 47.01 |
| Umu-Nneochi (Abia) | 4092.11 | 5663.48 | 46.08 |
| Okene (Kogi) | 2833.9 | 3922.12 | 41.08 |
| Ibesikpo Asutan (Akwa Ibom) | 2820.37 | 3903.40 | 41.02 |
| Ibarapa East (Oyo) | 2709.138 | 3749.45 | 40.48 |
| Oji-River (Enugu) | 2658.57 | 3679.47 | 40.23 |
| Ohafia (Abia) | 2562.92 | 3547.08 | 39.75 |
| Odukpani (Cross River) | 2522.59 | 3491.26 | 39.54 |
| Bottom 15 | | | |
| Roni (Jigawa) | -99.90 | -138.27 | -57.35 |
| Garki (Jigawa) | -99.86 | -138.20 | -54.82 |
| Maiyama (Kebbi) | -99.81 | -138.14 | -53.08 |
| Miga (Jigawa) | -99.81 | -138.14 | -52.96 |
| Kibiya (Kano) | -99.75 | -138.06 | -51.17 |
| Afikpo South (Ebonyi) | -99.68 | -137.95 | -49.31 |
| Ogun Waterside (Ogun) | -99.60 | -137.84 | -47.86 |
| Uzo-Uwani (Enugu) | -99.30 | -137.42 | -43.86 |
| Chibok (Borno) | -99.22 | -137.31 | -43.03 |
| Kala/Balge (Borno) | -99.14 | -137.20 | -42.37 |
| Kunchi (Kano) | -98.62 | -136.47 | -38.76 |
| Katcha (Niger) | -98.56 | -136.38 | -38.41 |
| Maiha (Adamawa) | -98.44 | -136.20 | -37.77 |
| Kalgo (Kebbi) | -97.31 | -134.58 | -33.40 |
| Sumaila (Kano) | -88.61 | -122.59 | -21.27 |

## Figure 1: GDP per capita across regions




## Figure 2: GDP per capita across countries

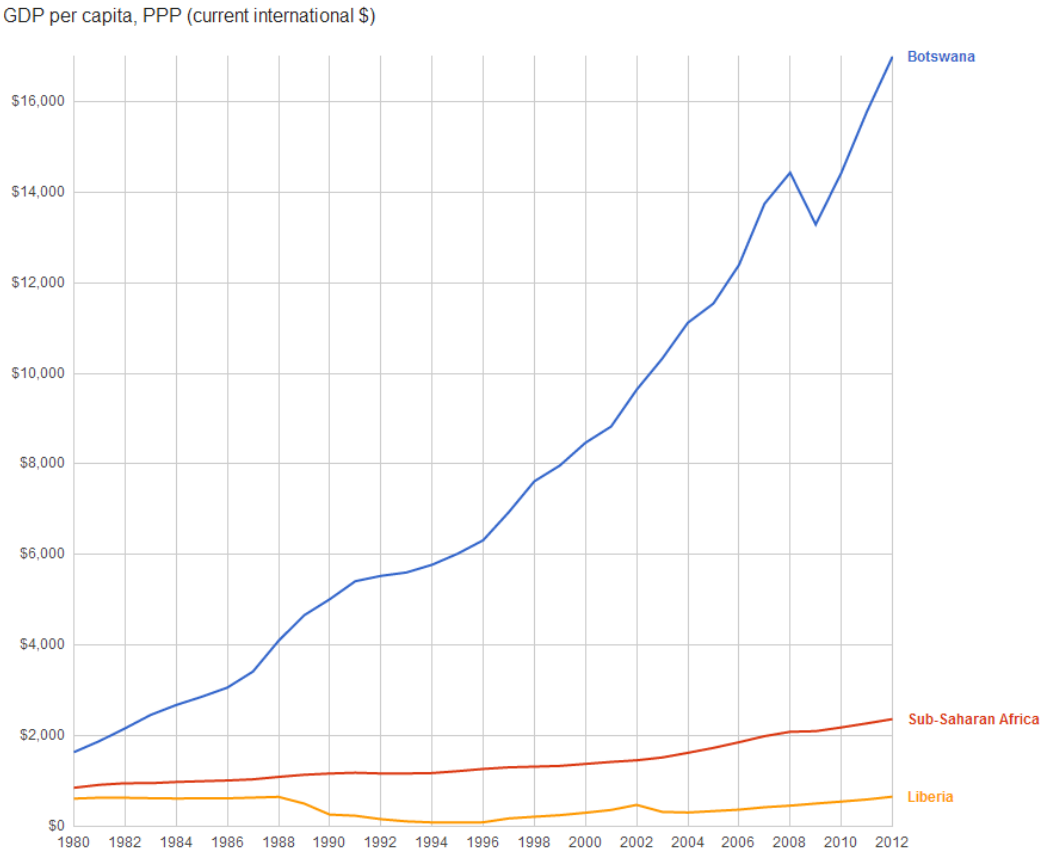


**Figure 3: GDP per capita across countries**

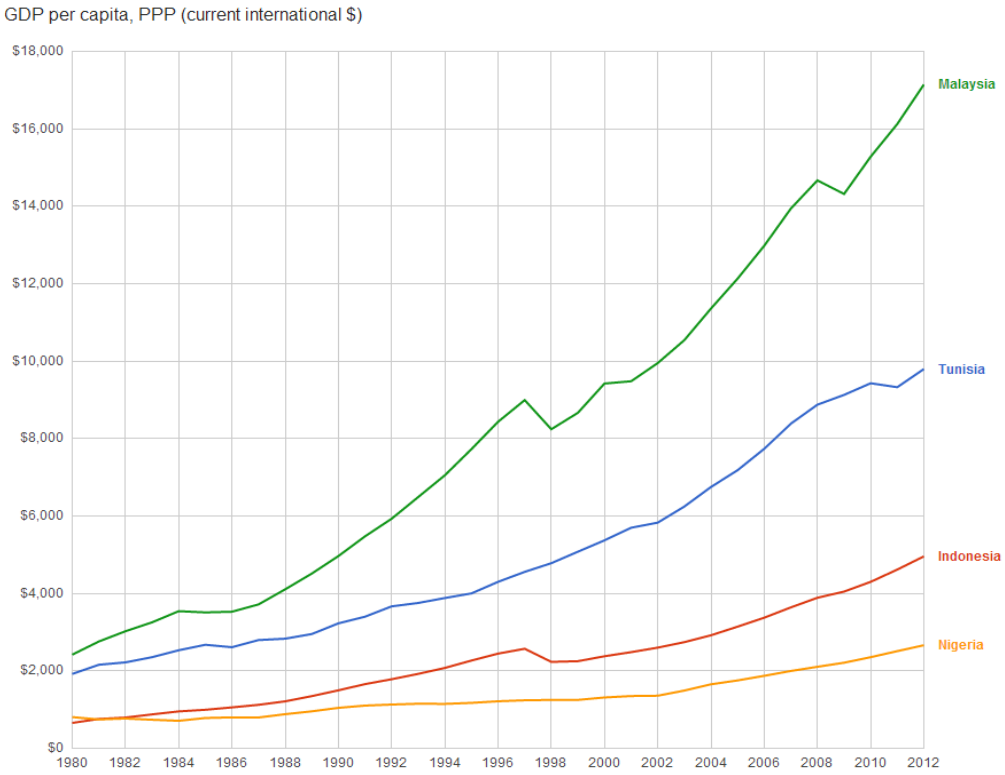



**Figure 4: ln GDP per capita and Average Night Lights - 1999**

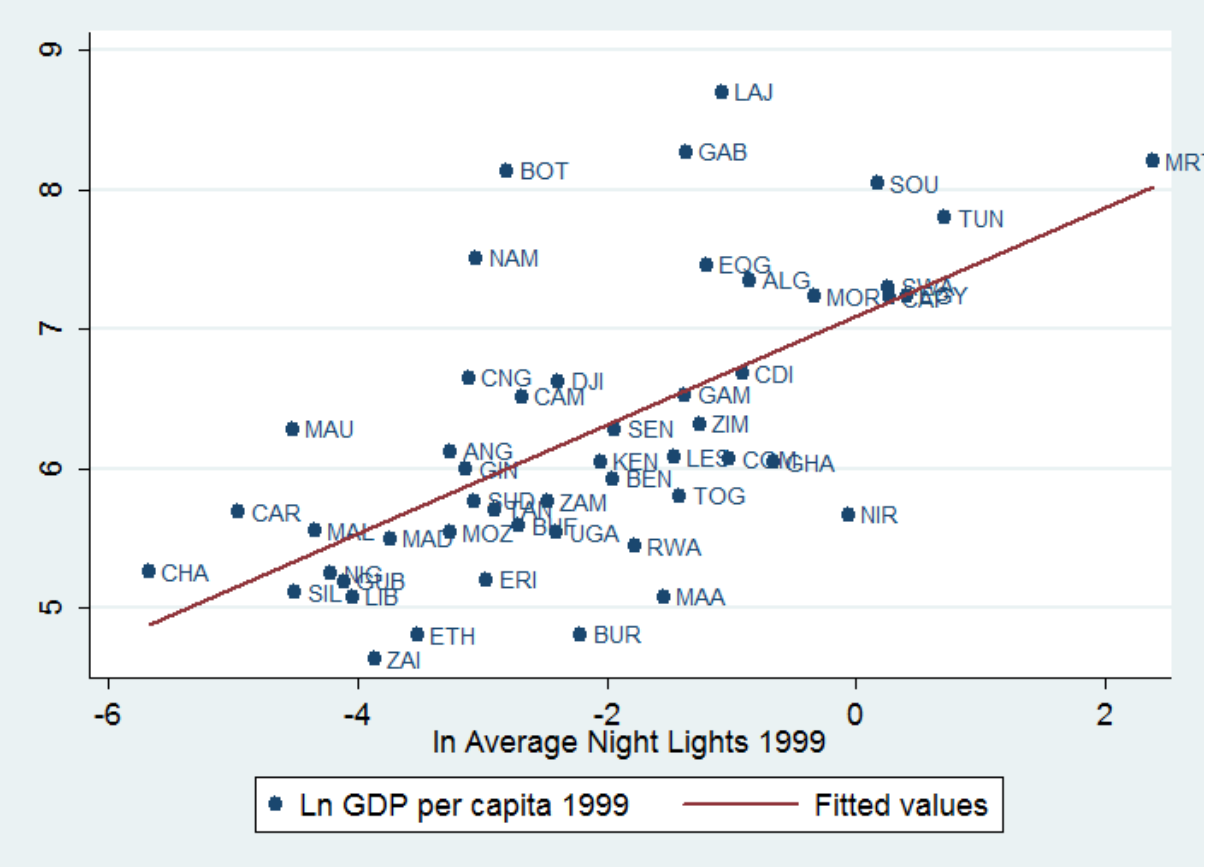


**Figure 5: ln GDP per capita and Average Night Lights - 2012**

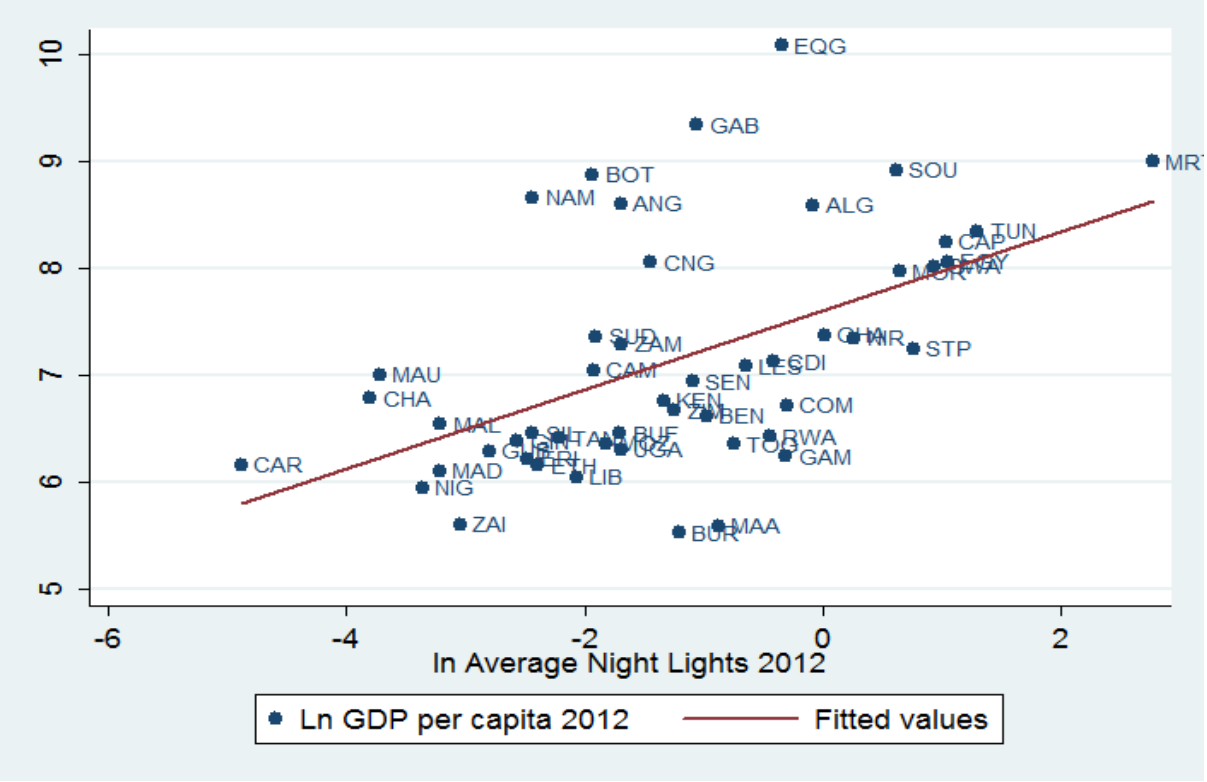



**Figure 6: ln GDP per capita and Average Night Lights/Population - 1999**

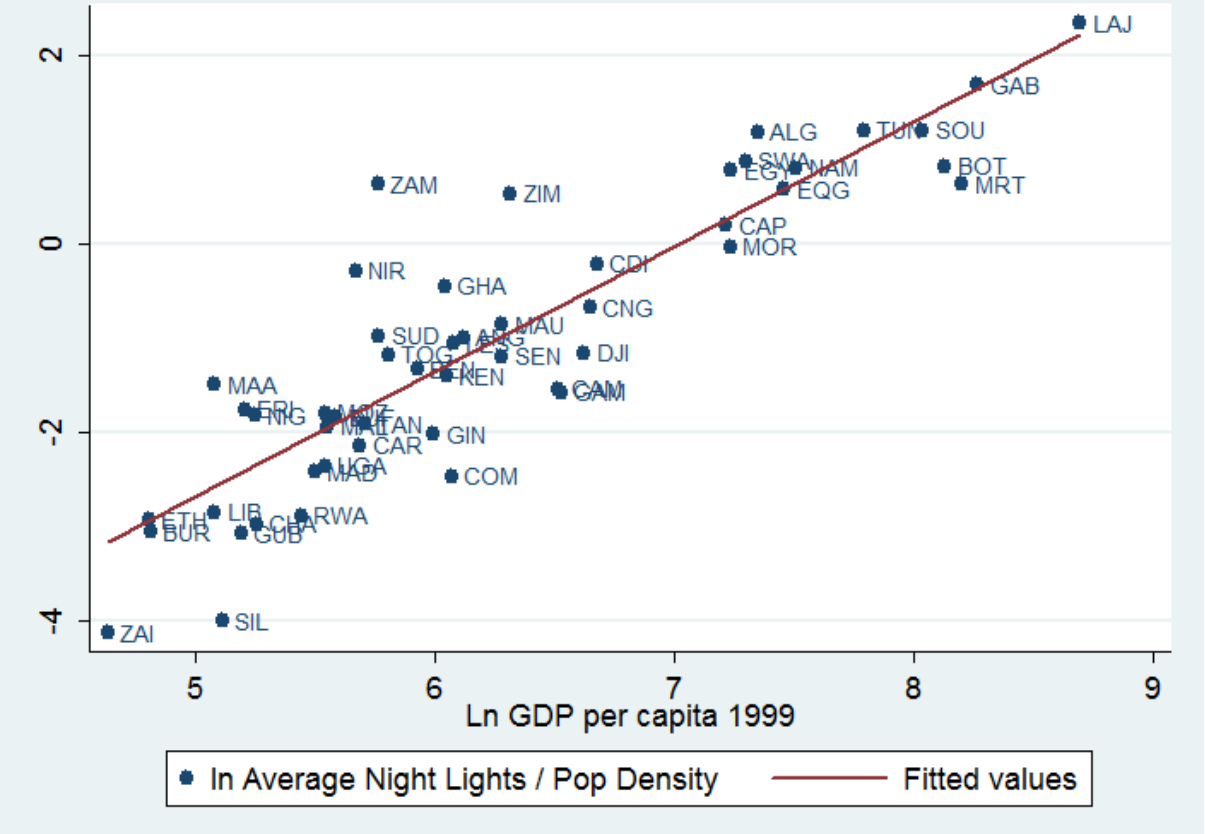


**Figure 7: ln GDP per capita and Average Night Lights/Population - 2012**

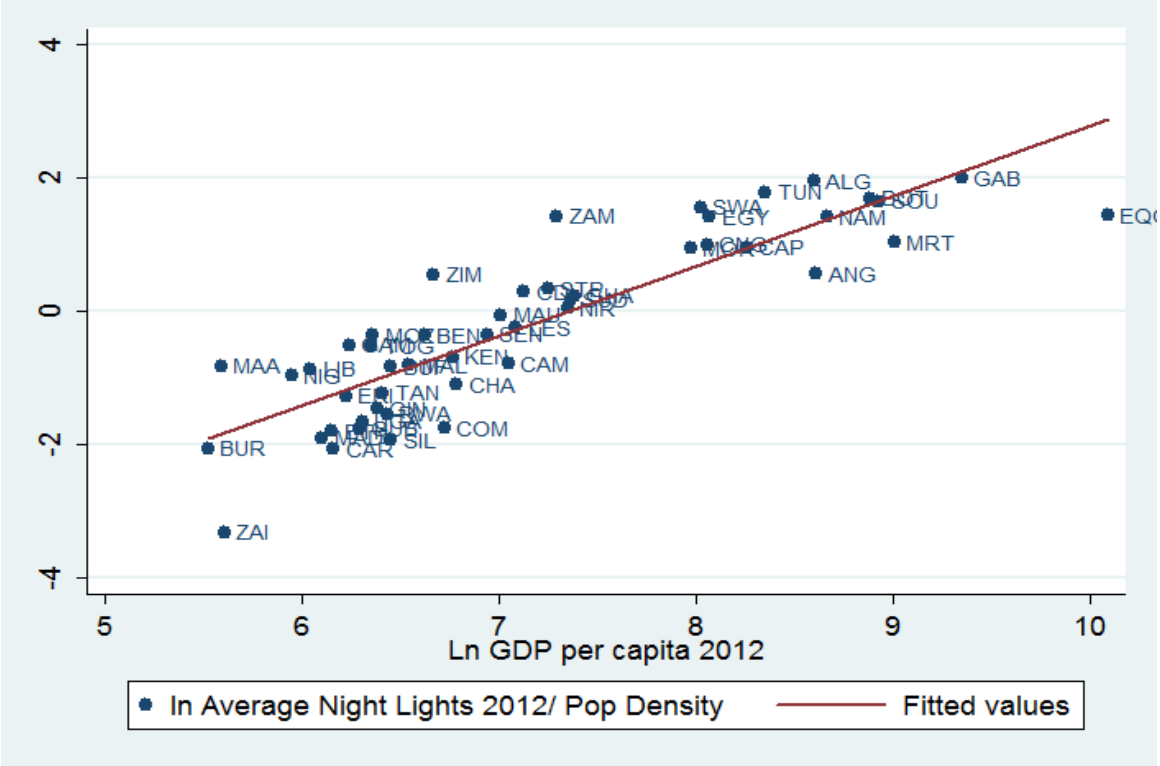



**Figure 8: GDP growth and Average Night Light Growth – 1999 - 2012**

**Figure 9: Infant Mortality and Average Night Lights - 1999**

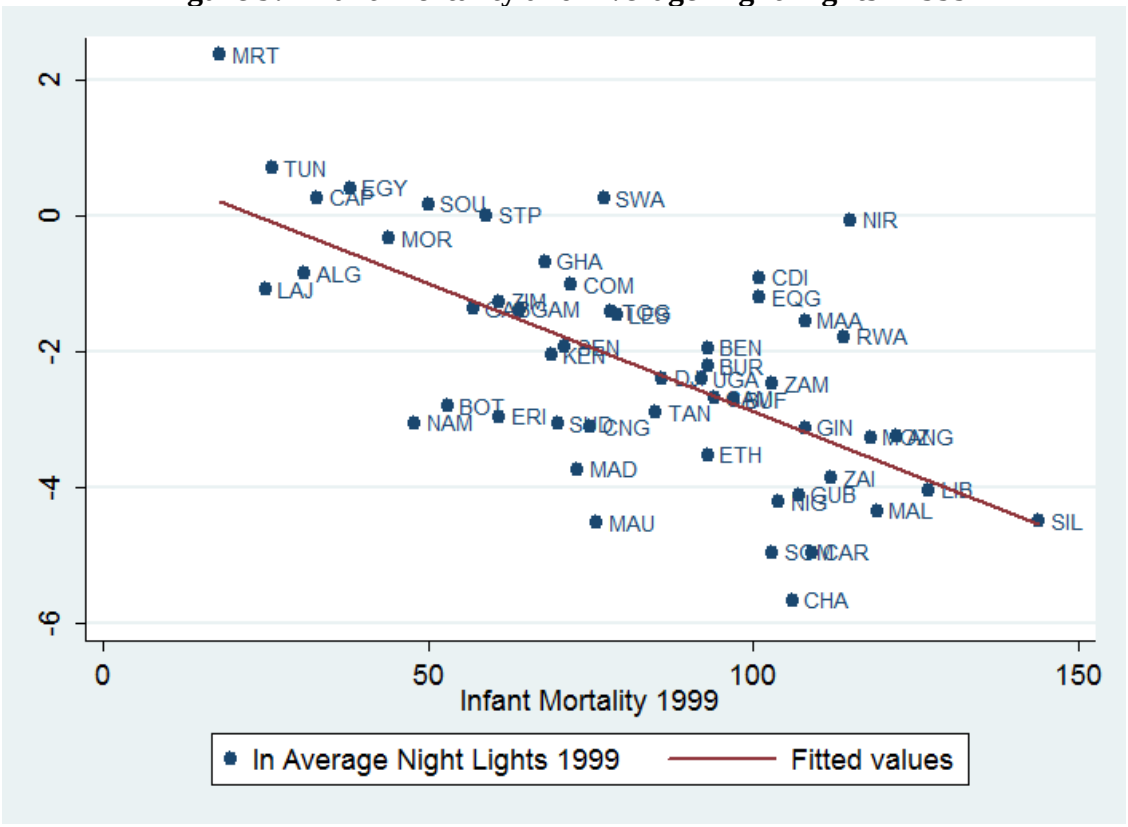



**Figure 10: Infant Mortality and Average Night Lights - 2012**

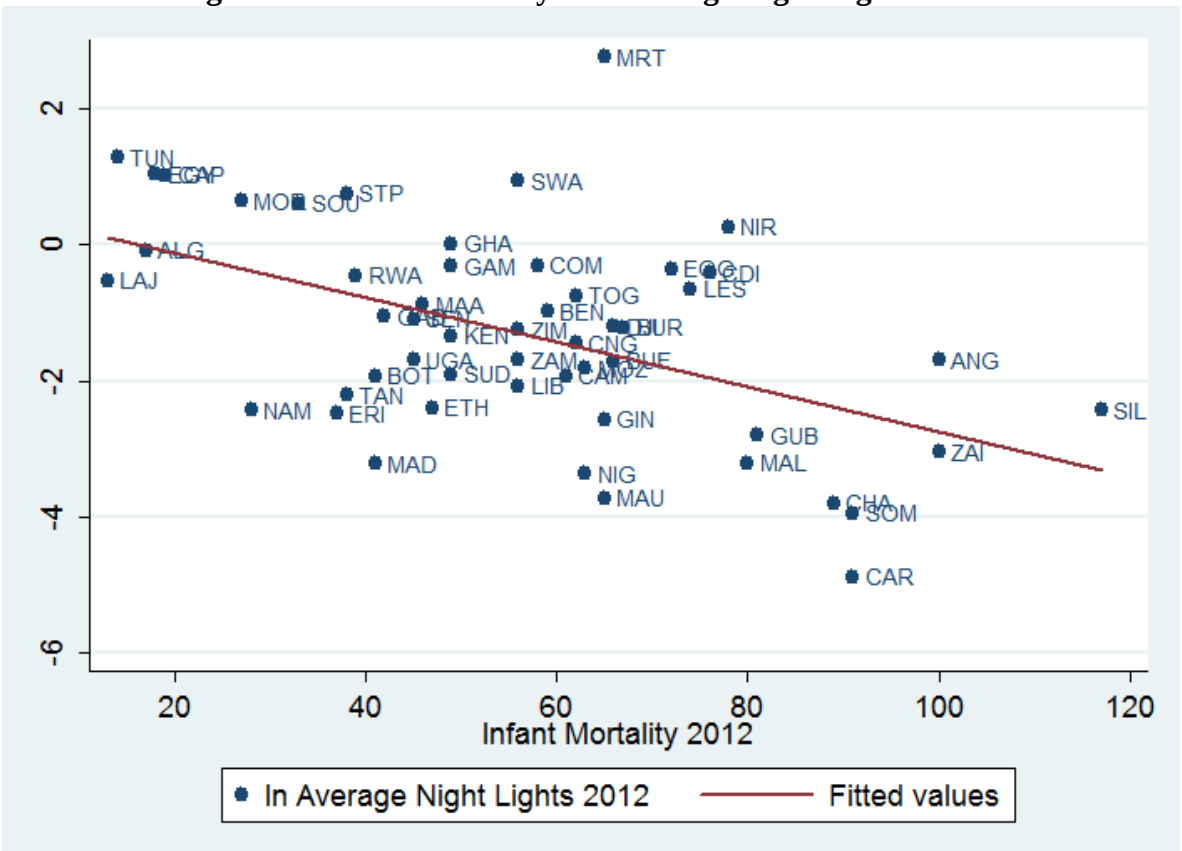


**Figure 11: State Literacy Rates and Average Night Lights - 2010**

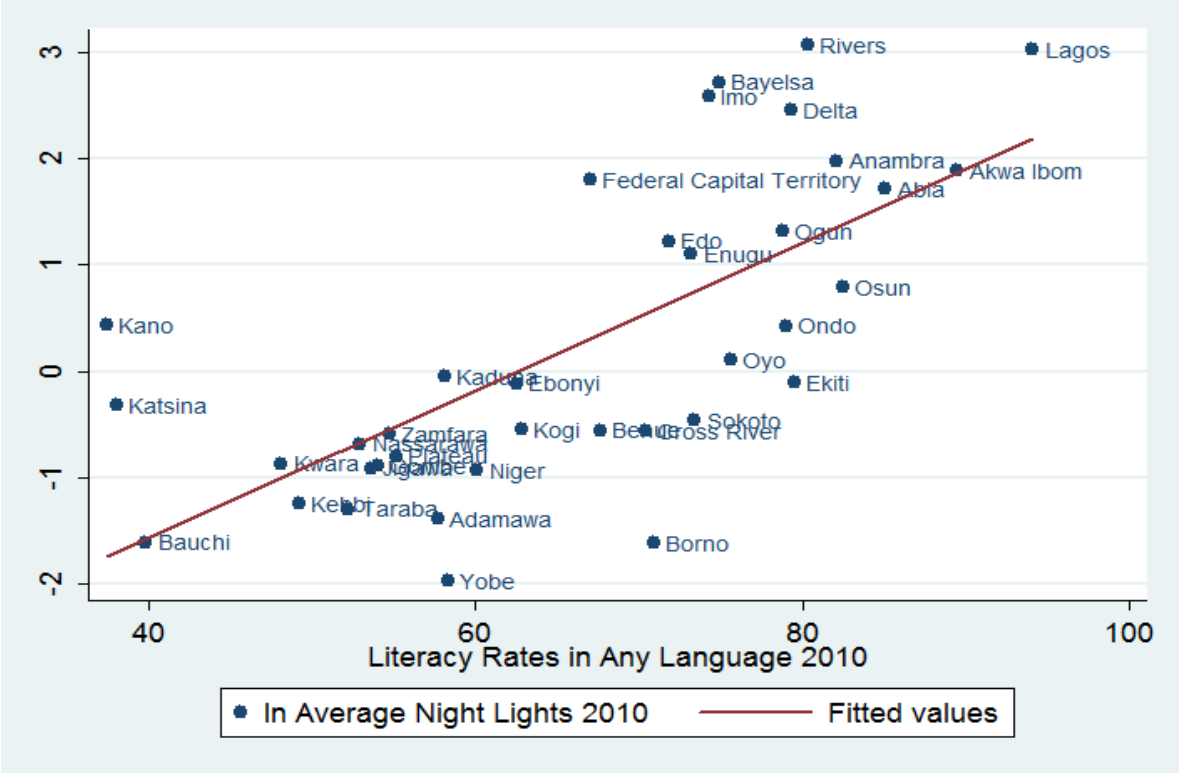



**Figure 12: Absolute Poverty and Average Night Lights - 2004**

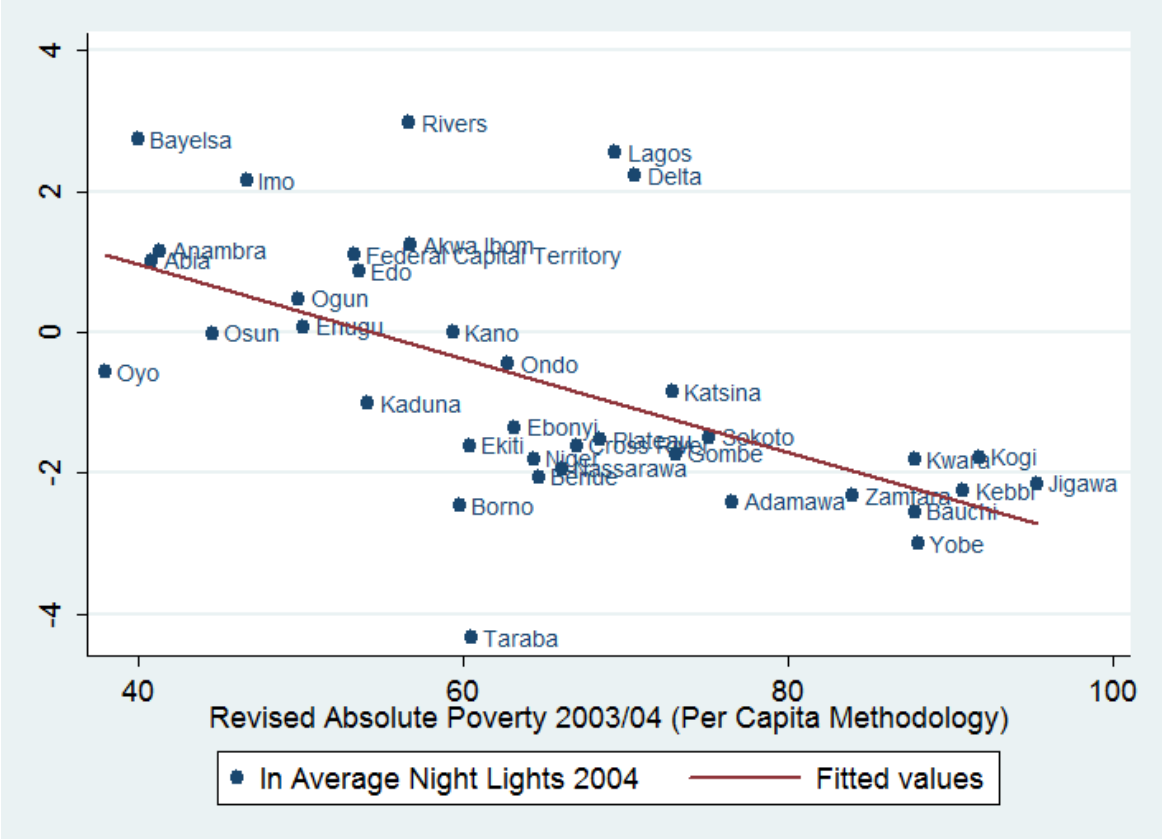


**Figure 13: Absolute Poverty and Average Night Lights - 2010**

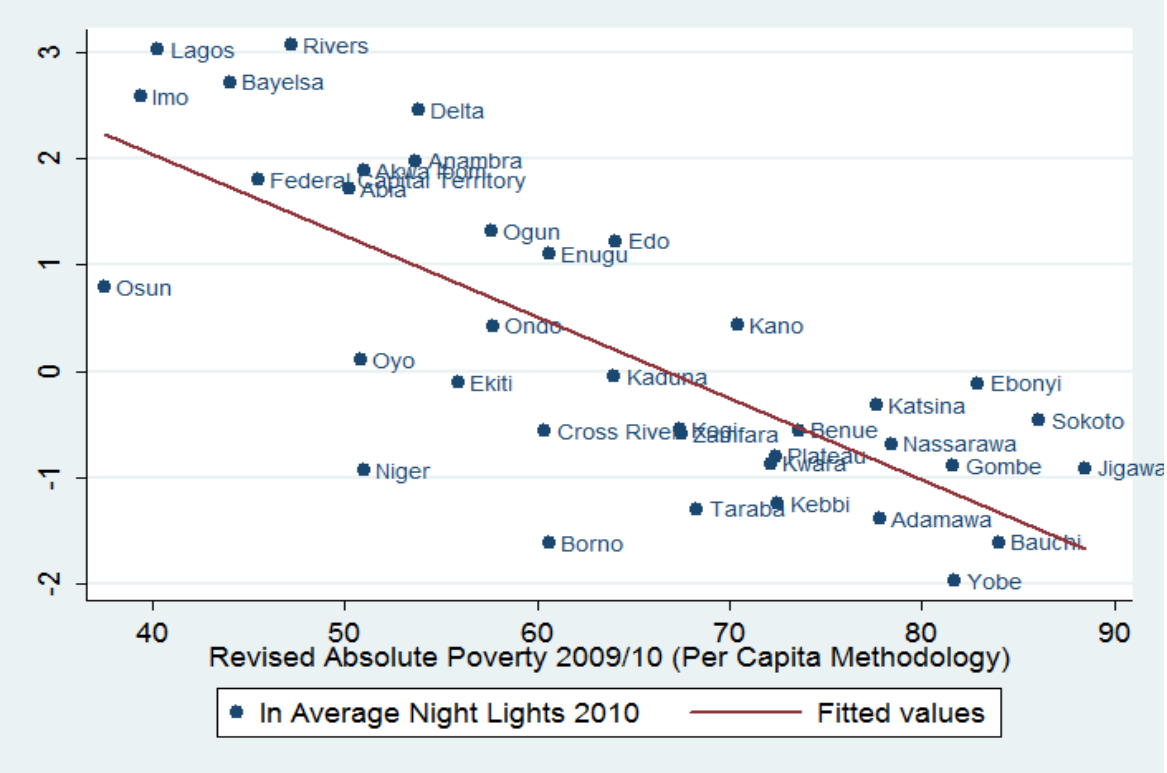



**Figure 14: Average Night Lights – Plateau and Kogi – 1992 -2012**

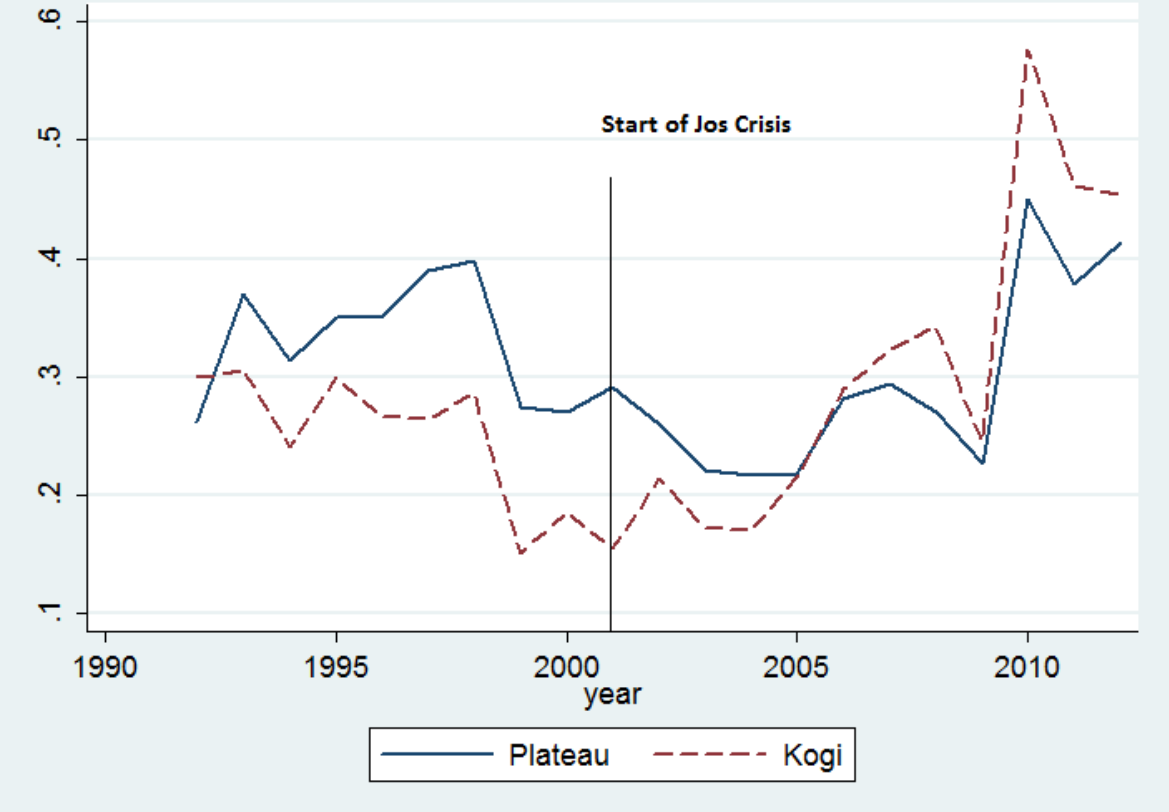


**Figure 15: Average Night Lights – Plateau and Benue – 1992 -2012**

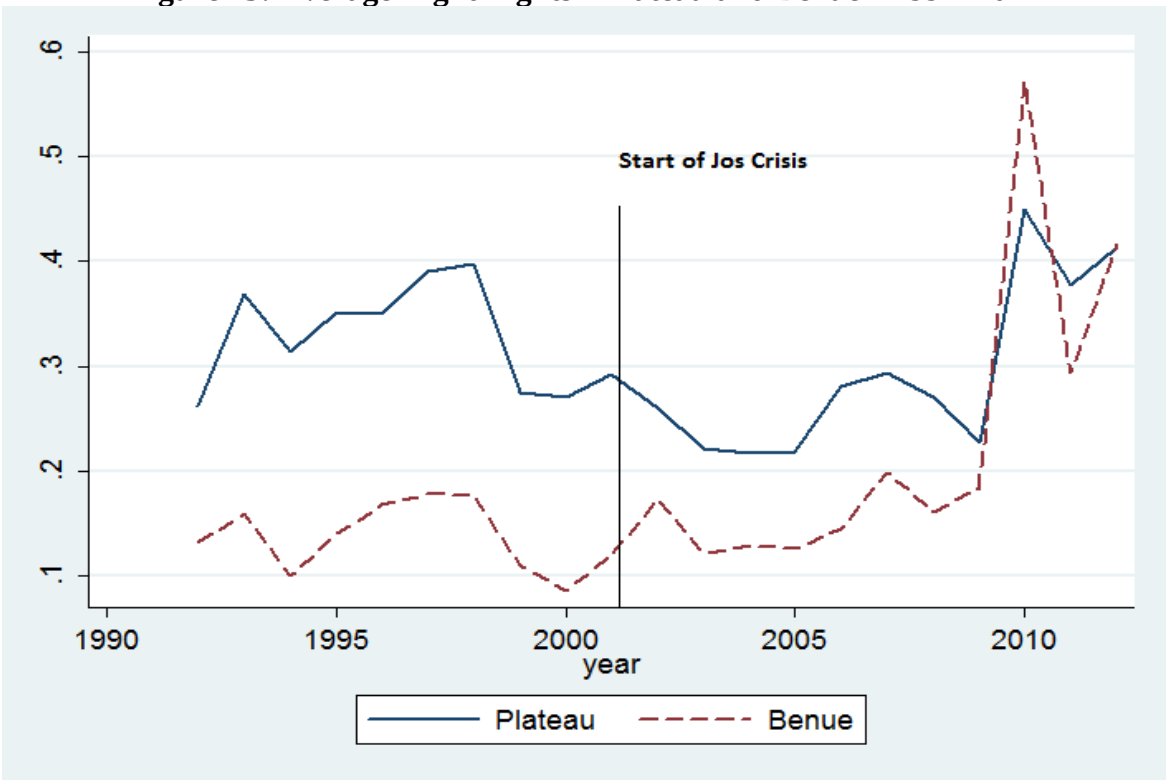



**Figure 16: Average Night Lights – Plateau and Kwara – 1992 -2012**

**Figure 17: Average Night Lights – Sokoto, Yobe and Borno – 1992 -2012**

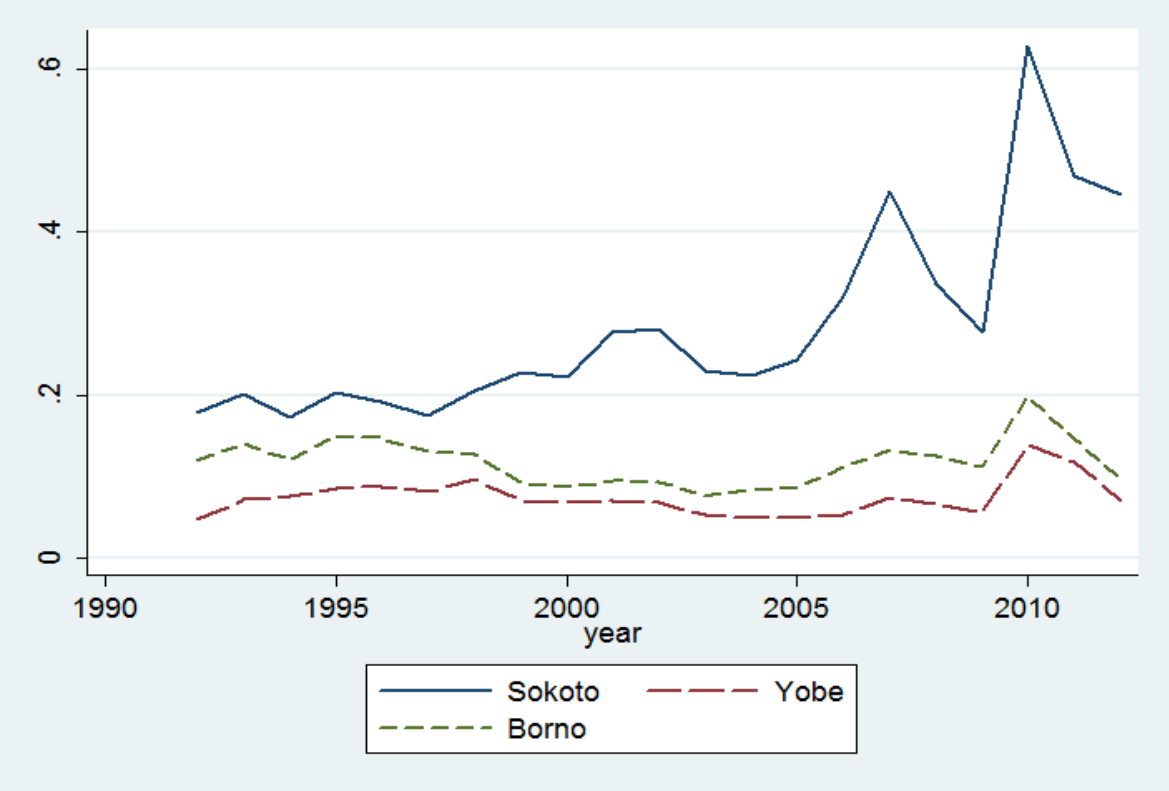



**Figure 18: Average Night Lights – Kebbi, Yobe and Borno – 1992 -2012**

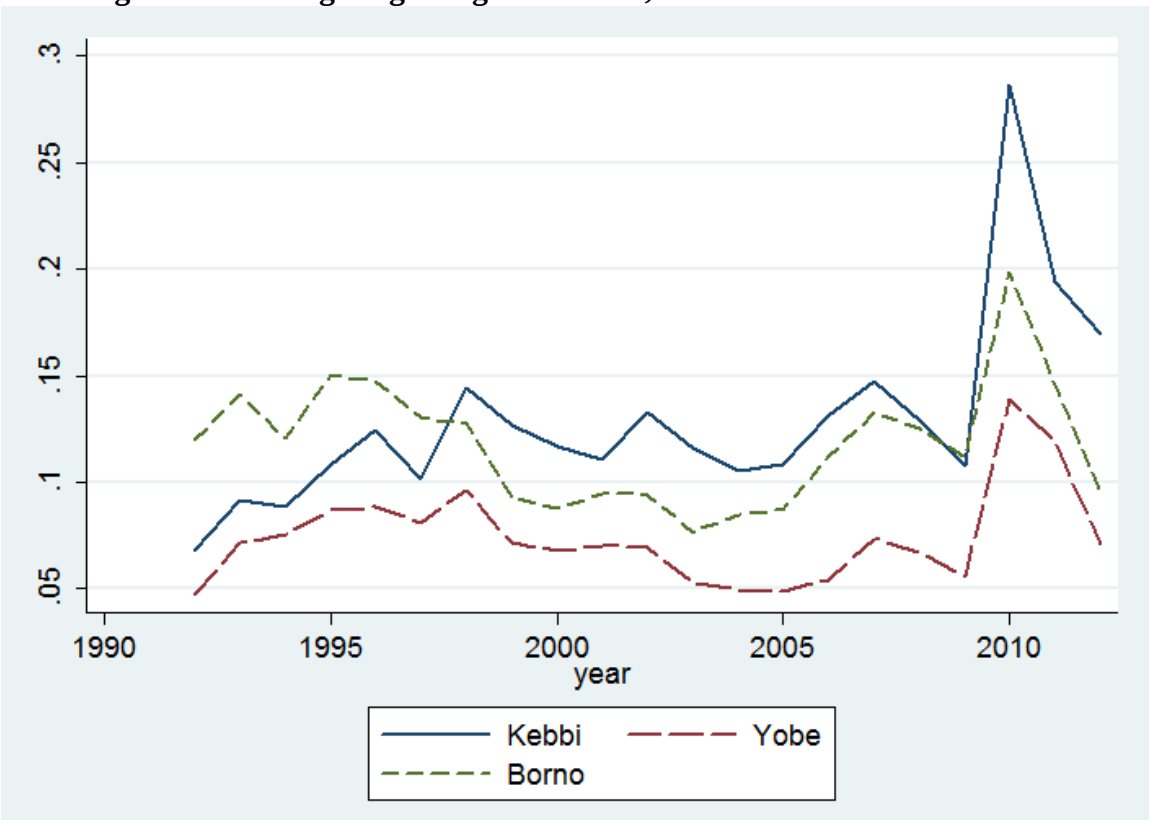


**Figure 19: Average Night Lights – Lagos and Kano – 1992 -2012**

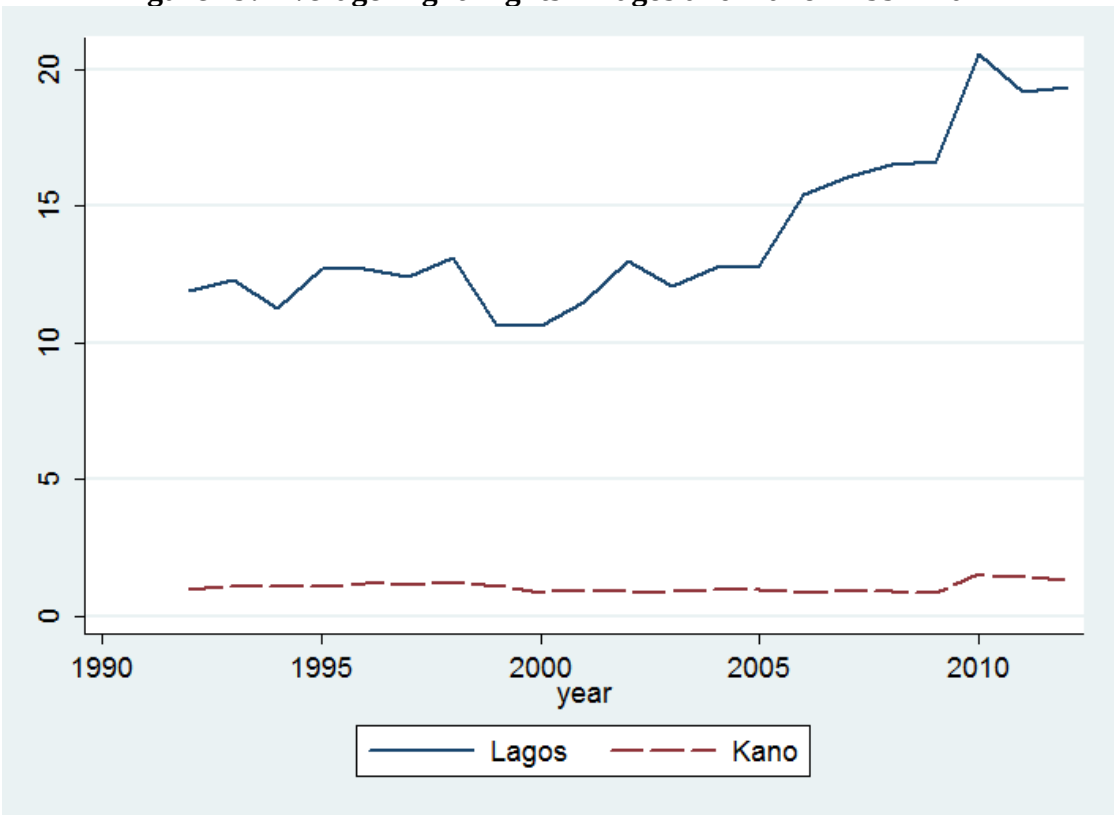



**Figure 20: Average Night Lights – Ogun and Kano – 1992 -2012**

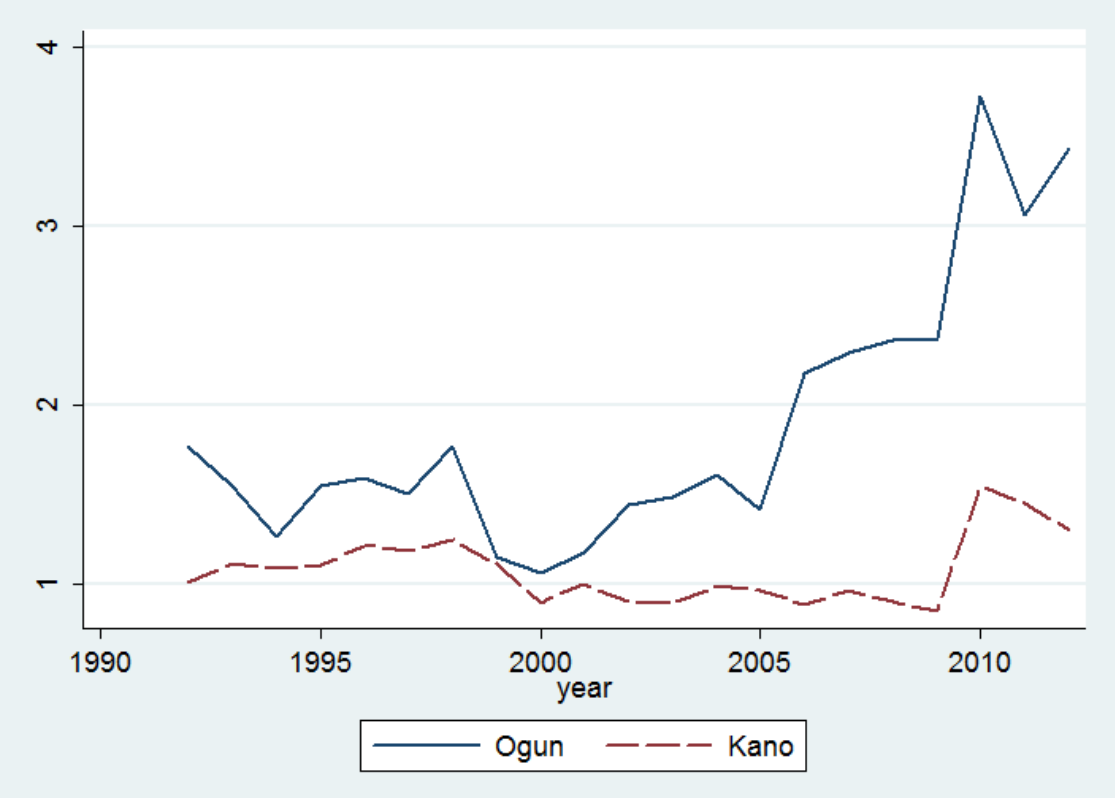


**Figure 21: Average Night Lights – Enugu and Kano – 1992 -2012**

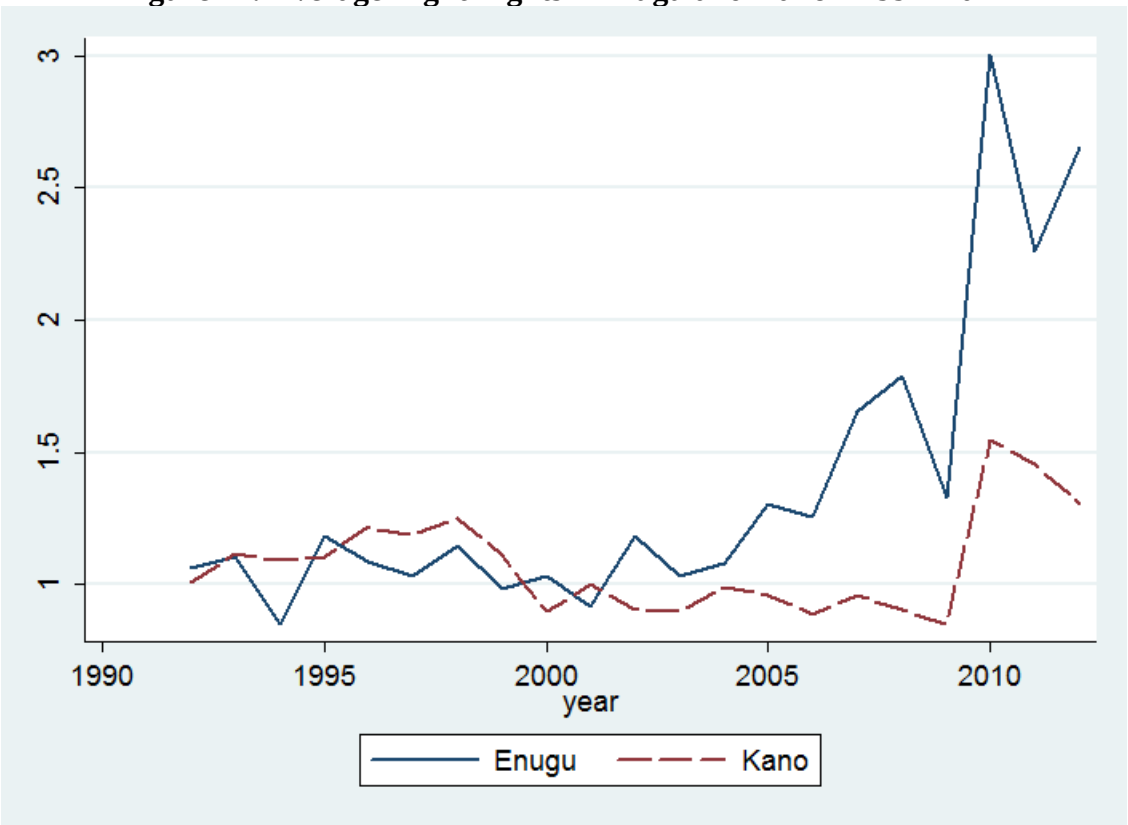



**Figure 22: Average Night Lights – Ogun and Katsina – 1992 -2012**

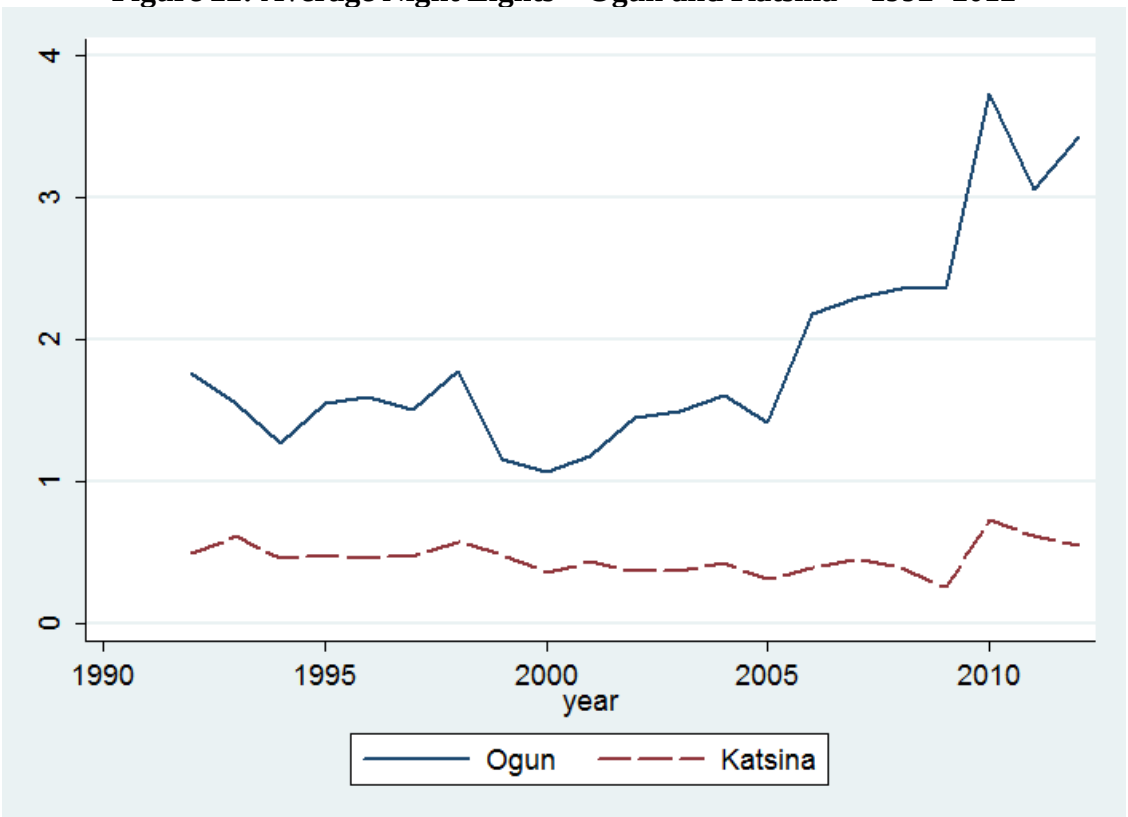


**Figure 23: Average Night Lights – Ogun and Kaduna – 1992 -2012**