

The Influence of Country Size and Population on Country GDP

Xiangyong Li*

Rensselaer Polytechnic Institute, Troy, NY, US

*Corresponding author: lix45@rpi.edu

Abstract. Gross National Product is the key to reflecting whether a country is strong or not, so many people are very concerned about what conditions GDP is based on. This is also a matter of national concern, so it is possible to know which factors contribute to a country's GDP, and thus the country can judge whether to strengthen these factors. This study focuses on the impact of country size and population on national GDP, so this experiment uses the OLS framework to predict the impact of country size and population on ITS GDP. At the same time, the impact of country size and population on GDP is obtained by recording and calculating. The impact of different factors on GDP is observed by comparison. China adopts the completely random sampling method to select 60 countries from all over the world for investigation and analysis, without personal factors, which can better ensure the accuracy of the results and thus reduce the error. When choosing countries, small countries or countries with small populations are always on the waiting list, ready to be chosen randomly. Through this experiment, we know that population has a more significant effect on the GDP of a country than the size of the country. Of course, this does not mean that the size of the country does not matter. Since the population is a necessary component of our traditional measurement and calculation of GDP, this experiment also proves that the impact of population on GDP is indispensable.

Keywords: Country size; Population; GDP.

1. Introduction

Whenever people want to describe or introduce a country, they may think of population, area, and GDP for the first time. However, it is difficult to say with any certainty and accuracy whether these factors are interrelated or interactional. Many studies or online sources show that population negatively correlates with national GDP per capita. According to the formula, national GDP per capita equals total GDP divided by population. However, theories about GDP tend to emphasize big countries or countries with strong international influence rather than small or obscure ones. Therefore, it does not consider all countries in the world (regardless of size, population, and influence). The population is the primary productive force and labor force of a country. In addition to population, GDP is a demonstration and essential indicator of a country's economic strength and development, so GDP reflects a country's national strength and economic strength. At the same time, each country's GDP is generated from each person's labor and productivity. In this way, a country's GDP can tell others about the quality of life of individuals in that country. Of course, the size of a country is also an essential factor in the embodiment of a country's economic strength. Large areas of the country will have various advantages in resource retention and storage. There will be more resources available to the country so that the development of the country's economy and overall national strength will be significantly improved. The greater the available area of a country, the more people it can live in. This may improve people's quality of life and development. However, the national land area is also large and small in countries with known high GDP. Therefore, it is difficult for us to draw the relationship between national land area and GNP directly.

Moreover, some countries are small in size, but their population is much larger than other countries of the same size. As a result, the relationship between population and GDP cannot be calculated. As a result, there is no way to determine the relationship between population, area, and GDP. In this case, through the use of macro data to carry out a specific study on the relationship between these three factors, it is necessary to investigate and according to the statistical data of countries in the world to find out whether these factors are related and how relevant, and finally draw a conclusion.

At the beginning of the 21st century, BRICS countries (Brazil, Russia, India, China, and South Africa), were the new giants of the fast-growing world economy. The BRICS countries cover a total area of 39,746,220 km², which is 26% of the world's territory, and their total population is 3.23 billion people, which is over 40% of the world population (United Nations, 2019). The BRICS countries stand out for their GDP growth rate, which averaged 7.9% from 2000 to 2010 and will increase to 8.1% between 2011 and 2015. Due to the fact that BRICS countries have a significant share of the global population and land area and are one of the main drivers of world economic growth, BRICS countries have in common a large territorial area and a large population [1, 2, 3].

But look back between the late 1960s and the 1990s, four small East Asian economies developed rapidly: Taiwan, Korea, Singapore, and Hong Kong. Their total land area is not as large as any of the BRICS countries, but their GDP is not low. Large land areas can more easily provide more natural resources, but managing public services and modes of transportation can become difficult and expensive. But a large population provides labor and a large domestic market with economies of scale, and vice versa, perhaps because a large population may occupy a small territory densely [1, 4, 5]. As in East Asia, where the land area is small but the population density is high, and the management of public services and modes of transportation may be easier and less costly with a more concentrated labor force [6, 7].

Harley addressed that a larger landmass does not always lead to larger GDP [8]. The paper compared the major world powers: Russia, China, the United States, and the European Union, and find out that Russia has a very low GDP with a higher land mass compared to others. It then took an insight into the GDP per kilometer squared to see if there are certain relations between the country's size and GDP. He concluded that there is no direct relation between them, at least for the very largest countries in the world. This finding though gives us insight into the variable we should compare, it did not use other tools to find the relation such as linear regression, logistic regression, and so on.

Alesina demonstrated that there are multiple benefits of having large country size such as: the per capita cost of many public goods is lower in larger countries, and the size of a country affects the size of its market, and so on [9]. Though some of them might not be true for the very largest countries such as Russian, it still gives us intuition that country size has some relation with the growth of GDP, though it might be small.

Jinill in 2016 illustrated a point that demographic changes account for a significant portion of growth slowdown in several OECD economies in recent years [10]. At the same time, Jinill used OLS model to make a prediction that demographics factors will continue to restrain GDP growth for a few years at least in most cases.

2. Methodology

To study the relationship between national size, population, and GDP, 60 countries were randomly selected from 195 countries in the world. The purpose of such random selection is to avoid bias and other effects mentioned at the beginning, which can greatly reduce the error. Because countries with high GDP may have different characteristics and play a leading role in economic growth, such as international trade, national policies, taxation, etc [4, 5]. Then the data on population, country size, and GDP of these 60 countries are collected and recorded. At the same time, the OLS model is used to check any relationship between these variables, and a relationship is constructed, “C” represents the country size; “P” represents the population in the formula; “u” represents other factors that have effects on GDP; B₀ represents a constant for GDP; B₁ represents the correlation between country size and GDP; B₂ represents the correlation between population and GDP; B₃ represents the correlation combined population and country size with GDP. The formula (1) shows the respective and common correlations of population and country size on GDP [11]:

$$GDP = B_0 + B_1 \times C + B_2 \times P + B_3 \times C \times P + u. \quad (1)$$

To test whether the country size and GDP are related: First, assume that the two variables are related, and then use the built-in formula of Excel to conduct a t-test analysis on the data, and according to the results obtained, get a p-value that can prove the correlation of the two variables. Then compare the coefficient B1 of the country size and the p-value between the country size and GDP with 0.05. If the final result proves that the P-value is less than 0.05, it indicates that the initial assumption is true. At the same time, it can be proved that the two variables of country size and GDP are related. Then check the R square data, and judge the impact of variable country size on GDP according to the size of the R square. Similarly, according to the country size of the first variable, use the same method to infer whether the population of the second variable and the interaction term between the country size and population of the third variable have a correlation and influence on GDP.

Because there is a certain correlation between the two variables of country size and population: a larger country size often means a larger population. We want to conduct two separate tests on each variable to avoid multidisciplinary problems. Therefore, the OLS model is used to establish two relationships between national size and population, and GDP, Formula (2) and Formula (3) respectively show the correlation between the two factors, population and country size, on GDP:

$$\text{GDP} = B_0 + B_1 \times C + u. \quad (2)$$

$$\text{GDP} = B_0 + B_2 \times P + u. \quad (3)$$

3. Results and Discussion

According to the collected data on population, country size, and GDP of 60 countries, the collected data will be recorded, and the calculated data will be combined with the previous data to analyze the impact of population and country size on GDP. Determine whether the population and national size are related to GDP by calculating the values of coefficients and p-value, and then judge the impact of population or national size on GDP according to the data of R^2 .

3.1 Analysis impact of Population on GDP

First of all, the relationship between population and GDP is shown in Table 1, the p-value of population calculated by the formula (3) is 0.0000000562, so it can be concluded that there is a correlation between population and GDP and there is a significant coefficient, the coefficient is 0.00000471. From the standard error of the population is 0.000000689, it can be seen that the error generated in the real calculation process is very small, which can ensure that the coefficient will not deviate too much, thus affecting the final experimental results. At the same time, by observing the R^2 in Table 2, we can see the influence degree and linear relationship of the population on GDP. Because we know that the value range of R^2 is [0, 1], and the closer the value of R^2 is to 1, the more GDP tends to be linear in the image, and vice versa. The value of the R^2 obtained in the experiment is 0.446, which shows that the impact of demographic factors on GDP is about 44%. From this data, we can see that the impact of population on national GDP accounts for the vast majority of all factors that can reflect GDP.

Table 1. Analysis of correlation between population and GDP.

	Coefficients	Standard Error	P-value	t Stat	Lower 95%	Upper 95%
Intercept	6.604	22.892	0.774	0.289	-39.219	52.429
Population	4.71×10^{-6}	6.89×10^{-7}	5.62×10^{-9}	6.832	3.33×10^{-6}	6.09×10^{-6}

Table 2. Regression analysis of population.

	R^2	Multiple R^2	Adjusted R^2	Standard Error	Observation
Regression Statistics	0.446	0.668	0.436	148.206	60

Moreover, in Figure 1, it can be seen that the GDP image tends to be linear in the early stage, but the later data becomes very scattered. This also proves that the impact of population on GDP is only 44%. If the impact is 100%, the GDP in the image will show a completely linear distribution.

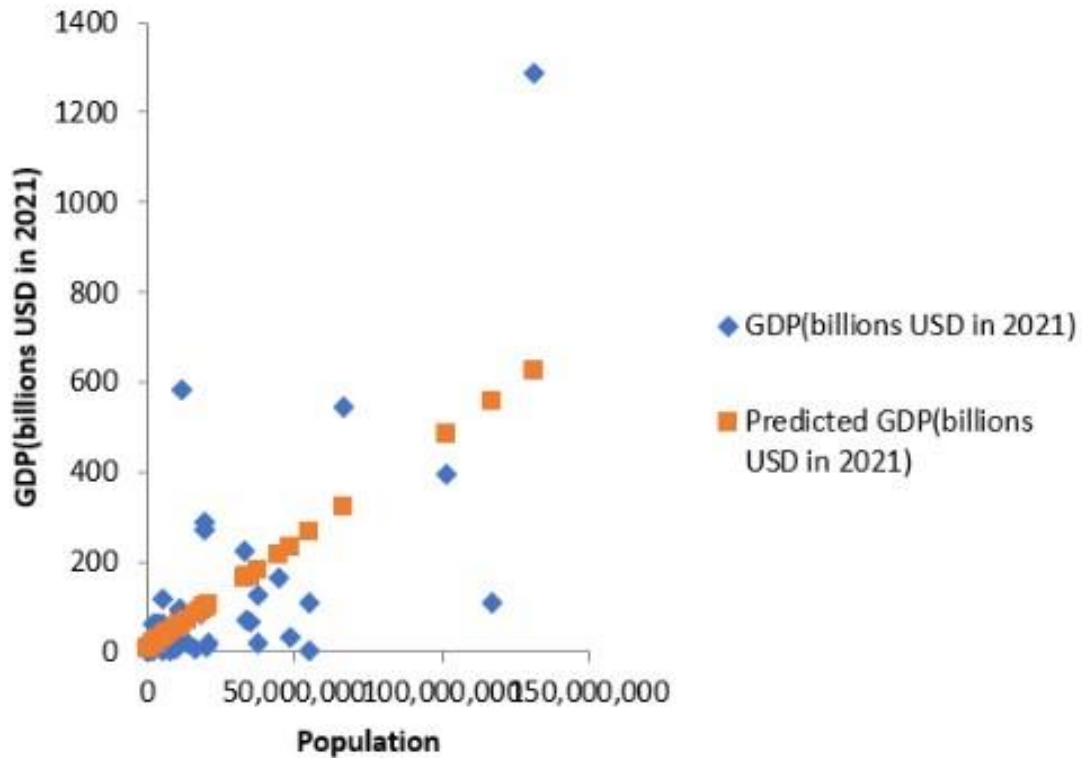


Fig 1. Relation between population and GDP.

3.2 Analysis Country Size affect GDP

Examine the relationship between national size and GDP. In formula (2), the p-value of the national scale is 0.000912, so it can be proved that there is a correlation between the national scale and GDP, and there is a significant coefficient, which is 0.000145. The standard error here is 0.0000414, which is also very small, which can ensure the accuracy of the data results. According to the influence of the value of R Square on GDP mentioned above and the display in the image, combined with the data of 0.174 obtained in Table 4, it can be seen that the influence of national size on GDP is about 17%.

Table 3. Analysis of correlation between country size and GDP.

	Coefficients	Standard Error	P-value	t Stat	Lower 95%	Upper 95%
Intercept	40.606	27.672	0.148	1.467	-14.785	95.997
Country Size	1.45×10^{-4}	4.14×10^{-5}	9.12×10^{-4}	3.496	6.19×10^{-5}	2.28×10^{-4}

Table 4. Regression analysis of Country Size.

	R ²	Multiple R ²	Adjusted R ²	Standard Error	Observation
Regression Statistics	0.174	0.417	0.159	180.942	60

At the same time, it can be seen in Figure 2 that the line fit plot of GDP is basically in a decentralized state, and very few tend to be linear. Thus, comparing the impact of population and country size on GDP, the population has a more significant impact on GDP to a certain extent. Of course, although the impact of national size on GDP is not as great as that of population, the impact of national size is also greater than 10%. This has also become an influential factor that cannot be ignored.

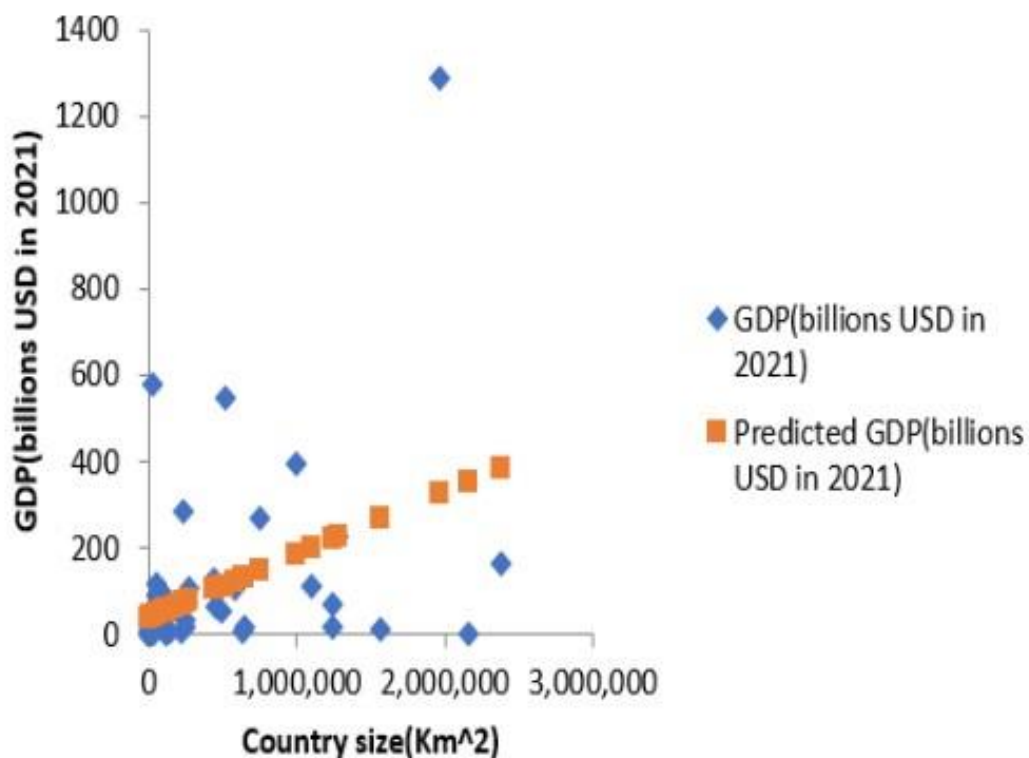


Fig 2. Relation between Country Size and GDP.

3.3 Combined with the impact of population and country size on GDP

Next, it examines the relationship and impact between population and country size data and GDP. Formula (1) is used here, and the same method is used here to analyze according to the three data of coefficient, p-value, and R square. Thus, in Table 5, the values of coefficients and p-value obtained by combining the data of population and country size are 0.000000000000426 and 0.0000193 respectively, which proves that the combination of population and country size also has a significant coefficient with GDP. Here you can see the standard error, 0.0000000000000912, is much smaller than the previous two experimental data. Combining the values of standard error and R square in Table 5 and Table 6, it can be shown that in addition to population and country size, few factors can affect GDP, or the degree of impact is smaller than that of country size. Because according to the value of R square, the combined impact of these two factors on GDP accounts for about 60%. This also proves that the greater the impact on GDP, the value of R square will tend to 1 and tend to a linear relationship.

Table 5. Population and Country Size combined with data analysis.

	Coefficients	Standard Error	P-value	t Stat	Lower 95%	Upper 95%
Intercept	50.618	22.896	0.0312	2.211	4.752	96.485
Country Size	-6.1×10^{-5}	3.95×10^{-5}	0.129	-1.539	-1.4×10^{-4}	1.83×10^{-5}
Population	-1.8×10^{-8}	1.18×10^{-6}	0.988	-0.0154	-2.4×10^{-6}	2.35×10^{-6}
P X S	4.26×10^{-12}	9.12×10^{-13}	1.93×10^{-5}	4.669	2.43×10^{-12}	6.09×10^{-12}

Table 6. Regression analysis combined with Population and Country Size.

	R ²	Multiple R ²	Adjusted R ²	Standard Error	Observation
Regression Statistics	0.604	0.777	0.583	127.465	60

3.4 Summary of Analysis

Finally, through these three experiments, we can get that the impact of different factors on national GDP is completely different. However, it can be seen that population and country size have a greater

impact on GDP than all other impacts combined. Then, when comparing the population with the size of the country, the proportion of the population is larger than the size of the country. It can be concluded that the population is the foundation of a country and an indispensable part of the country. From a historical point of view, first of all, there must be people, and places with people can become the territory of this country, and then can be counted on the national scale. This shows that to a certain extent, the impact of national size on GDP may be partly due to population. This is a topic and research that we can further discuss later

4. Conclusion

In general, the OLS model shows that there is a certain relationship between a country's land area, population and country size, and GDP. To avoid bias in trade policy, population density, culture, and other aspects, countries are excluded from the analysis, so our model cannot be said to apply to every country in the world. Because there are exceptions to everything, there are also developed countries with small country size and a small population in the world. For example, San Marino, a European country, has an area of 62 square kilometers and a population of only 30000, but its per capita GDP is as high as \$59000. Everyone living here can be called a rich man, and its unemployment rate can be ignored nationwide. Similar countries include Singapore, Switzerland, Norway, and other countries. Therefore, it is impossible to generalize that the experimental results are perfect according to the random sampling of 60 countries. On the other hand, in addition to population and country size, it is recognized that other factors play a role and have an impact on the growth or decline of GDP. For example, how is the construction of the transportation system and how is the management of public services.

To sum up, the OLS model can be applied to most countries and can show the relationship between population, country size, and GDP, but there are many factors affecting GDP growth, or whether the impact of population and country size on GDP overlaps. For example, what is the impact of country size on GDP due to population? These need further research.

References

- [1] Alouini Olfa. Country size, economic performance and volatility, *Revue de l'OFCE*, 2019/4, (164), p.139-163.
- [2] PopulationU. Research papers on Population dynamics and social affairs. 2019-2022. URL: <http://www.populationu.com/gen/countries-by-gdp>
- [3] Largest Countries in the World (by area). List of countries (and dependencies) ranked by area. URL: <https://www.worldometers.info/geography/largest-countries-in-the-world/>
- [4] Hervé Boulhol, Alain de Serres and Margit Molnar, *The Contribution of Economic Geography to GDP per Capita*, ISSN 1995-2848, *OECD Journal: Economic Studies*, Volume 2008.
- [5] Peterson EWF. *The Role of Population in Economic Growth*. SAGE Open. October 2017.
- [6] Salmond R. *Size Matters for Growth: Government Size, Country Size, and GDP Growth*. 2006.
- [7] Wacziarg R, Alesina A. Openness, country size and government. *Journal of Public Economics*, 1998.
- [8] Harley Hahn, *GDP and the Physical size of a Region, Understanding Gross Domestic Product: Part Eight*, 2014/11.
- [9] Alesina, Alberto. The size of countries: Does it matter? *Journal of the European Economic Association* 1, 2003, no. 2-3: 301-316.
- [10] Jinill Kim. *The Effects of Demographic Change on GDP Growth in OECD Economies*, IFDP Notes. Washington: Board of Governors of the Federal Reserve System, 09/28/2016.
- [11] World Bank national accounts data, and OECD National Accounts data files. URL: https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?most_recent_value_desc=true