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Economic Crisis Changing Brightness of Nighttime Lights in Venezuela: A Geographically Faceted Visualization

Jingru Tian

School of Economics and Management, Shanghai Maritime University, Shanghai, China
Email: jrtian@shmtu.edu.cn

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Abstract

Venezuela's present economic crisis that began in 2013 has triggered a series of social and political issues. There is a lack of reliable official data to analyze Venezuela's economic situation. In this study, I use data extracted from the latest brightness of nighttime lights (NTL) image products to create a visualization of Venezuela's severe economic depression by exhibiting temporal changes in brightness of NTL from 2013 to 2018 of Venezuela.

Keywords

Economic Crisis, Nighttime Lights, Visualization

1. Introduction

Venezuela's present economic crisis that began in 2013 has triggered a series of social and political issues. With increasing deterioration of the economic situation, especially uncontrolled inflation, the government of Venezuela has stopped releasing major economic indicators (Gupta, 2017). Moreover, due to the dramatically large differences in actual market values (e.g. the exchange rate to the U.S. dollar), even the limited official data have become untrustworthy.

Brightness of nighttime lights (NTL) observed by satellites has been extensively demonstrated to be an objective and reliable proxy of economy for large geographic areas (Chen & Nordhaus, 2011). In this study, I create a visualization of Venezuela's severe economic depression by exhibiting temporal changes in brightness of NTL from 2013 to 2018 with data extracted from the latest NTL image products, i.e. the Visible Infrared Imaging Radiometer Suite (VIIRS) Day/Night Band (DNB) monthly image composites.

2. Data and Methodology

Compared with the old NTL image products (e.g. the Defense Meteorological Satellite Program's Operational Linescan System annual stable light image composites), a significant improvement in VIIRS-DNB image composites is that pixel radiance values are compatible across different time periods. However, radiance of NTL in the VIIRS-DNB image products is considerably affected by albedo of land surface and shows an apparent seasonality (Levin, 2017).

The latest VIIRS-DNB image composite is for May 2018 when we conducted the research on September 4, 2018. To minimize the seasonal effect, I select six VIIRS-DNB image products for the same month of May to represent NTL situations of the six years (2013-2018). Pixels with radiances smaller than 1 $nW{\cdot}cm^{-2}{\cdot}sr^{-1}$ are revalued as 0 to remove background noise (Zhao et al., 2017) and then summed radiances of 23 states, one Capital District (Distrito Capital in Spanish), and the Federal Dependencies (Dependencias Federales in Spanish) (henceforth referring to all as states) are calculated for each of the six years. The summed radiance of a state for any one year is divided by that of the state for 2013 to obtain a ratio. Thus, if a state's ratio for one year is smaller/larger than 1, it indicates the state experienced decreased/increased brightness of NTL compared with 2013 and allows us to infer economic decline/development (Zhao et al., 2015).

3. Visualization

Traditional geographical visualization methods (e.g. the most commonly used choropleth maps) visually favor large geographic entities over small ones. However, it is common to see that major geographic entities of economy in a country (e.g. *Distrito Capital* in Venezuela) have relatively small areas. Although it enlarges or shrinks a geographic entity based on the size of the investigated variable, a cartogram cannot show time-series values for each geographic entity. Thus, I use the geofaceting method to give all of Venezuela's states an "equal chance" to display their temporal changes in brightness of NTL in a map.

In the geofacet map (i.e. **Figure 1**), one grid represents a (combined) state. The original geographic topology is mimicked by relative locations of the grids. It needs to be particularly explained that Aragua and Miranda, Carabobo and Yaracuy, and Vargas and *Distrito Capital* are combined into three individual grids to avoid appearance of wrong geographic topology. It can be seen from the geofacet map that 20 of the 22 geographic entities experienced apparent decreases in brightness of NTL from 2013 to 2018. Summed radiances of many populated states (e.g. Aragua, Miranda, and *Distrito Capital*) in 2018 are less than half of the radiances in 2013. Táchira's summed radiance in 2018 is just 35 percent of that in 2013. Many residents escaping to the neighboring country of Colombia may be a reason resulting in the extra low radiance in Táchira. *Dependencias Federales* is the only state that did not experience a decrease in brightness of NTL. However, summed radiances of *Dependencias Federales* in

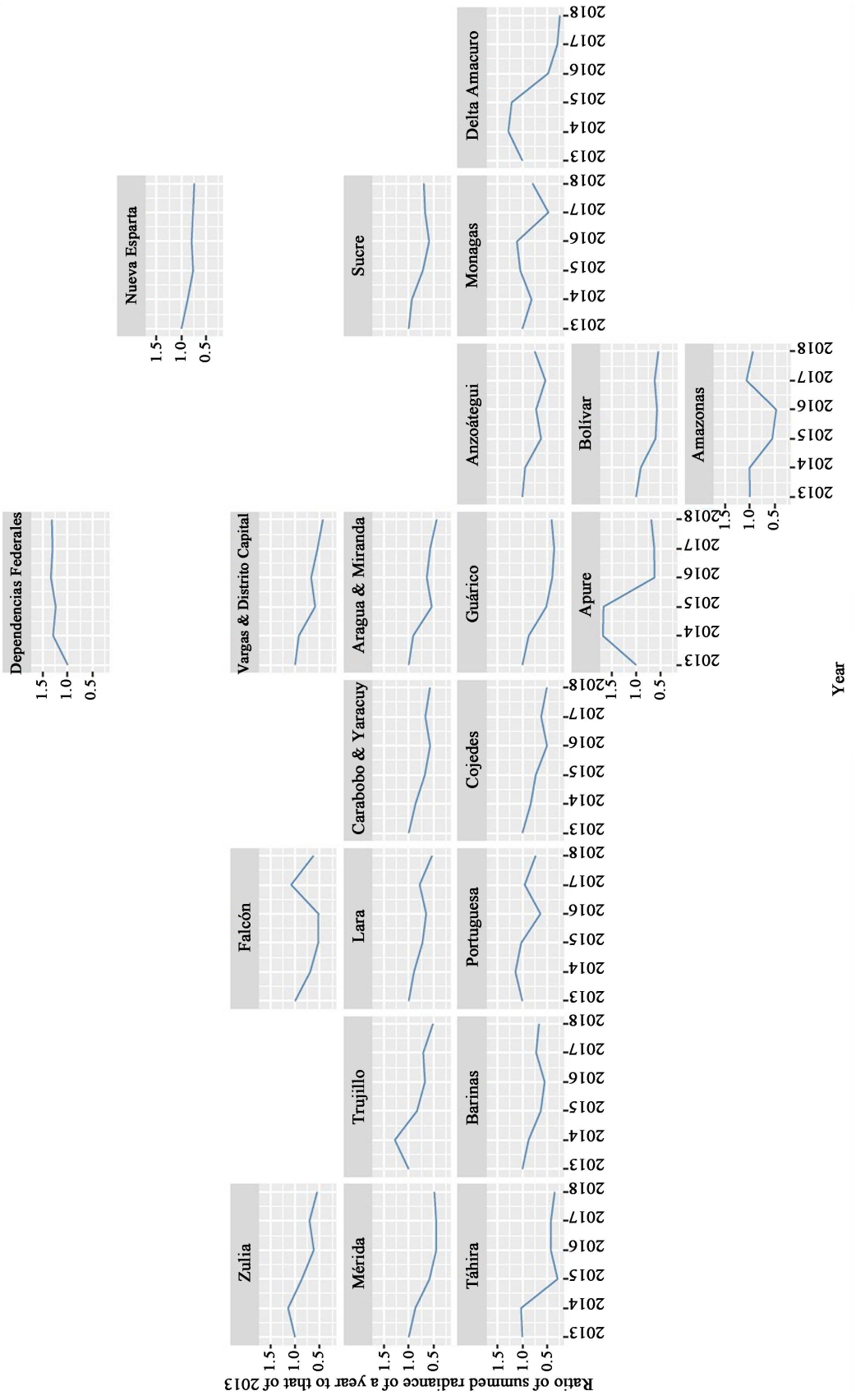

Figure 1. Temporal changes in brightness of NTL from 2013 to 2018.

2013 and 2018 are only 27.39 $nW \cdot cm^{-2} \cdot sr^{-1}$ and 36.18 $nW \cdot cm^{-2} \cdot sr^{-1}$ respectively. These small radiances indicate that stable economic activities are rare in *Dependencias Federales*. Another state that did not suffer from apparent decrease in brightness of NTL is Amazonas. Amazonas is the most remote state in Venezuela with the smallest population, save for *Dependencias Federales*. Approximately 60 percent of the total radiance of Venezuela is contributed by the state of Monagas. The extremely bright light in Monagas is derived from gas flaring associated with oil extraction. Excluding Monagas's radiances, we find that Venezuela's total radiance of NTL decreases 38 percent from 2013 to 2018. This decreasing percentage is nearly equal to the declining rate (36 percent) of Venezuela's real gross domestic product estimated by the International Monetary Fund (2022).

4. Conclusion

In this study, I create a geographically faceted visualization of changes in brightness of nighttime lights from 2013 to 2018 in Venezuela to demonstrate an objective and reliable proxy for estimating Venezuela's economic situation. Due to the time limited, I only processed data from 2013 to 2018 from the NTL image products. In further research, we can expand the time range of the visualization study, and apply this method in other countries when we need more objective and timely assessments of economic situation.

Software

The NTL image products are processed using ArcGIS 10.4.1. The geofacet map is created using the packages "ggplot2" and "geofacet" in R statistical computing environment.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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