EE406 CONTEMPORARY ECONOMIC ISSUES

Semester 1/2021

Could the Nighttime-Light Index be a good representative for the GDP of Thailand?

By

6104640716 Nichanun Subsomboon

FACULTY OF ECONOMICS

THAMMASAT UNIVERSITY

December 2021

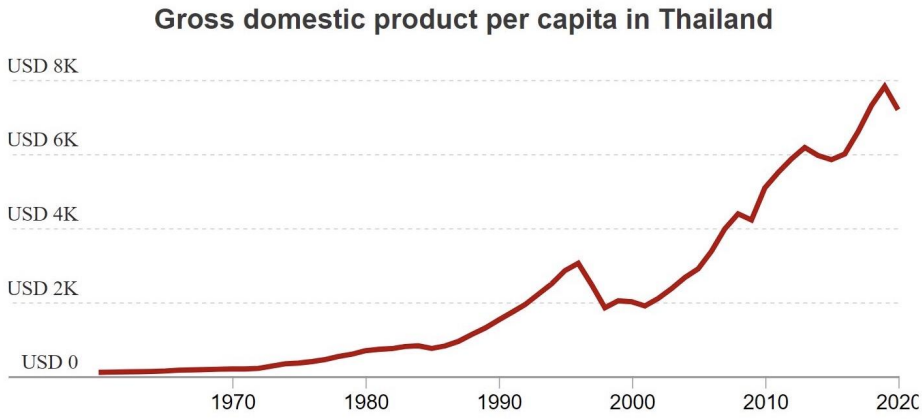
Table of Contents

Introduction

Nighttime-light data, the indicator that provides the usage of the nighttime-light captured from the satellite. According to the information from The National Aeronautics and Space Administration (NASA), nighttime-light data could imply the social, economic, and cultural patterns and behaviors within urban environments, from electrification, conflict-induced migration, holidays, and more. According to the Table: VIIRS Country statistics of Thailand from 2013 to 2021 (see Table 0 in the Appendix,) the nighttime-light index of Thailand had been increasing continuously. From (Hu and Zhang, 2020) the nighttime-light index of the World is also increasing continuously.

GDP, or the Gross domestic product, according to Fernando (2021), is "the total monetary or market value of all the finished goods and services produced within a country's borders in a specific time period."

Figure 1: Annually Gross Domestic Product (GDP) per capita in Thailand from the World Bank



(See table 1 in the Appendix)

This figure shows the GDP of Thailand from 1970 to 2020. We can see that the Thailand GDP continuously increased until the financial crisis in 1997 and went back to increase in 2003. Even though both the trend of the Nighttime-light and GDP is increasing, there was a decrease in the GDP but there was not in the Nighttime-light. This means that there is a difference in the trend of GDP and Nighttime-light data and there could be errors if we use the Nighttime-Light as a proxy of the GDP. This made me curious that then, the fact that the nighttime-light can imply

economic growth, is this true? If it is true, then what is the range that it can imply. I want to know “Does the nighttime-light index really imply the GDP?” and if it is really can, “Could the Nighttime-Light Index be a good representative for the GDP of Thailand?” and those are my research questions.

Literature Review

There are many related researches to the usage of the nighttime-light data as a proxy for GDP, which can be separated into main 3 categories;

1) Literature related to the correlation between nighttime-light and GDP,
   - Xaquín et al. (2021) research found that even though there is the limited capacity to measure the economic activities in the highly densely forested areas, the Nighttime-Light Index shows a good proxy of economic activities from the empirical evidence from the rural area in Colombia.
   - Henderson et al. (2011) research found that, looking at the difference between the average for the first two years of their sample (1992 and 1993) and the last two (2005 and 2006), there is clearly a strong relationship between light growth and measured income growth, although there are a number of outliers. However, there are extremely large gaps in some countries in order to use the light to predict income growth.
   - Dai et al. (2017) result from the estimation of the relationship between nighttime-light data and GDP statistical data at the provincial and city levels in Mainland China shows that the accuracy of GDP estimation based on nighttime light data is affected by the resolution of the data and the spatial scale of the study area, as well as by the land cover types and industrial structures of the study area. They also suggest using the NPP/VIIRS nighttime light data rathan the DMSP/OLS data in order to estimate GDP because of the higher correlation between data.

● Agnihotri and Mishra (2021) regression analysis shows that there is a strong correlation between GDP and nighttime lights in India. They suggest using the nighttime lights as the tool to forecast the economic indicators.

● Gibson and Boe-Gibson (2021) found that NTL data were a less useful proxy for economic activity in less densely populated areas. They also suggest being careful in using NTL data as a proxy for economic activity.

● Määttä et al. (2021) research found that based on the data of Namibia, Nighttime-light data can be useful in measuring economic activity at the macro level. However, it is more useful at the local level. They also encourage the use of nighttime-light data in the very small spatial units.

● Xiao et al. (2021) research found that based on the data of China, there is a significant difference between the results of club convergence between NTL and GDP in both the size and the location of concentration. They also stated that the factors of regional convergence, technological innovation, and industrial structure have a significant impact on the nighttime-light data and GDP.

2) Literature related to the nighttime-light data

● Anna (2018) confirmed that the variation in the nighttime lights captures a substantial share of the variation in local development across very small units. She confirmed that nighttime light can capture human development as measured in household wealth, education and health. It can be the indicator of a relatively wealthy, well-educated and healthy population.

● Li et al. (2020) research stated that although there are uncertainties in NTL pixels with DN values lower than 10, the influence of these uncertainties in low-DN areas on applications is limited. They suggest that the nighttime-light has great potential for monitoring human activities, and also, long-term dynamics of human activities such as the carbon emission, electricity consumption, urban expansion, and light pollution across local, regional to global scales.

● Wang et al. (2021) found that the angular and atmospheric effects dominate retrieval uncertainty of Satellite observations of nighttime lights (NTL) from Suomi-NPP and NOAA-20 VIIRS Day/Night Band data.

● Hu and Zhang (2020) found that, from constructing a long time series global nighttime-light dataset from 1992 to 2017, combining the DMSP-OLS and NPP-VIIRS, they observed that Global nighttime lights have become brighter and become more uniform than before. Leading the trend by China, India, and the United States with the respective degree of increasing.

● Proville el al. (2017) research found that there is a high link between the night-time lights area on the one hand, and GDP, electricity consumption, and CO2 emissions on the other.

3) Other literatures,

● Chen et al. (2011) research found that the nighttime light data is likely to add value as a proxy for output for countries with poorer statistical systems more than those with higher statistical systems. That happens because there is high measurement error of the nighttime light data but there is low measurement error in the high quality or low missing data countries.

● Mellander (2015) research found that, as captured by density more than total population, total number of establishments, or total production or consumption in terms of wages, Night-time light might be a better proxy for the degree of urbanization. However, we should be careful when using the saturated light from the annual data series.

● Liu (2020) research stated that , from the data in 1982 to 2018 there is an unidirectional causal relationship between GDP and the primary energy consumption of the four major Asian countries: China, India, Japan and South Korea.

● Hakimah et al. (2019) research found that the electricity price elasticity is positive in the industrial sector but negative in the commercial sector and insignificant in the mining and agricultural sectors.

● Zhu et al. (2019) research stated that the nighttime-light data is more appropriate for estimating electric power consumption in developing countries, such as China, India, and others because there are some factors that need to be added in the model for estimating in the developed countries. Also, there is the strong existence of the light spillover effect that makes the estimation of socioeconomic indicators in the contiguous regions between developed countries and developing countries are not suitable.

Research Gap

Compared to the other research, unfortunately, in this research, there is a limitation on data accessibility for the country data of average nighttime-light, even though the data is very updated, the time series for the provinces is too short, and it is not sufficient for doing regression analysis. Moreover, the data for the GDP is the quarterly data. Even though i have the monthly nighttime-light data

Data and Methodology

For the research data, due to the limitation on data accessibility that i had identified in the before section, i had used the quarterly data of the Gross Domestic Product (GDP) of Thailand from the Office of the National Economic and Social Development Council (NESDEC) for the total number of 10 quarters or 30 months, from the second quarter of year 2019 until the third quarter of year 2021. And I collected and used the VIIRS nighttime-light data from the satellite. Since the data of the GDP is in the form of percentage roll-up quarterly number form but the Nighttime-Light Index is in the monthly form, hence i converted the Nighttime-Light Index from monthly to quarterly and do the percentage roll-up to make both indices to be in the same form. Next, I normalized the data in order to do the regression due to the range of the data.

For the regression model, I used the Ordinary Least Square Regression (OLS), or the linear regression function. That is,

OLS regression function: $Yi = \alpha+\beta Xi+Ui$

Where Yi = Dependent variable

α = Intercept of the model

β = Coefficient

Xi = Corresponds to i explanatory variable of the model

Ui = the random error with the expectation 0 and variance σ^2

With more explanatory variables of the model, the OLS regression function will be:

$$Yi = \alpha+\beta_1X_1 + \beta_2X_2 +\beta_3X_3 + \beta_4X_4+Ui$$

The dependent variable Y is the Thailand's Gross Domestic Product (GDP),
The independent variable X_1 is the Nighttime-Light Index of Bangkok, independent variable X_2 is the Nighttime-Light Index of Chonburi, independent X_3 is the Nighttime-Light Index of Chiang Mai and independent variable X_4 is the Nighttime-Light Index of Phuket and
Beta (β), is the degree of correlation coefficient of X, Nighttime-Light Index to Y, Gross Domestic Product, that I want to measure.

Result Analysis

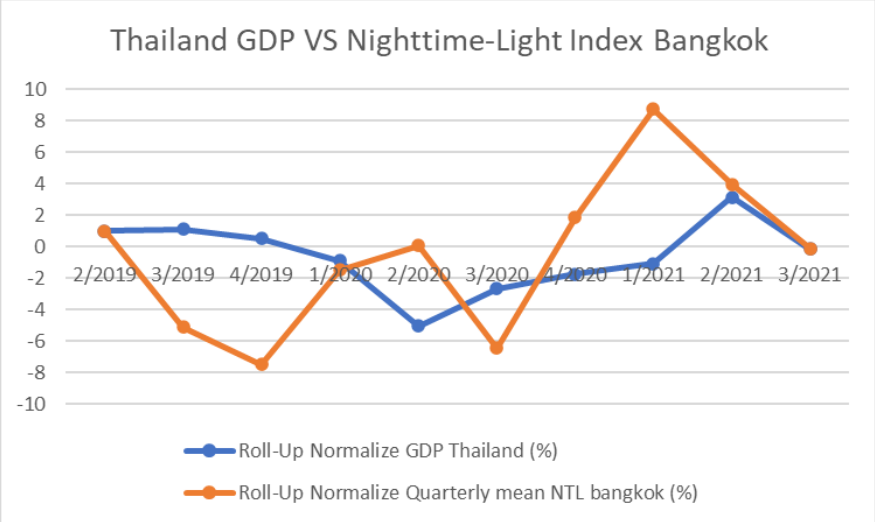
Table: The correlation coefficient (R square) between the percentage roll-up normalized quarterly Thailand Gross Domestic Product and Nighttime-Light Index of Bangkok, Chonburi, Chiang Mai and Phuket according to the quarterly data from the second quarter of year 2019 to the third quarter of year 2021.

	NTL Bangkok	NTL Chonburi	NTL Chiang Mai	NTL Phuket
Thailand GDP	0.00377847	0.003313624	0.137252017	0.041100228

(see the full regression table at Table 3,4,5 and 6 at the Appendix)

From the table, the correlation between Bangkok nighttime-light data and Thailand GDP is 0.00377847, the correlation between Chonburi nighttime-light data and Thailand GDP is 0.003313624, the correlation between Chiang Mai nighttime-light data and Thailand GDP is 0.137252017 and the correlation between Phuket nighttime-light data and Thailand GDP is 0.041100228. All of the correlation coefficients are positive.

Figure 3: Percentage roll-up normalized quarterly data of Thailand Gross Domestic Product and Bangkok Nighttime-Light Index from the quarter 2 of year 2019 until quarter 3 of year 2021.

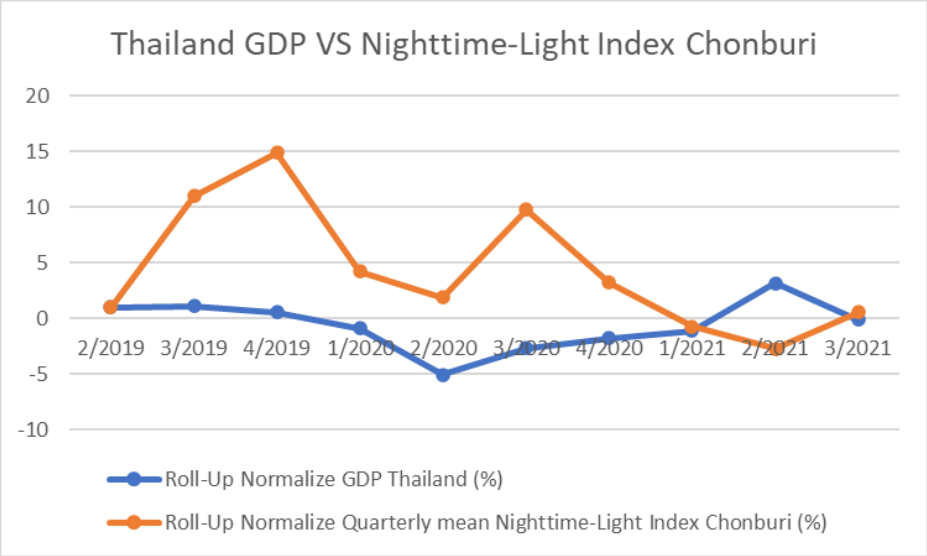


(see the full regression at Table 3 at the Appendix)

According to Figure 3, we could differentiate it into three sections of the time period, the first period is starting with the second quarter of the year 2019 and ending with the fourth quarter of the year 2019. This period is when the GDP and NTL went in the same direction. The second period is starting with the second quarter of the year 2019 and ends with the third quarter of the year 2020. This period is when the GDP and NTL went in the opposite direction. The third period is starting with the third quarter of the year 2020 until the latest data, third quarter of the year 2021. Overall, there are both positive and negative correlations, but higher in the positive, corresponding to the correlation coefficient.

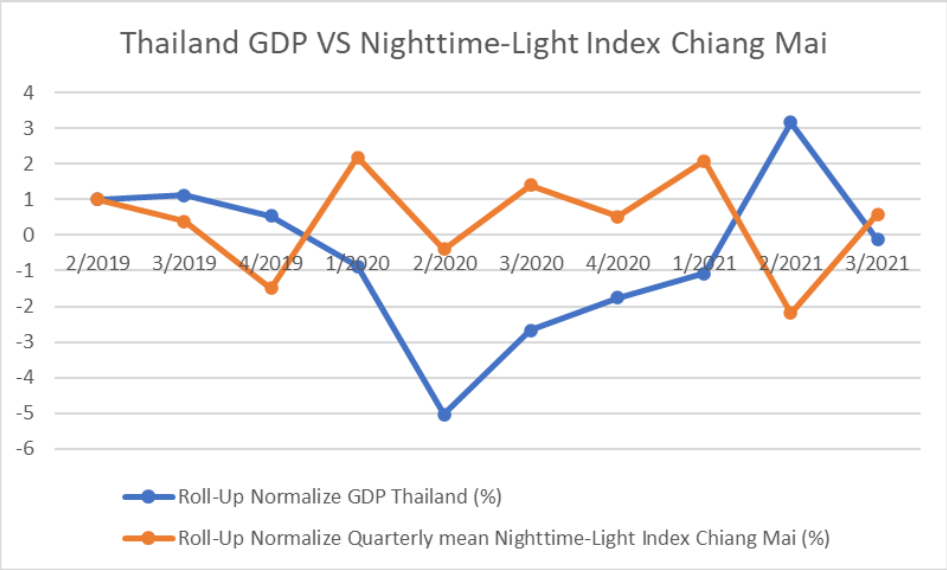
According to Figure 4, we could differentiate it into two sections of the time period, the first section is starting from the second quarter in 2019 until the third quarter of the year 2020. This is the period that both GDP and NTL went in the same way, in the other words, has a positive correlation to each other. The second section is starting from the third quarter of year 2020 to the latest data, third quarter of the year 2021. In this period, NTL and GDP has gone in the opposite direction, in the other words, has a negative correlation. Overall, there are both positive and negative correlations, but higher in the positive, corresponding to the correlation coefficient, but the correlation of Chonburi is a little bit lower than Bangkok's.

Figure 4: Percentage roll-up normalized quarterly data of Thailand Gross Domestic Product and Chonburi Nighttime-Light Index from the quarter 2 of year 2019 until quarter 3 of year 2021.



(see the full regression at Table 4 at the Appendix)

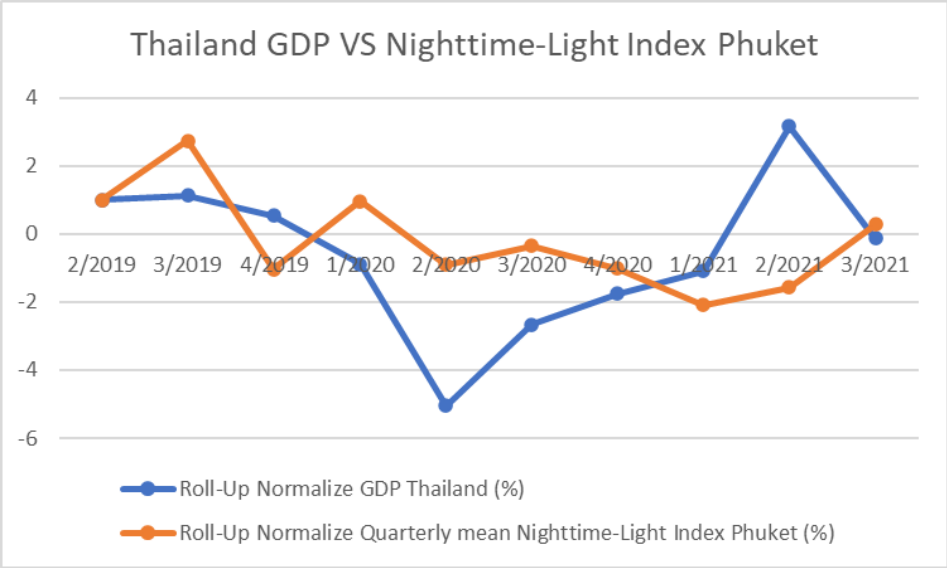
Figure 5: Percentage roll-up normalized quarterly data of Thailand Gross Domestic Product and Chiang Mai Nighttime-Light Index from the quarter 2 of year 2019 until quarter 3 of year 2021.



(see the full regression at Table 5 at the Appendix)

According to the Figure 5, we could differentiate it into 6 sections of the time period, the first section is starting from the second and end at the fourth quarter of the year 2019, same trend and positive correlation, the second section is starting from the fourth quarter of the year 2019 to the first quarter of year 2020, opposite trend and negative correlation, the third section is starting from the first and end at the third quarter of year 2020, same trend and positive correlation, the fourth section is starting from the third and end at the fourth quarter of year 2020, opposite trend and negative correlation, the fifth section is starting from the fourth quarter of year 2020 and end with the first quarter of the year 2021, and the sixth section that is starting from the first quarter until the third quarter of the year 2021. Overall, there are both positive and negative correlations, but higher in the positive, corresponding to the correlation coefficient, but the correlation of Chiang Mai is the highest among Bangkok, Chonburi, Chiang Mai and Phuket. However, even though it has the highest positive correlation, it is very volatile.

Figure 6: Percentage roll-up normalized quarterly data of Thailand Gross Domestic Product and Phuket Nighttime-Light Index from the quarter 2 of year 2019 until quarter 3 of year 2021.



(see the full regression at Table 6 at the Appendix)

According to the Figure 6, we could differentiate it into 6 sections of the time period, the first section is starting from the second to fourth quarter of year 2019, same direction and positive correlation, the second section is starting from the fourth quarter of year 2019 until the first quarter of year 2020, opposite direction and negative correlation, the third section is starting from the first to the third quarter of year 2020, same direction and positive correlation, the fourth section is starting from the third quarter of year 2020 to the first quarter of year 2021, opposite direction and negative correlation, the fifth section is starting from the first to the second quarter of year 2021, same direction and positive correlation, and the sixth section is starting from the second to the third quarter of year 2021. Overall, there are both positive and negative correlations, but higher in the positive, corresponding to the correlation coefficient, but even though Phuket is very volatile like Chiang Mai, it has a lesser correlation. Phuket has a higher correlation coefficient than Bangkok and Chonburi.

Conclusion

There is a positive correlation between nighttime-light data and GDP in Bangkok, Chonburi, Chiang Mai and Phuket, all of the sample provinces. However, even though all of the correlation is positive, it is not that high. Hence, based on this research, I suggest that we should not use nighttime-light as a proxy for the GDP directly. If we want to use it as a proxy for each other, we must be careful while using it and try to reduce the errors as much as possible.

However, because of the low number of data and short period of time in this research compile with the current situation, when COVID-19 disease is existing and spreading, the data might not be accurate enough to captured the correlation between nighttime-light and income growth as the data from a longer period of time.

Policy recommendations

- In order to estimate the income growth of Thailand, the government or who is in charge could use the nighttime-light as one of the tools for estimation since there is a positive correlation between nighttime-light data and GDP. But, they must be using it with care since there are some errors existing. As we can see in the results discussion, the data is not perfectly correlated, even volatile, and they are not correlated at a high degree.
- According to Dai (2015), since the errors in the ability of the nighttime-light data to predict the income growth is positively correlated with the width of the area, if the government or who is in charge want to use the nighttime-light data as a proxy for the income growth, they should divide it in as small area as possible. They might consider using it as each district to reduce the errors in the measurement, for example, using Bangkok nighttime-light data as the proxy of Bangkok's GDP or Chonburi nighttime-light data as the proxy of Chonburi's GDP. However, doing this will increase the cost of collecting data.

● Changing the price of the electricity bill might directly affect the electricity usage and the nighttime-light data. It might affect the GDP too but to a different degree. Because of this, the correlation between the nighttime light and GDP would be more volatile than before changing, increasing or decreasing. Hence, if we want to use the nighttime-light data as the proxy of GDP, we might not change the price of electricity bill too many times or we would need to do the research again to find the updated correlation.

Further improvement for this research

Because of the recentness of this research, I believe that this will be helpful for people that want to study in this field and adapt it with what they are currently doing. However, due to the lack of data, I cannot do a full research for a long period of time in many provinces. This might affect the accuracy of the analysis. In the future if there is more data available, it might be better if we consider doing this research again, at that time we might get the more accurate results and analysis and can use the data to adapt and do benefit to the many fields.

Bibliography

Agnihotri, J., & Mishra, S. (2021, February). Indian economy and Nighttime Lights. International Conference on Computational Intelligence and Knowledge Economy (ICCIKE). https://doi.org/10.1109/ICCIKE51210.2021.9410767

Bruederle, A., & Hodler, R. (2017). Nighttime Lights as a Proxy for Human Development at the Local Level. SSRN Electronic Journal. Published. https://doi.org/10.2139/ssrn.3013006

Chen, X., & Nordhaus, W. D. (2011). Using luminosity data as a proxy for economic statistics. Proceedings of the National Academy of Sciences, 108(21), 8589–8594. https://doi.org/10.1073/pnas.1017031108

Dai, Z., Hu, Y., & Zhao, G. (2017). The Suitability of Different Nighttime Light Data for GDP Estimation at Different Spatial Scales and Regional Levels. Sustainability, 9(2), 305. https://doi.org/10.3390/su9020305

Fernando, J. (2021, September 8). Gross Domestic Product (GDP). Investopedia. Retrieved December 16, 2021, from https://www.investopedia.com/terms/g/gdp.asp

Gibson, J., & Boe-Gibson, G. (2021). Nighttime Lights and County-Level Economic Activity in the United States: 2001 to 2019. Remote Sensing, 13(14), 2741. https://doi.org/10.3390/rs13142741

Hakimah, Y., Nugraha, A. T., Surya, A., Ananda, A. R. W., & Astuty, P. (2019). DOES THE ELECTRICITY CONSUMPTION DETERMINE THE ECONOMIC GROWTH AND ENERGY PRICES IN ASEAN COUNTRIES? Journal of Security and Sustainability Issues, 489–503. https://doi.org/10.9770/jssi.2019.9.2(10)

Henderson, V., Storeygard, A., & Weil, D. N. (2011). A Bright Idea for Measuring Economic Growth. American Economic Review, 101(3), 194–199. https://doi.org/10.1257/aer.101.3.194

Hu, Y., & Zhang, Y. (2020). Global Nighttime Light Change from 1992 to 2017: Brighter and More Uniform. Sustainability, 12(12), 4905. https://doi.org/10.3390/su12124905

Li, X., Zhou, Y., Zhao, M., & Zhao, X. (2020). A harmonized global nighttime light dataset 1992–2018. Scientific Data, 7(1). https://doi.org/10.1038/s41597-020-0510-y

Liu, W. C. (2020). The Relationship between Primary Energy Consumption and Real Gross Domestic Product: Evidence from Major Asian Countries. Sustainability, 12(6), 2568. https://doi.org/10.3390/su12062568

Määttä, I., Ferreira, T., & Leßmann, C. (2021). Nighttime lights and wealth in very small areas: Review of Regional Research. Published. https://doi.org/10.1007/s10037-021-00159-6

Mellander, C., Lobo, J., Stolarick, K., & Matheson, Z. (2015). Night-Time Light Data: A Good Proxy Measure for Economic Activity? PLOS ONE, 10(10), e0139779. https://doi.org/10.1371/journal.pone.0139779

NASA. (2021, May 18). Nighttime Lights | Earthdata. EARTHDATA. Retrieved December 16, 2021, from https://earthdata.nasa.gov/learn/backgrounders/nighttime-lights

Office of the National Economic and Social Development Council. (n.d.). QGDP Dashboard. Google Data Studio. Retrieved November 19, 2021, from https://datastudio.google.com/reporting/52a283c8-91f9-4b35-8157-2b2b42312602/page/p_ny1bybg6oc

Pérez-Sindín, X. S., Chen, T. H. K., & Prishchepov, A. V. (2021). Are night-time lights a good proxy of economic activity in rural areas in middle and low-income countries? Examining the empirical evidence from Colombia. Remote Sensing Applications: Society and Environment, 24, 100647. https://doi.org/10.1016/j.rsase.2021.100647

Proville, J., Zavala-Araiza, D., & Wagner, G. (2017). Night-time lights: A global, long term look at links to socio-economic trends. PLOS ONE, 12(3), e0174610. https://doi.org/10.1371/journal.pone.0174610

Thailand - Place Explorer - Data Commons. (n.d.). Data Commons. Retrieved December 2, 2021, from https://datacommons.org/place/country/THA?utm_medium=explore&mprop=amount& popt=EconomicActivity&cpv=activitySource%2CGrossDomesticProduction&hl=en

Wang, Z., Román, M. O., Kalb, V. L., Miller, S. D., Zhang, J., & Shrestha, R. M. (2021). Quantifying uncertainties in nighttime light retrievals from Suomi-NPP and NOAA-20 VIIRS Day/Night Band data. Remote Sensing of Environment, 263, 112557. https://doi.org/10.1016/j.rse.2021.112557

Xiao, Q. L., Wang, Y., & Zhou, W. X. (2021). Regional Economic Convergence in China: A Comparative Study of Nighttime Light and GDP. Frontiers in Physics, 9. https://doi.org/10.3389/fphy.2021.525162

Zhu, Y., Xu, D., Ali, S. H., Ma, R., & Cheng, J. (2019). Can Nighttime Light Data Be Used to Estimate Electric Power Consumption? New Evidence from Causal-Effect Inference. Energies, 12(16), 3154. https://doi.org/10.3390/en12163154

Appendix

Table 0: VIIRS Country statistics of Thailand from year 2013 to 2021

Year	Pixel count	Sum	Rad. / 1000 pop.	Mean
2013	2,516,654	1,371,107	20.7	0.5684
2014	2,516,654	1,439,853	21.7	0.5969
2015	2,516,654	1,527,237	23	0.6331
2016	2,516,654	1,644,118	24.8	0.6816
2017	2,516,654	1,686,722	25.4	0.6993
2018	2,516,654	1,740,320	26.2	0.7215
2019	2,516,654	1,936,923	29.2	0.803
2020	2,516,654	1,955,496	29.5	0.8107
2021	2,516,654	2,117,769	31.9	0.878

Table 1: Annual GDP of Thailand since year 1960 to year 2020 from the World Bank

Year	GDP Per Capita	Year	GDP Per Capita	Year	GDP Per Capita
2020	7189.041835	2000	2007.735271	1980	682.9299728
2019	7817.011522	1999	2033.258009	1979	589.88506
2018	7296.879608	1998	1845.82887	1978	528.6267551
2017	6593.818352	1997	2468.18473	1977	445.4208525
2016	5993.305516	1996	3043.980314	1976	391.5693898
2015	5840.053067	1995	2846.586834	1975	351.6193358
2014	5951.883487	1994	2491.427836	1974	332.1752699
2013	6168.261356	1993	2209.36303	1973	269.8879592
2012	5860.581471	1992	1927.882603	1972	209.3747807
2011	5492.1215	1991	1716.41542	1971	194.266671
2010	5076.339872	1990	1508.94247	1970	192.127686
2009	4213.006654	1989	1295.464722	1969	186.8791675

2008	4379.658787	1988	1123.437643	1968	174.7847538
2007	3973.017172	1987	936.7804583	1967	166.9230634
2006	3369.543198	1986	813.4515045	1966	161.0055216
2005	2894.062656	1985	747.7034373	1965	137.9186467
2004	2660.126835	1984	818.0389335	1964	125.9386942
2003	2359.116831	1983	798.0804499	1963	118.143907
2002	2096.187802	1982	742.8512326	1962	113.7828498
2001	1893.264239	1981	721.0593448	1961	107.498001
				1960	100.767475

Table 2.5: Relationship between GDP and Nighttime-Light Index for Bangkok, Chonburi, Chiang Mai and Phuket

Quarter/Year	Roll-Up Normalize GDP Thailand (%)	Roll-Up Normalize Quarterly mean NTL bangkok (%)	Roll-Up Normalize Quarterly mean Nighttime-Light Index Chonburi (%)	Roll-Up Normalize Quarterly mean Nighttime-Light Index Chiang Mai (%)	Roll-Up Normalize Quarterly mean Nighttime-Light Index Phuket (%)
2/2019	1	1	1	1	1
3/2019	1.125	-5.110542829	11.01697664	0.392073681	2.738922825
4/2019	0.541666667	-7.47537374	14.90464312	-1.493384297	-1.033752799
1/2020	-0.875	-1.460929603	4.232145247	2.192266832	0.967879942
2/2020	-5.041666667	0.076578883	1.903285073	-0.393501807	-0.893977882
3/2020	-2.666666667	-6.430741507	9.754594148	1.40930199	-0.342890142
4/2020	-1.75	1.847508765	3.214301134	0.523741129	-1.015513518
1/2021	-1.083333333	8.74802493	-0.743586048	2.094156835	-2.086035541

2/2021	3.166666667	3.951959033	-2.724322325	-2.186580232	-1.562220307
3/2021	-0.125	-0.088246612	0.532988668	0.59369302	0.288393487

Table 3: Regression data between the percentage Roll-Up Normalize Quarterly mean Bangkok NTL and the percentage Roll-Up Normalize Thailand GDP

SUMMARY OUTPUT								
			Y - Roll-Up Normalize Thailand GDP(%)					
Regression Statistics			X - Roll-Up Normalize Quarterly mean NTL bangkok (%)					
Multiple R	0.061469							
R Square	0.003778							
Adjusted R Square	-0.12075							
Standard Error	2.416042							
Observations	10							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	1	0.177116	0.177116	0.030342	0.866043			
Residual	8	46.69806	5.837257					
Total	9	46.87517						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-0.5568	0.768256	-0.72476	0.489253	-2.3284	1.214801	-2.3284	1.214801

X Variable 1	0.028398	0.163031	0.174191	0.866043	-0.34755	0.404349	-0.34755	0.404349

Table 4: Regression data between the percentage Roll-Up Normalize Quarterly mean Chonburi NTL and the percentage Roll-Up Normalize Thailand GDP

SUMMARY OUTPUT								
			Y - Roll-Up Normalize Thailand GDP (%)					
Regression Statistics			X - Roll-Up Normalize Quarterly					
Multiple R	0.057564		mean Chonburi Nighttime-Light Index(%)					
R Square	0.003314							
Adjusted R Square	-0.12127							
Standard Error	2.416605							
Observations	10							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	1	0.155327	0.155327	0.026597	0.874495			
Residual	8	46.71985	5.839981					
Total	9	46.87517						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-0.47181	0.97606	-0.48338	0.641779	-2.72261	1.778992	-2.72261	1.778992
X Variable 1	-0.02298	0.140912	-0.16309	0.874495	-0.34792	0.301962	-0.34792	0.301962

Table 5: Regression data between the percentage Roll-Up Normalize Quarterly mean Chiang Mai NTL and the percentage Roll-Up Normalize Thailand GDP

SUMMARY OUTPUT								
			Y - Roll-Up Normalize Thailand GDP (%)					
Regression Statistics			X - Roll-Up Normalize Quarterly					
Multiple R	0.370475		mean Chiang Mai Nighttime-Light Index(%)					
R Square	0.137252							
Adjusted R Square	0.029409							
Standard Error	2.248373							
Observations	10							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	1	6.433712	6.433712	1.272696	0.291955			
Residual	8	40.44146	5.055183					
Total	9	46.87517						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-0.32663	0.74322	-0.43948	0.671946	-2.0405	1.387241	-2.0405	1.387241
X Variable 1	-0.59104	0.52391	-1.12814	0.291955	-1.79918	0.617096	-1.79918	0.617096

Table 6: Regression data between the percentage Roll-Up Normalize Quarterly mean Phuket NTL and the percentage Roll-Up Normalize Thailand GDP

SUMMARY OUTPUT								
			Y - Roll-Up Normalize Thailand GDP (%)					
Regression Statistics			X - Roll-Up Normalize Quarterly					
Multiple R	0.202732		mean Phuket Nighttime-Light Index(%)					
R Square	0.0411							
Adjusted R Square	-0.07876							
Standard Error	2.370353							
Observations	10							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	1	1.92658	1.92658	0.342895	0.574306			
Residual	8	44.94859	5.618574					
Total	9	46.87517						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-0.50901	0.756971	-0.67243	0.520256	-2.25459	1.236568	-2.25459	1.236568
X Variable 1	0.318815	0.54445	0.585572	0.574306	-0.93669	1.57432	-0.93669	1.57432