Life Expectancy Is About More than GDP

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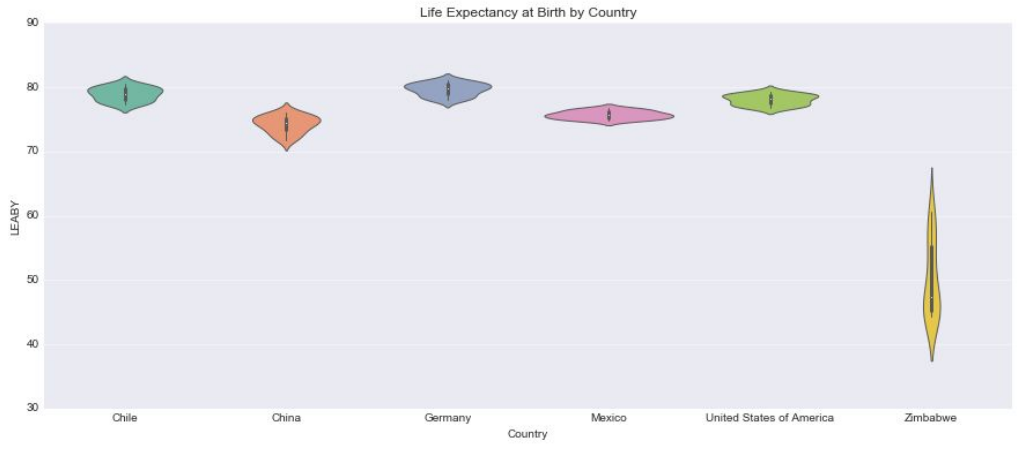
International leaders may assume that the key to extending their citizens' life spans is to grow their nation's economies. Although a more robust economy may benefit the country in some ways, improved health is not a guarantee. There may be other unstudied factors contributing to the citizens' longevity.

Data from the World Bank and World Health Organization from demonstrates that a tenuous relationship between a country's GDP (a common measure of an economy's size), and life expectancy (a common measure of health). GDP is a measure of the value of country's entire output of goods and services within year. However, the *GDP per capita* may be more illuminating statistic on health. GDP per capita is the value of a country's economy divided by the country's population. GDP per capita is a more accurate measure for a country's relative wealth because it controls for the size of the country. Traditionally, a country's level of development is classified based on its GDP *per capita*. According to World Bank, a country is defined as a high-income or developed economy if its GDP per capita is above $12,000.

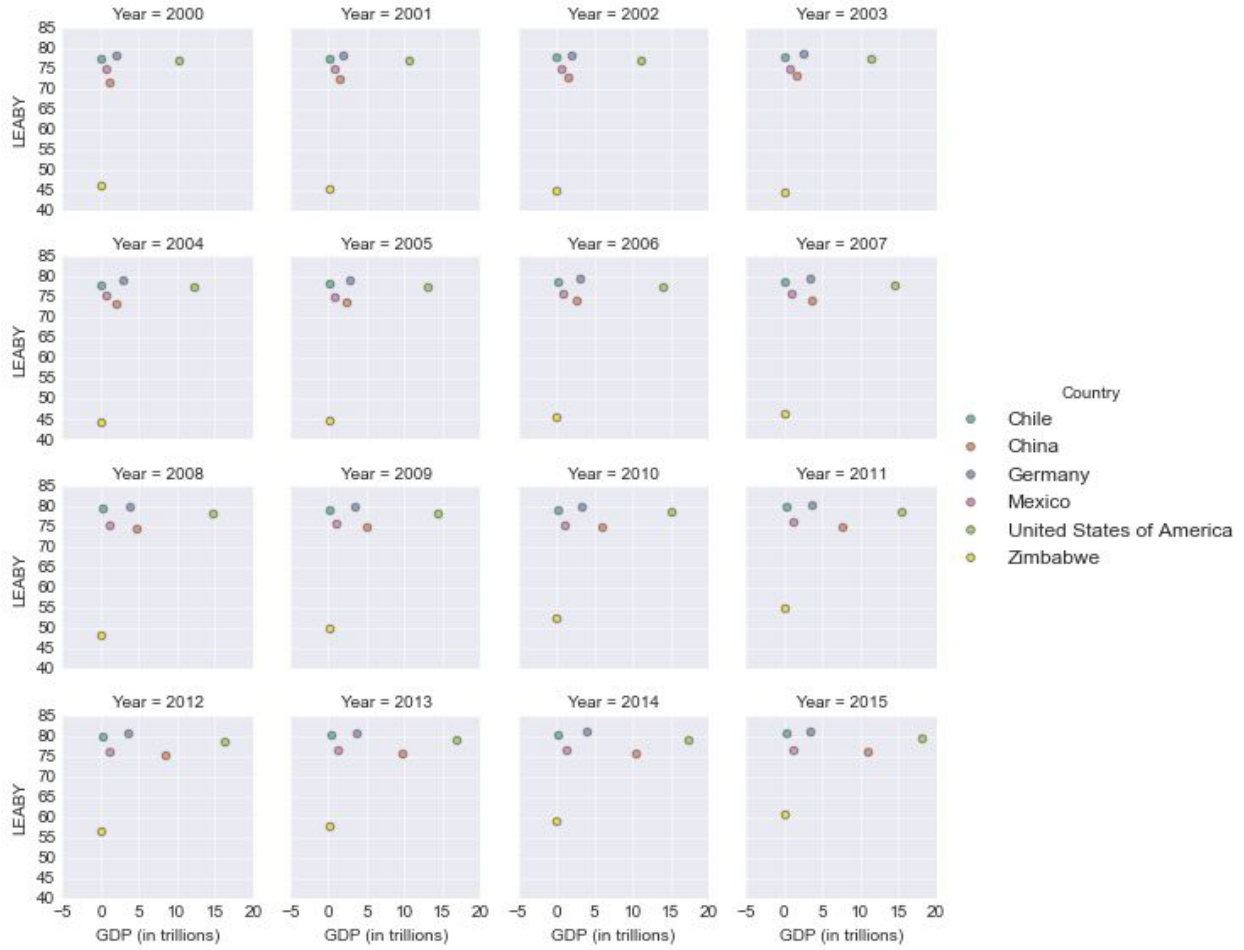
Before diving into driving factors of health, let's simply examine how life expectancy has varied across countries over the years. The graph below shows the distribution of life expectancy from 2000-2015 in six countries at various stages of development: Chile, China, Germany, Mexico, U.S., and Zimbabwe.



Among these countries, Germany and Chile and the United States have the highest life expectancies in the high 70s to low 80s. Following closely behind, Mexico and China have life expectancies in the low-to-mid 70s. In contrast, Zimbabwe has seen dramatic changes

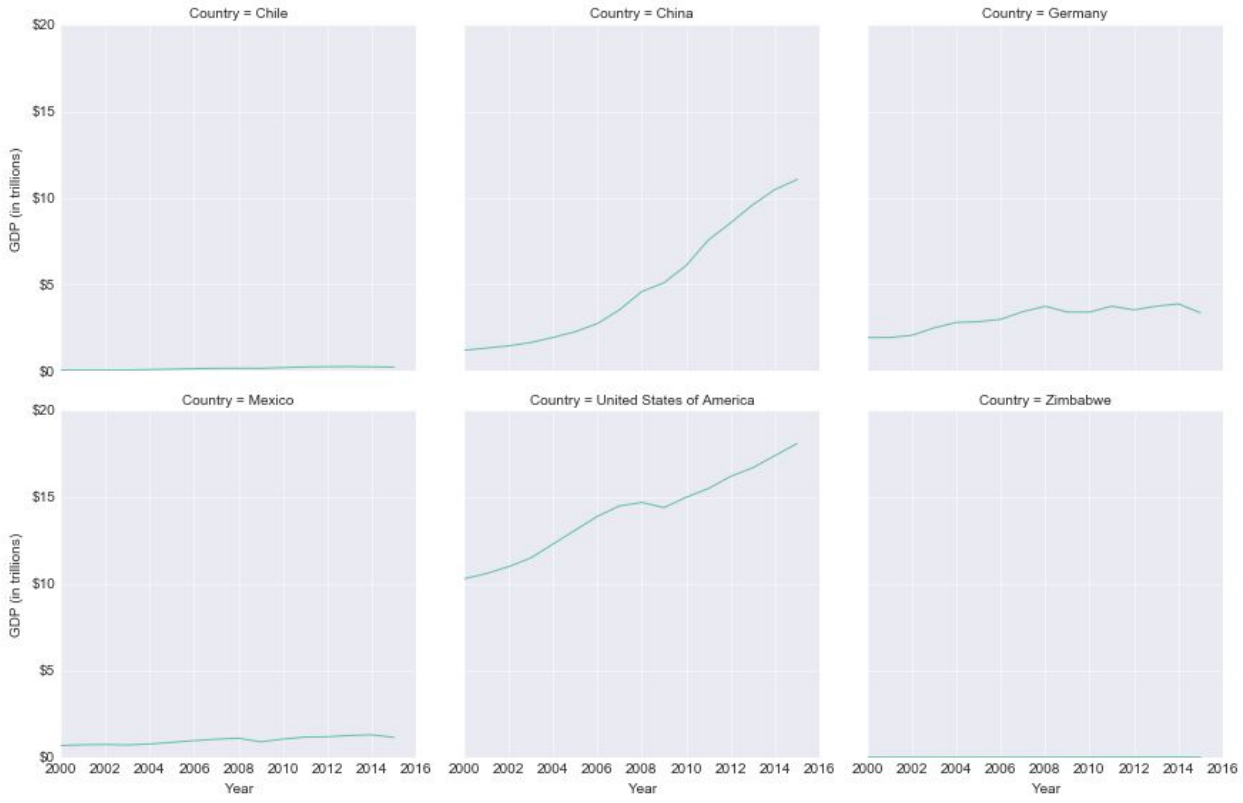
in its life expectancy in this fifteen year period: the life expectancy ranges from the high 30s to the high 60s in this period. This wide range in Zimbabwean life expectancies indicates events in the nation's history during this period. Some other nuances to appreciate include: Mexico's life expectancy is particularly stagnant (concentrated at median values), and China began at a lower starting point than other mid-developed countries, but is progressing at a faster rate.

Although the violin plots provide us some insight into the patterns in the data, we can take another cross-section by using FacetGrids. These plots show each country's GDP and life expectancy for each year of study. You can examine each country's progress by examining the movement of it's point throughout the years.



As you can see, China experiences the most dramatic change in GDP (the x-axis) – moving from $2 trillion to $12 trillion in fifteen years. However, despite China's incredible rate of GDP growth, its rate of change of life expectancy did not significantly exceed that of other nations. Additionally, Zimbabwe made dramatic improvements in life expectancy at birth (the y-axis) – after stagnating in the early 2000s, Zimbabwe's life expectancy begins to steadily improve after 2008. However, Zimbabwe's dramatic improvement in life expectancy did not concur with

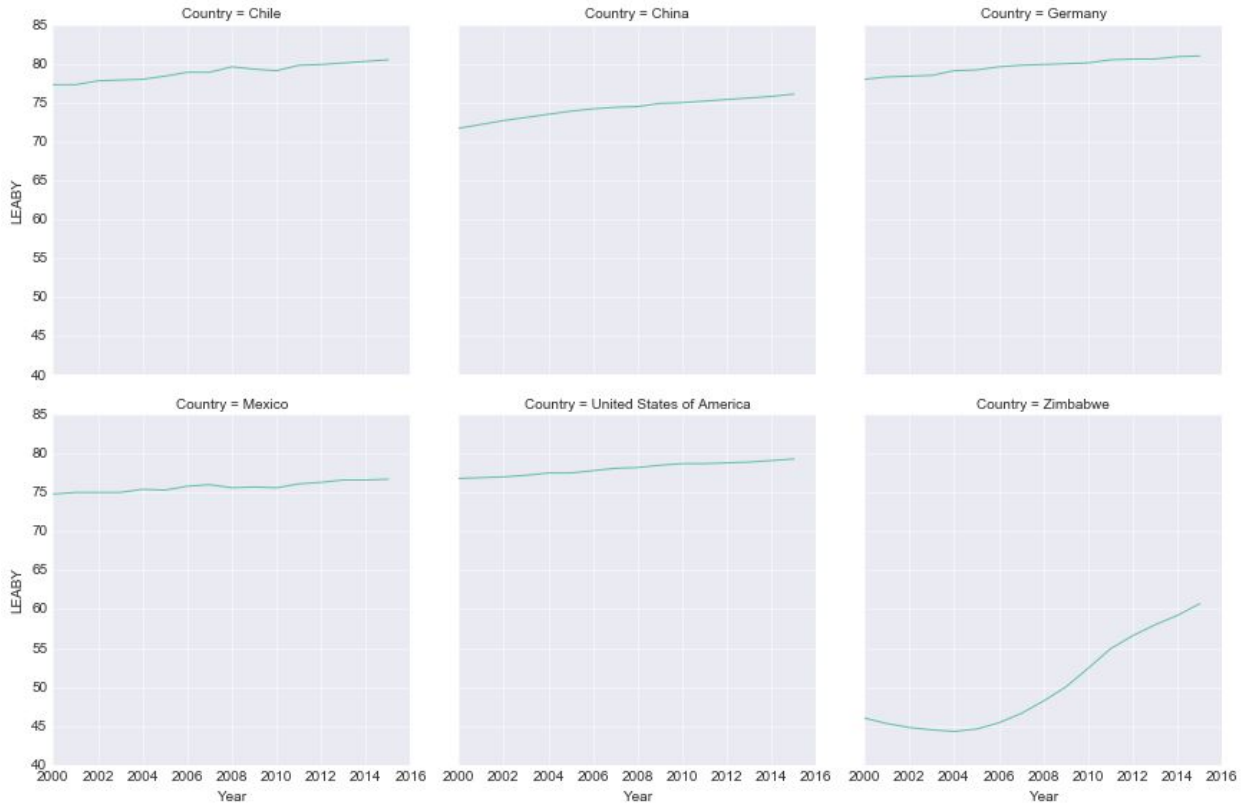
a significant change in GDP. The lack of correlation between GDP and LEABY for China and Zimbabwe suggests that there are other factors that contribute to health besides the economy's size.



As you can appreciate in this charts depicting the GDP of each country from 2000 to 2015- all the economies grew steadily over the fifteen year period. There was a brief period of downturn (or slowing, in China's case) in the years during the 2008-2009 economic recession. These charts all demonstrate the impressive rate at which China's economy is growing: China's economy in 2015 in nearly 5x it's size in 2000.

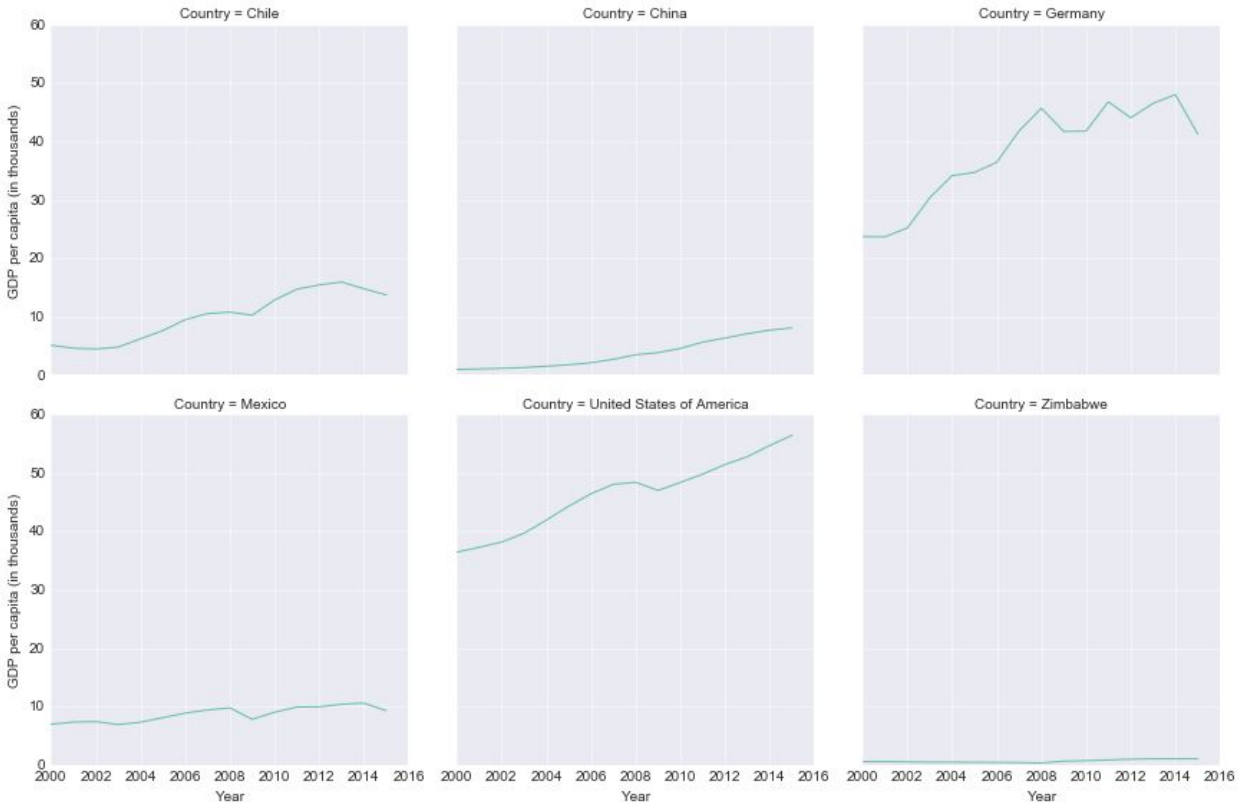
However, this impressive rate of growth is not mirrored in China's life expectancy at birth. In fact, China's life expectancy at birth grew at a similar pace as Chile, Germany and Mexico – all nations that did not experience any dramatic economic growth. This suggests that increasing life spans rely on more than absolute economic growth.

Supporting this claim is Zimbabwe's healthcare progress during this period. Even though has the smallest economy, this nation experienced the most dramatic improvements in life expectancy. At the beginning of the twentieth century, Zimbabwe was still struggling with the fallout from the HIV/AIDS epidemic and was struck again with a cholera outbreak in 2008. However, after runaway inflation was controlled in 2008, Zimbabwe was able to rebuild its health infrastructure and recover its life expectancy.

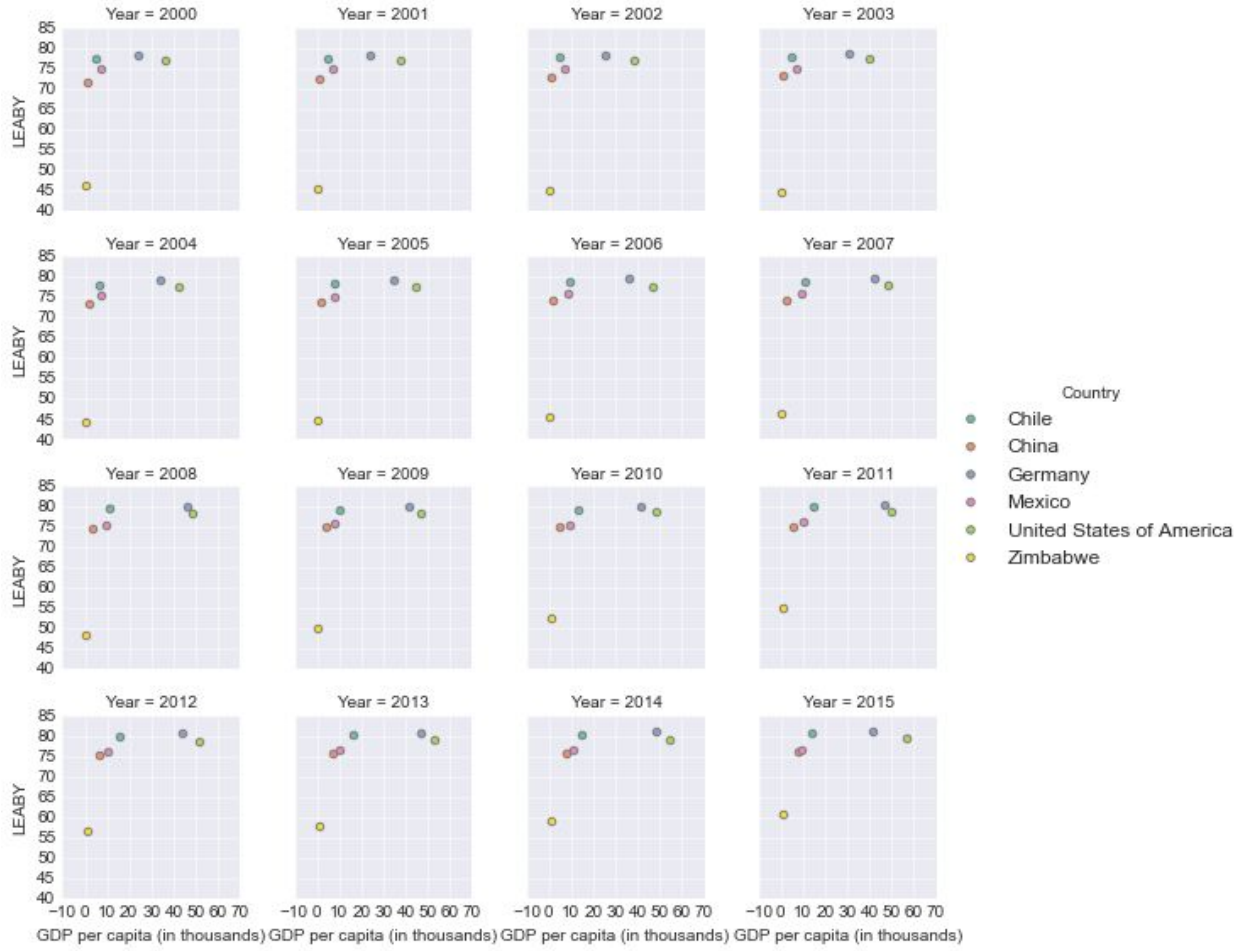


As I have alluded to before, GDP alone is not predictive of a nation's life expectancy. One has to examine other factors, like population size. Instead of an economy's absolute size, a measure like GDP per capita measures how much wealth a nation has for each citizen. Also, increases in GDP per capita are more revealing than increases in GDP alone. It is possible that GDP increased as a function of population growth: meaning simply that there are more people working and contributing to the economy, so the economy grew. However, if the GDP per capita grows, that means that the economy has become more "efficient" and the average individual's work has become more valuable. Typically, this means that the average citizen is more financially secure and has a larger disposable income to spend on healthcare or other quality-of-life improvements.

In contrast to our previous analysis, a very different pattern emerges when we look at GDP per capita. As you can see in the FacetGrid below, Germany and the U.S. have experienced the greatest growth in GDP per capita in the fifteen year period. Chile has also experienced some growth while Mexico's GDP per capita has remained relatively stable. Though China's GDP per capita has also grown during this period, the gains are not nearly as remarkable as when looking at GDP alone. This reveals that a driving factor behind China's overall growth in GDP is its growing population.



Similarly, if you examine the FacetGrid of GDP per capita versus life expectancy below - you will reach much different conclusions about the country's various economic developments during this period. In fact, you will be most impressed by Germany's performance from 2000 to 2011, when the GDP per capita nearly doubled from $25k to $50k. This also seems to better explain China's current life expectancy rates: from 2000 to 2015 China's GDP per capita improved until it nearly matches Mexico's - at the same rate, China also improved its life expectancy until it nearly matches Mexico's. This lends support to the idea that there are other economic measures that are better correlated with health outcomes better than GDP.



In fact, I even tested the impact of the two different measures of the economy (GDP vs. GDP per capita) with linear regression models. You examine impact and statistical significance in the table below. When using GDP alone, we cannot prove that the economy size has any statistical significant impact on life expectancy. This is because the p-value of the GDP of coefficient is equal to 0.113 which is above the threshold of 10%. However, in the model that uses GDP per capita as an economic measure, we can claim that GDP per capita has a positive impact on life expectancy at a 10% significance level (the p-value = 0.058). This supports the hypothesis that GDP per capita and life expectancy are positively correlated, meaning that as a country's GDP per capita grows: we can also expect the citizen's lives to be longer.

Impact of Economic Measures on LEABY

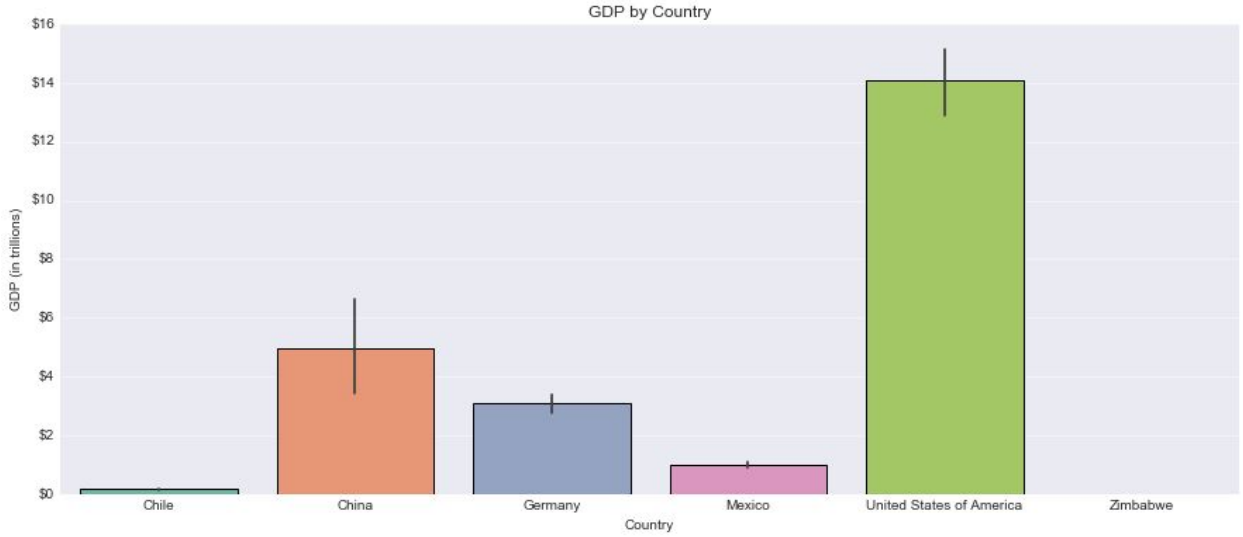
Variable	GDP	GDP per capita
Year	+ ***	+ ***
[economic measure]	+	+ *

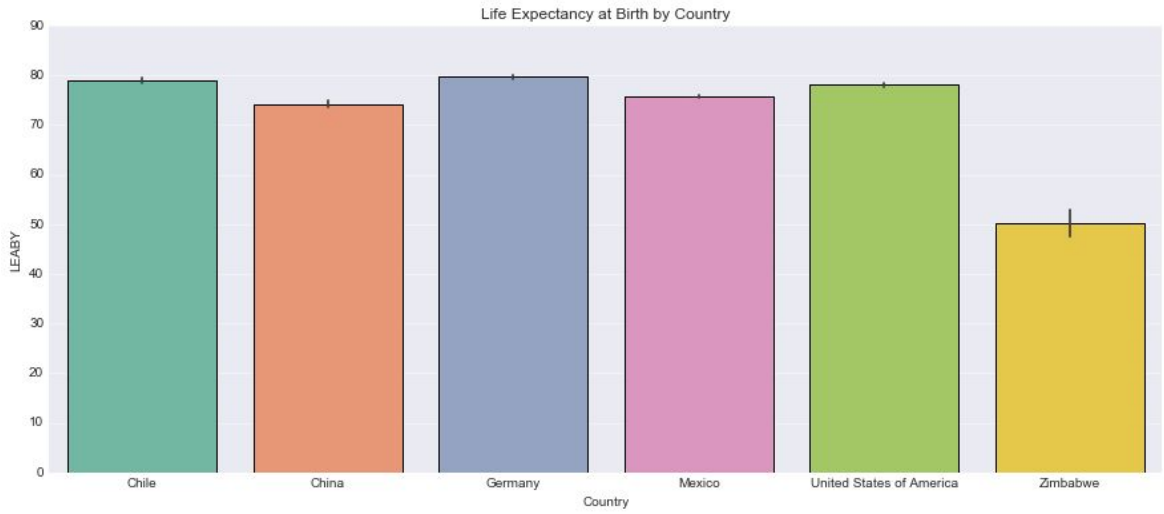
Year*[economic measure]	-	- *
China	- ***	- ***
Germany	+	+ **
Mexico	- ***	- ***
U.S.	+	+
Zimbabwe	- ***	- ***

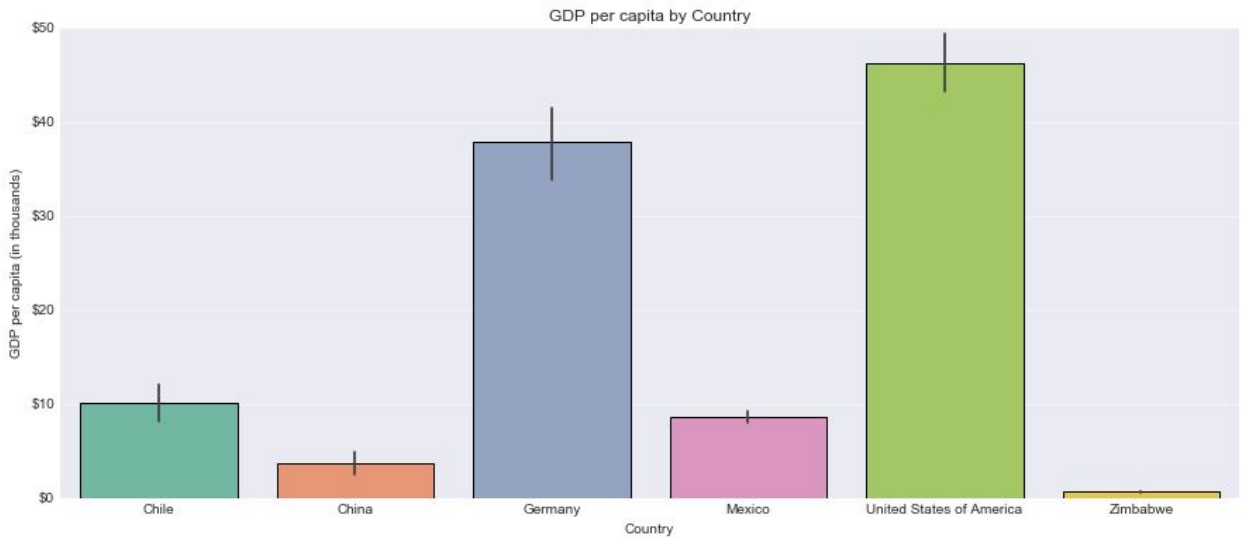
* p value < 0.10, ** p value < 0.05, *** p value < 0.01

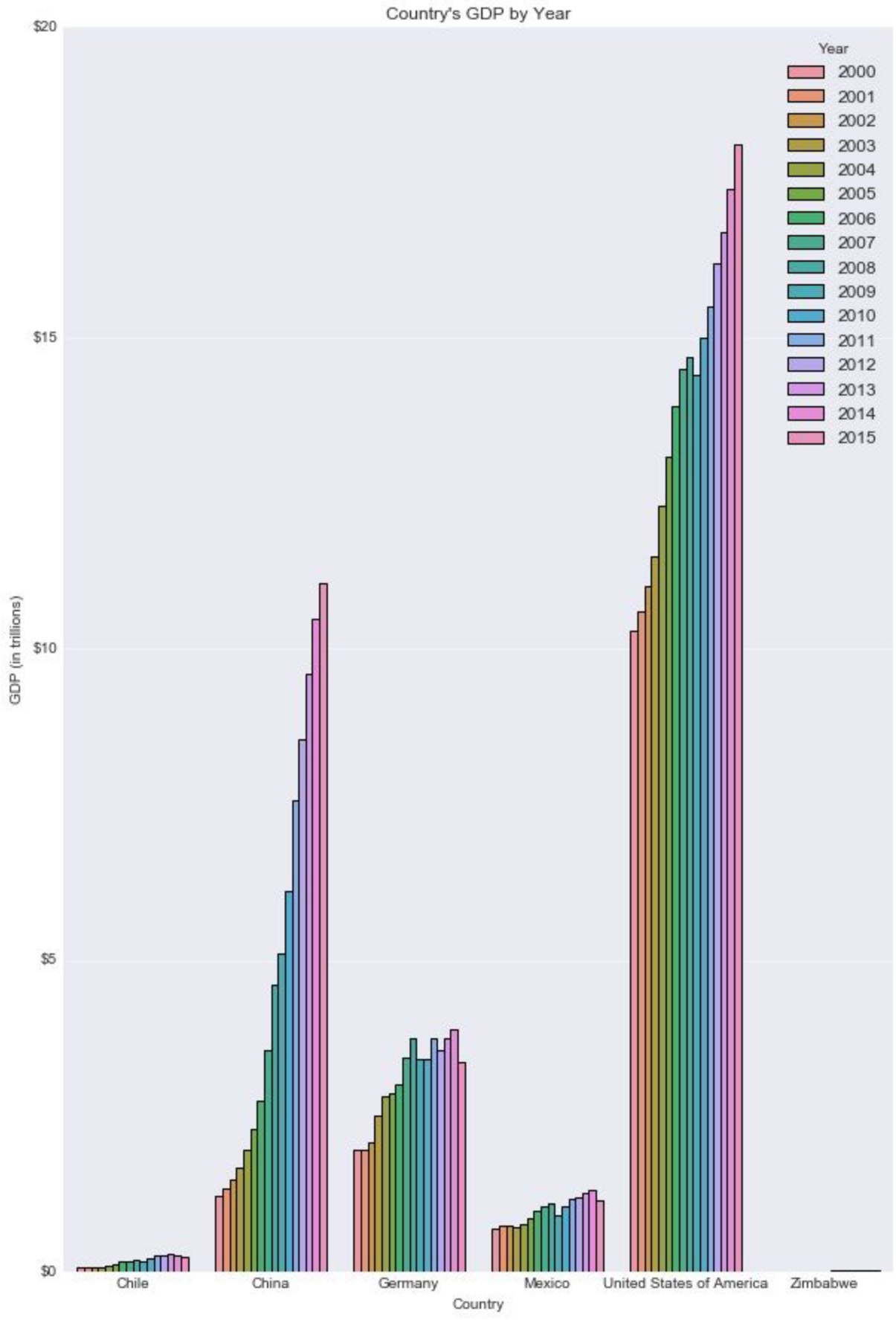
Nonetheless, there are still other areas for research on nationwide factors on life expectancy. As you can see in the charts above, Chile defies the trend because even though it has a smaller GDP per capita, it still has a longer life expectancy at birth than other higher income nations, like the United States. It is possible that there are other nation-wide factors contributing to life expectancy like the environment (i.e. level of pollution, mountainous), the lifestyle (i.e. cuisine, activity), social integration (i.e. involved in local community, multigenerational support within families), and genetic disposition (i.e. resistance to diseases).

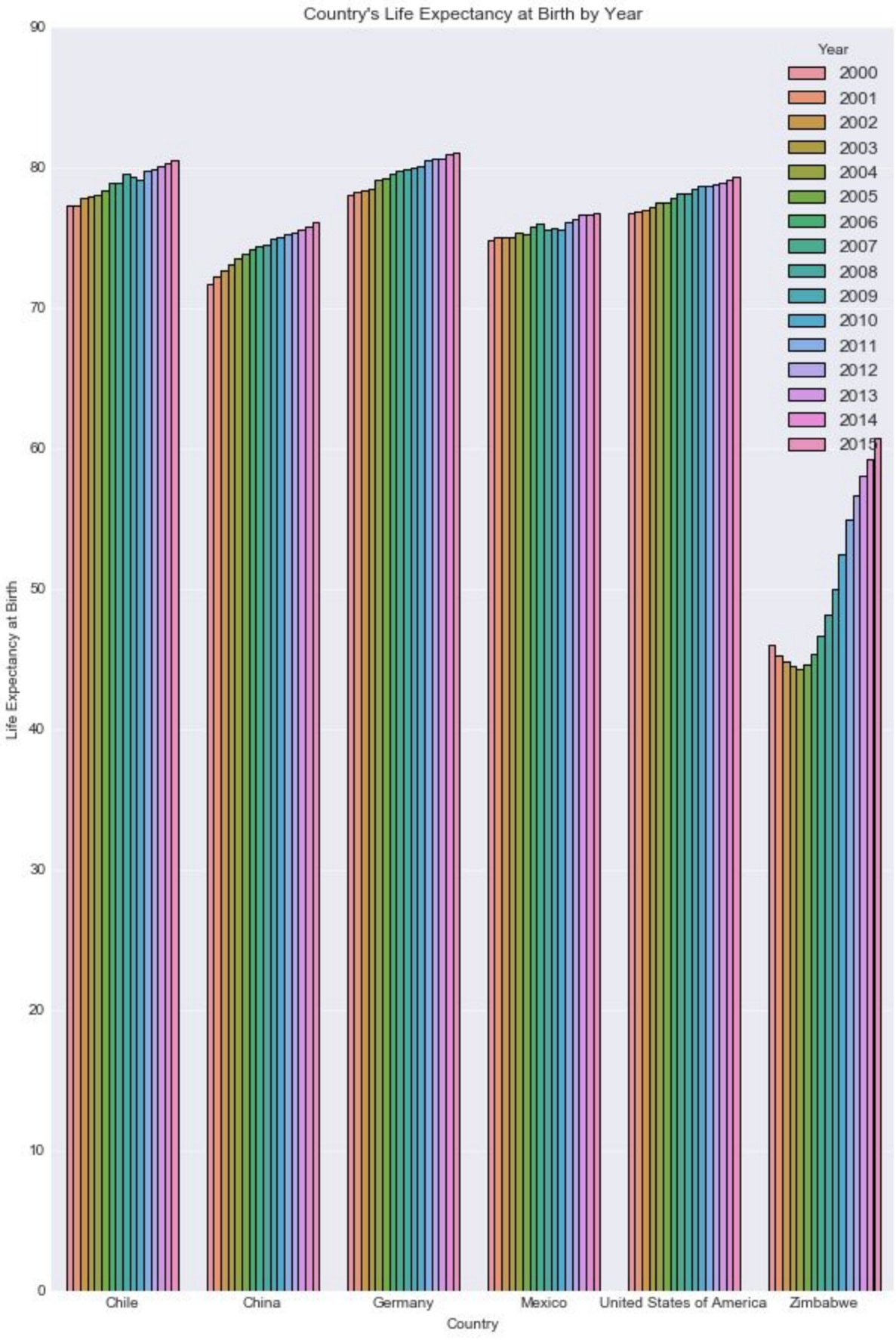
Appendix (Other Charts)

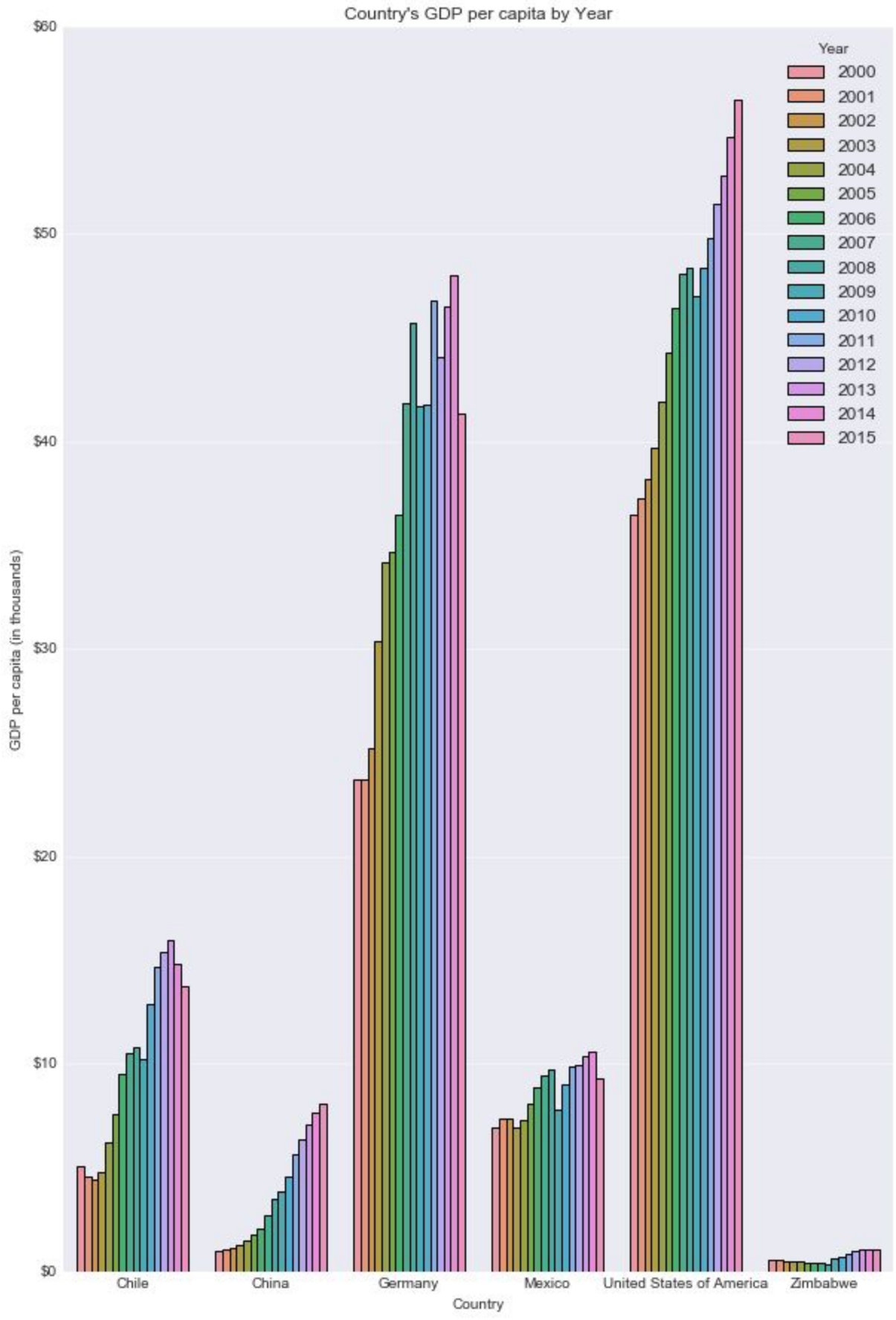







Country's GDP by Year
$20
$15
$10
$5
$0
GDP (in trillions)
Year
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Chile
China
Germany
Mexico
United States of America
Zimbabwe
Country


Country's Life Expectancy at Birth by Year
Year
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Life Expectancy at Birth
0
10
20
30
40
50
60
70
80
90
Chile
China
Germany
Mexico
United States of America
Zimbabwe
Country


Country's GDP per capita by Year
GDP per capita (in thousands)
$60
$50
$40
$30
$20
$10
$0
Year
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Chile
China
Germany
Mexico
United States of America
Zimbabwe
Country