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Yu Jun Kim April 04, 2023

The Paradoxical Influence of Economic Growth on South Korea's Birth Rate Dilemma

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An abstract of
a thesis submitted to the Faculty of Emory College of Arts and Sciences
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Abstract
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Since the 1960s, while South Korea's birth rate has rapidly decreased, economic development has increased. Among OECD countries, South Korea has the lowest birth rate, and South Korea is expecting scarce labor in its labor market. It can be easily predicted that a low birth rate will hinder potential economic prosperity. However, we can't easily predict the influence of economic development on the birth rate. Despite continuous economic growth and childcare policy, the birth rate in South Korea is decreasing. Economic prosperity results in a better economic environment for citizens in South Korea. The economic development of South Korea led to increase in life quality. However, the decline in the birth rate shows that economic development negatively impacts the birth rate. Increase in quality-of-life improved citizens' life and provided better living condition. The inverse relationship between economic development and birth rate seems to be indescribable. This irony can explain by Household Production Theory. This theory implies the production made by households is directly consumed by them, not by other consumers. Since caring for children is a household production and as the cost to maintain this production is rising, people refuse to have a child regardless of economic growth. Through this research, I will describe how household production theory resulted in a low birth rate by analyzing the relationship between economic variables and birth rate. Various data, graphs, and statistical tests will be used to explain this common birth rate phenomenon in South Korea.

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The Paradoxical Influence of Economic Growth on South Korea's Birth Rate Dilemma

Yu Jun Kim, Emory University

I. Introduction

The South Korea national assembly budget office mentioned that South Korea has relatively slow population growth rate and demographic changes are quickly happening. Consequently, this would lead decrease in labor force participation rate and potential economic development will be weakened, leading to decrease in both supply and demand (Sung, 2009).

In 1980s, South Korea's birth rate was 2.82 which was the seventh highest birth rate in OECD countries. However, in 2021, South Korea has recorded birth rate of 0.81 which was the lowest birth rate in the world (Bae, 2022). On the other hand, South Korea's GDP per capita has increased rapidly since 1980s. According to OECD, South Korea's GDP per capita in 2021 increased by 20 times that in 1980. The GDP per capita (Gross Domestic Product per person) is a useful metric to calculate economic development as it represents the average output per person. The increase in GDP per capita ultimately means a reduction in poverty and an increase in people's quality of life. The increase in quality of life and stronger socio-economic status should have provided a better environment for people to raise their children. Ironically, the birth rate in South Korea has been decreasing since the 1960s, showing an indirect relationship with the economic development of South Korea. How could a country that had high birth rate became a country with the lowest birth rate? This honors thesis was conducted to discover the influence of economic development on the birth rate of South Korea.

Researchers in economics explained this ironic phenomenon with Household production theory. Household production theory states that the production made by households is consumed by the household, not by other consumers. For instance, cleaning the house, cooking for the family, and having a child is good or service produced by the household for them to consume. This theory explains the phenomenon that households use their own supplies to create products to be consumed by themselves.

Economics views caring for children as goods produced by their parents. Coincidently, as the price of this good (caring for children) increases, the demand for the good will decrease due to the law of demand.

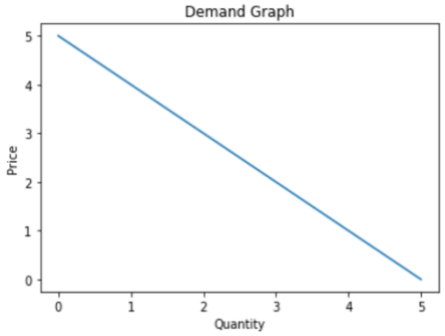


Figure 1 Demand Graph

According to figure 1, we can observe that the increase in price decreases the demand to purchase the product, and the decline in price increases the demand to purchase the product. Therefore, as the cost of having a child increase, people are unwilling to have a baby, regardless of better socioeconomic status. People are willing to spend their income on better goods with lower prices.

Another reason that made this research interesting is that South Korea is showing the opposite trend from the OECD countries. According to Matthias Doepke's NBER paper 'The Economics of Fertility: A New Era', it shows that the relationship between fertility rate and economic development has changed since 2000. The OECD countries had a dilemma: economic growth led to a decrease in the birth rate (Doepke, 2022).

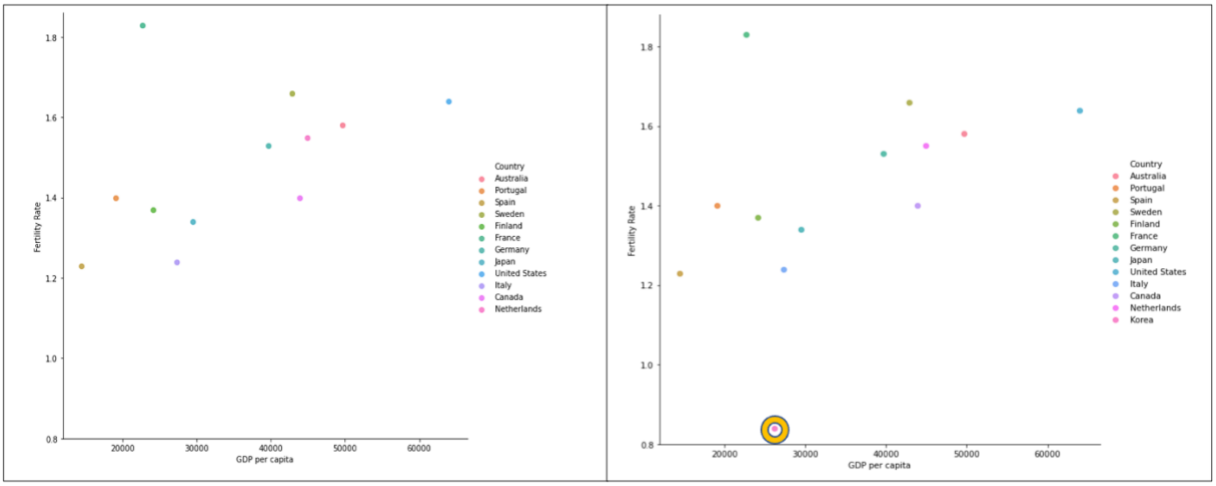


Figure 2 OECD without South Korea and OECD with South Korea GDP per capita vs Birth rate

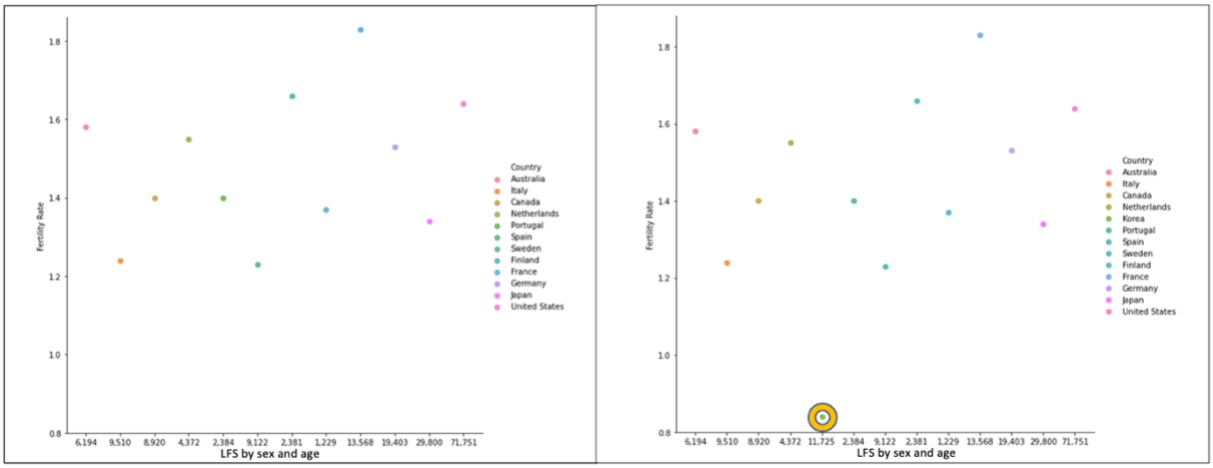


Figure 3 OECD Labor force without South Korea and OECD with South Korea (female) vs Birth rate

The figure 2 is a graph that shows the relationship between GDP per capita and birth rate. The figure 3 is a graph that shows the relationship between female labor force participation rate and birth rate. The graph on left is a graph of 12 OECD countries and the graph on right is a graph of 13 OECD countries including South Korea. The value of South Korea is circled.

However, as shown in the figure, it shows that since 2000, this dilemma has changed. As the GDP and female labor force participation rate increase, the OECD countries also show an increase in the birth rate. In figure 2, the general trend of the scatter plot is positive. In 2021, it was clearly shown that countries with high GDP per capita have higher birth rates. However, South Korea is an outlier in this graph as their birth rate is too low compared to other countries. The problem is South Korea is showing an opposite trend in the birth rate. Figure 3 proves that a female's high labor force participation rate is not the cause of the low birth rate. It shows that countries with high labor participation rates of females have high birth rates. However, South Korea is showing a low birth rate compared to OECD countries with a higher labor force participation rate of females.

As Matthias Doepke stated, this dilemma has been changing since 2021. Economic development is no longer related to the low birth rate. However, South Korea is an outlier, showing a decrease in birth rate as they economically develop. Economists in South Korea illustrated that the Gini coefficient is the reason behind this decrease in the birth rate (Nam, 2018). According to the OECD, South Korea's income difference between gender is three times larger than the average of OECD countries. Also, OECD data showed South Korea has the highest percentage of temporary workers. As the cooperation hires more temporary workers than full-time workers, the average income decreases, and people's source of income is not guaranteed.

		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Female	Monthly income	1,815	1,873	1,925	1,944	2,040	2,112	2,259	2,371	2,408	2,476
	Female to Male ratio (%)	61.0	60.5	59.8	59.5	60.6	61.5	63.3	64.4	64.7	64.6
Male	Monthly income	2,974	3,095	3,218	3,269	3,364	3,433	3,569	3,682	3,722	3,833

Figure 4 Income difference by gender in South Korea

		2017	2018	2019	2020	2021
Number of Employees	Permanent employee	13,428	13,431	13,078	13,020	12,927
	Temporary employee	6,578	6,614	7,481	7,426	8,066
Ratio	Permanent employee	67.1	67.0	63.6	63.7	61.6
	Temporary employee	32.9	33.0	36.4	36.3	38.4

Figure 5 Number of Permanent and Temporary employees in South Korea

According to the figure above, female laborers are getting 40% less income than male laborers. Until 2015, the difference between female and male labor decreased by about 1%. However, since 2016, the income difference has increased by about 4%. For the number of employees, the number of temporary employees is rising, and the number of permanent employees is decreasing. From 2017 to 2021, the number of permanent employees decreased by about 5.5%, and the number of temporary employees increased by 5.5%. The increasing gap between the income of female workers and male workers and the decrease in hiring permanent employees caused Gini coefficient to increase, ultimately leading to a decrease in the birth rate (Nam, 2018). Unfortunately, due to the lack of data, the income difference by gender, and between permanent and temporary employees will not be included in my statistical test.

In this honors paper, the graphical and statistical analysis will determine how each variable is related to the birth rate in South Korea. As I determine the relationship between variables and birth rate, I will analyze how each variable influenced the birth rate of South Korea and the social norm.

II. Methods

I chose this topic after reading the research conducted by Matthias Doepke on the birth rate dilemma in OECD countries, especially South Korea. After the literary review, I wanted to conduct a thesis about what kind of economic variable caused South Korea's birth rate to decrease rapidly compared to other countries. For comparison and analysis, using graphical and statistical analyses would be the practical method to illustrate my research.

For the graphical analysis, I used a heatmap to represent the background of South Korea's economy and a time series graph to illustrate the timeline of South Korea's economy. By using a heatmap, I introduced the background of South Korea, and as I compare it with the birth rate, readers might understand how birth rate and economic variables are related, as the regional birth rate shows a clear difference. Also, I used a time series graph to show a general trend of expansion of South Korea's economy. Since this thesis will discuss mainly how South Korea's economic expansion led to the birth rate dilemma, showing the general trend of South Korea's economy would be crucial.

For the statistical analysis, I used general OLS model, and Fixed effect model. For the general OLS model, I used South Korea, Italy, and United States to compare their birth rate and economic growth trends. For the Fixed effect model, I ran analysis with 5 countries (South Korea, Italy, Japan, Canada, and United States) to get a summarized table of all OLS regression. For the fixed effect model, and to determine the influence of each economic variable on the birth rate, I set countries and year as fixed variables. I included all variables of 5 countries to determine which variable has the most relationship with the birth rate. In this way, I can analyze the trend in each country, compare how each country are different to each other, and determine which economic variable had the greatest effect in birth rate regardless of country.

All of the economic variables and birth rate data for South Korea, the United States, Italy, Japan, and Canada are from CEIC, The Global Economy, Trading Economics, KOSIS, KLI, OECD, and World Bank.

CEIC, The Global Economy, Trading Economics – These database websites provide a significant volume of data about Italy, Japan, and Canada. Most of the data for these three countries are from this database.

KOSIS, KLI – KOSIS is the database for Korea's statistical data operated by Statistics Korea. KLI is the database for Korea's statistical data related to the labor force operated by the Department of Labor. These two databases were used for collecting data related to South Korea.

OECD – OECD, the organization for economic cooperation and development, has unique data on 38 OECD countries and various developing countries. The OECD stats platform stored socio-economic data for about 50 countries provided by major official reports and country surveys.

World Bank - World bank works closely with member countries to store macro, financial, and sector data. The member countries and other official sources provide these reliable sources. Using its vast database, the World Bank organizes and stores these data to monitor each country's economic and environmental trends.

Compared to other research papers with similar topics, my research will mainly handle the paradoxical relationship between South Korea's economic expansion and decreasing birth rate. As Doepke mentioned, while other countries are improving with this birth rate dilemma, South Korea's birth rate continuously decreases as the economy grows. Thus, my main focus would be on what kind of economic variables negatively influences the birth rate the most, and by comparing it to other countries trend, I would like to discuss the problem of South Korea as well.

III. Graphical Analysis

1) Time series graph of OECD countries

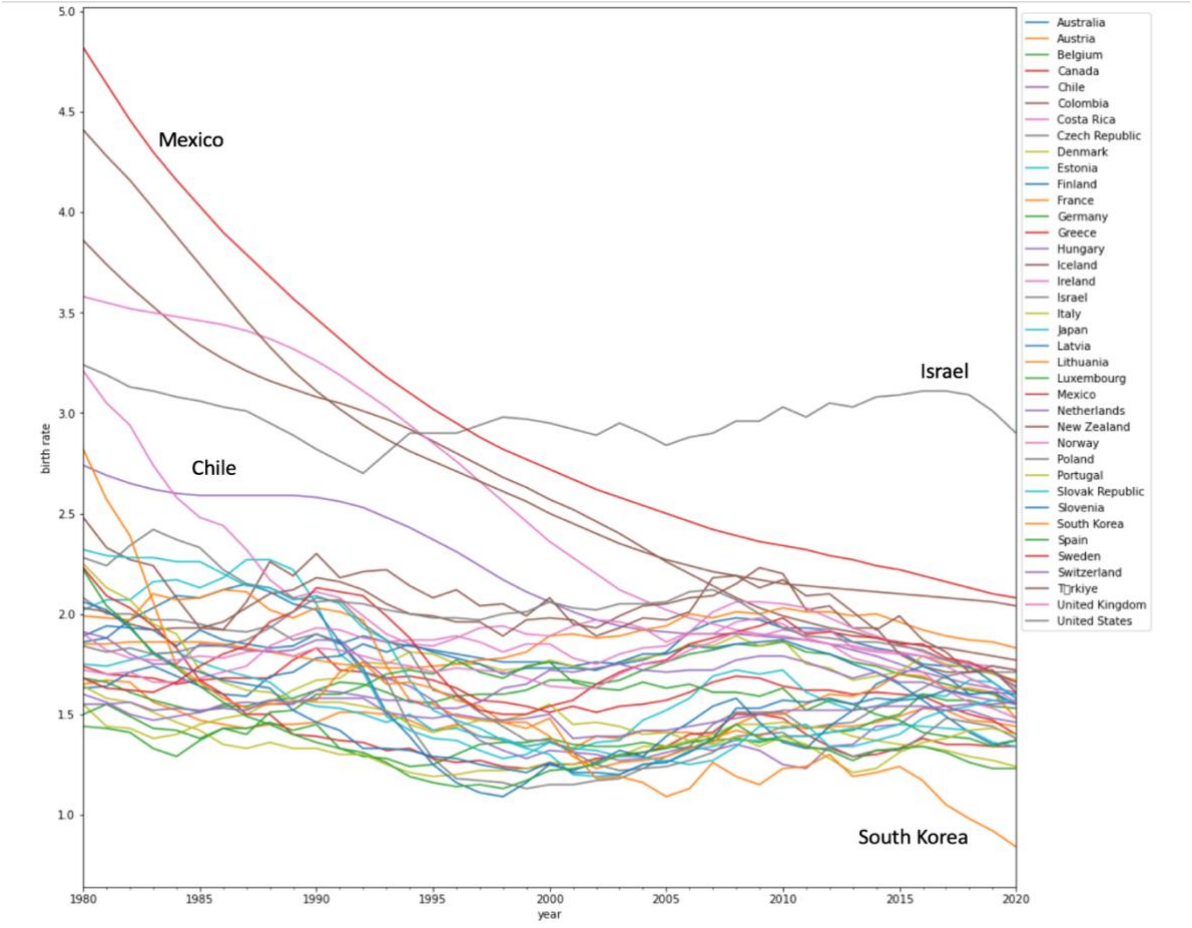


Figure 6 Time series graph of birth rate of OECD countries

The graph above is a time-series graph of 38 OECD countries on the birth rate since 1980. OECD (Organization for Economic Co-operation and Development) is an organization where 38 democratic governments with market-based economies work together for economic

development. OECD countries can be implied as a country who has more extensive and vigorous economic fundamentals than non-OECD countries.

As shown in the graph, 38 countries' birth rate is visualized in a different color. Among these 38 countries, I focused on four countries: Mexico, Israel, Chile, and South Korea. I chose Mexico as it had the highest birth rate in the 1980s and showed the fastest decline in the birth rate in 1980. Also, I chose Israel because it had a high birth rate in the 1980s, and its birth rate had no significant difference. Lastly, Chile was picked as it had a similar birth rate as South Korea in the 1980s. Mexico recorded a birth rate of 4.82 and was the country with the highest birth rate, and Germany had the lowest birth rate of 1.44. In 1980, South Korea had a birth rate of 2.82, which was the seventh highest country among OECD countries. However, in 2020, Israel was the only country with a birth rate close to 3.0. We can clearly observe that Mexico had the most radical decrease since the 1980s. What about South Korea? In 2020, South Korea recorded the lowest birth rate among all OECD countries, with a birth rate of 0.84. This means that about 0.84 children are born by a single woman in South Korea. According to this graph, we can observe that most OECD countries are experiencing an extreme decline in birth rate regardless of their birth rate in the 1980s. However, not all OECD countries are experiencing a rapid decline in the birth rate. Although the birth rate has decreased, Israel, the United States, and the birth rate of Luxembourg has not reduced as much as in other countries. The IMF (International Monetary Fund) states that countries that accept many immigrants are showing less decline in the birth rate. Even though the natives refuse to have a child, the immigrants favor having a child as it can become an advantage for them to live as a foreigner in a particular country (Peri, 2020). However, this alternatively means that if a country is not accepting many immigrants, the birth rate will decrease rapidly.

Ultimately, the decrease in birth rate is trending in OECD countries, and South Korea has been recorded as the country with the lowest birth rate among OECD countries in the world. This research paper will discuss how economic variables and development influenced South Korea's birth rate to decrease.

2) Geographical Heatmap of South Korea

Depending on the regional characteristics and difference in culture, each regions show different statistics. The statistic of South Korea is an average of sum of all regions, so it is hard to see which region affects each variable the most. For instance, region near the capital (Seoul) will have better economic environment than those rural regions. Geographical Heatmap of South Korea can easily visualize the difference in variables including economic development and birth rate by the region. The analysis of graph will show how each variables influenced the birth rate by their regional differences.

South Korea can be divided into 17 main regions: Seoul, Busan, Daegu, Incheon, Gwangju, Daejeon, Ulsan, Sejong, Gyeonggi-do, Gangwon-do, Chungcheongbuk-do, Chungcheongnam-do, Jeollabuk-do, Jellanam-do, Gyeongsangbuk-do, Gyeongsangnam-do, and Jeju-do. In this research paper, I didn't use the data from Sejong because Sejong was created in 2012 and there

was not sufficient data to use. Also, other than other region, Sejong has no specific trait because people from capital and other rural areas joined Sejong. To use data from Sejong, specific regional trait must be shown but due to the short history, it was vague to use data from Sejong.

The geographical heatmap was made by plotting South Korea's map using geojson, a python library. I used geojson.io to create a regional map of South Korea with 16 regions and used python to create a heatmap based on the data provided by KOSIS (KOSTAT).

Variables used to show regional economic difference are 1) birth rate, 2) unemployment rate, 3) employment, 4) income, 5) household expenditure, 6) household expenditure without Seoul and Gyeonggi-do, 7) number of businesses/farms/services, and 8) number of businesses without Seoul and Gyeonggi-do.

Number of Households: Difference in households can show which region is concentrated with employees and give an idea of structure of South Korea

Birth rate: Difference in Birth rate can show how economic environment of specific region influenced the birth rate in that specific region of South Korea

Unemployment rate: Difference in unemployment represents the economic environment of specific region. A region with high unemployment rate implies recession in that region and low unemployment rate implies expansion in that region.

Employment rate: Similar to unemployment, employment rate can represent the economic environment and status of specific region.

Income: Difference in income measures the quality of life in the specific region. For instance, a region with high income represents that they are having an economic advantage than another region.

Household expenditure: I hypothesize that household expenditure will follow the income trend. However, this household expenditure variable will be used to calculate how much money should people spend to maintain their lifestyle. Based on the average income and price index of region, household expenditure will be different. To compare in detail, I also made a heatmap without data from Seoul and Gyeonggi-do which can be seen as capital city. These two regions make hard to visualize the household expenditure of other regions.

Educational expenditure: Education is essential in raising a child. If the educational expenditure increases, it will hinder parents from having a child. This can explain how an increased expenditure for raising a child influenced the birth rate.

House price: Similar to household expenditure and educational expenditure, the change in house price will influence how much money household can spend. As the house price increases,

it limits people from spending more money. The limitation in expenditure will have influence on birth rate as well.

Below is a general map of South Korea with the name of regions that will be discussed. South Korea could be divided into three main regions: 1) Capital region: Seoul, Gyeonggi-do, and Incheon 2) Metropolitan region: Daejeon, Gwangju, Daegu, Ulsan, and Busan 3) Rural region.

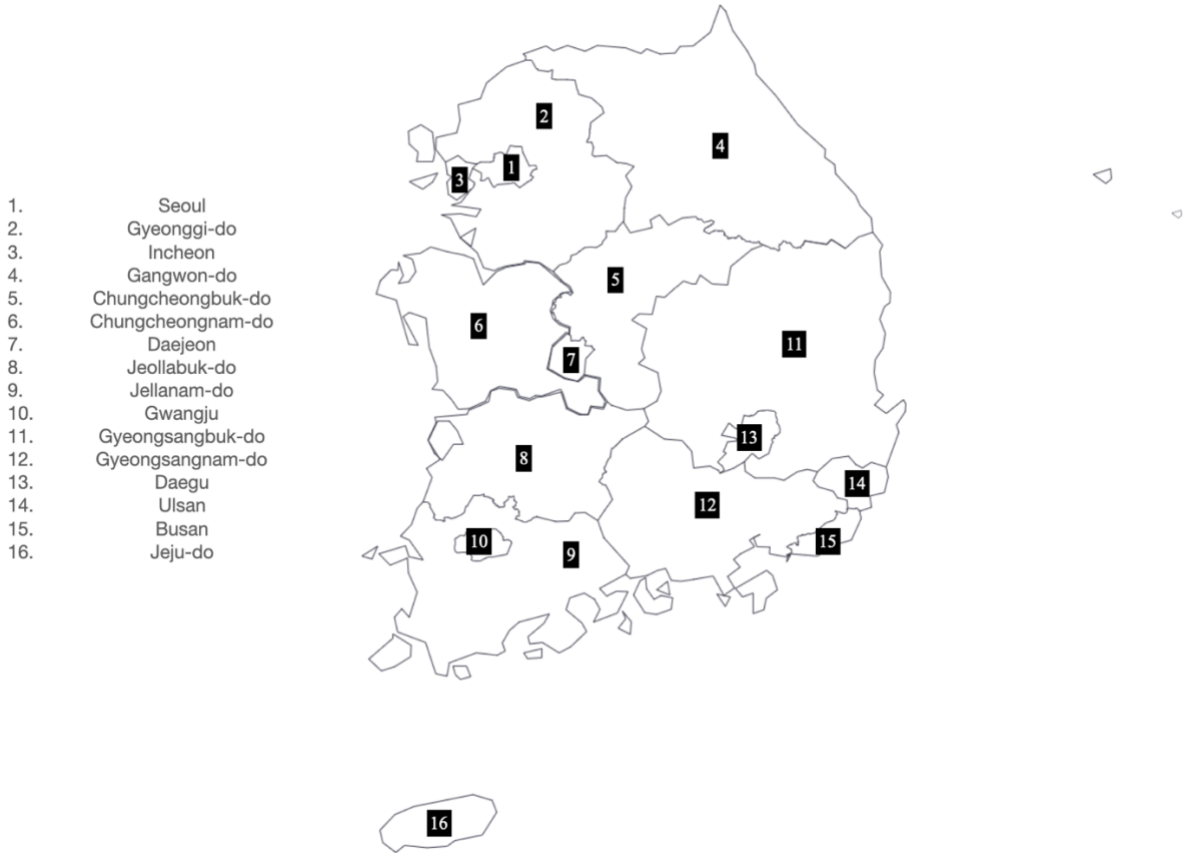


Figure 7 The general map of South Korea created by geojson

i) Number of Households

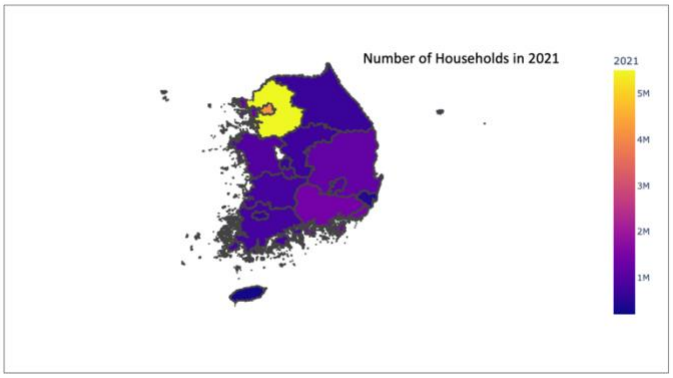


Figure 8 Number of Households in South Korea

In 2021, the range number of households in South Korea was 5,492,783~278,458. Since Jeju-do is an island in South Korea, the number of households in Jeju-do is obviously meager. The capital region has 10,900,673 households, the metropolitan region has 4,195,075 households, and the rural region has 6,779,658 households. However, each region has a different number of counties. On average, a county in the capital region has an average of 3,633,558 households, a county in the metropolitan region has an average of 1,398,358 households, and a county in the rural region has 847,457 households on average. The difference in the number of households in the capital, metropolitan, and rural regions is clear. According to Dr. Kang, the capital and metropolitan areas are economically more developed than other regions. Even though the metropolitan area is surrounded by the rural area, the movement of people to the capital region and metropolitan region is based on the desire to live in a better environment (Kang, 2007). As the region is more developed and has a better environment for households, people tend to live in that specific region. The graph below shows that capital region and metropolitan region have a smaller number of farms and rural region has high number of farms. This shows that which region is more socio-economically developed.

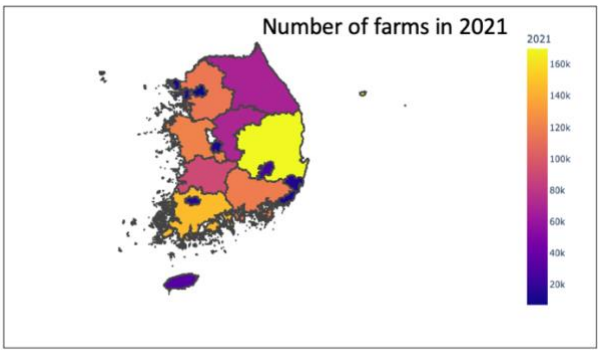


Figure 9 Number of farms in South Korea

ii) Birth Rate

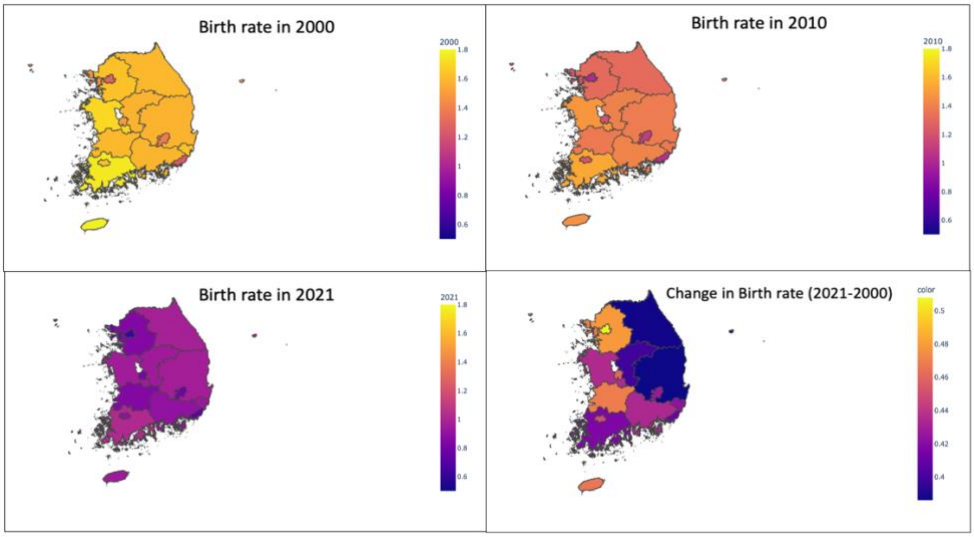


Figure 10 Birth rate of South Korea

Before the analysis, the color of the scales is all set equal for better comparison. Setting the scale range to 1.8 to 0.6 allowed readers to visualize and compare the statistics more efficiently.

In 2000, the birth rate range was 1.78 ~ 1.28, and all regions in South Korea had higher birth rates than 1.0. Seoul, Daegu, and Busan had the lowest birth rate, and Chungcheongnam-do, Jellanam-do, and Jeju-do have the highest birth rate. In the heatmap, we can observe that Seoul and the metropolitan region have the lowest birth rate compared to the birth rate of rural areas.

In 2010, we can clearly see that the overall birth rate in South Korea decreased significantly. The range of birth rate in 2010 was 1.46 ~ 1.02. The birth rate didn't decrease below 1.0, but still, the birth rate has decreased by approximately 0.3. Once again, Seoul, Daegu, and Busan recorded the lowest birth rate in South Korea, and Chungcheongnam-do, Jellanam-do, and Jeju-do record the highest birth rate. In the heatmap, only Seoul's color has changed to purple. One thing to recognize is that the birth rate of Gyeonggi-do, a region closest to the capital city, has decreased by 0.32, which is the most significant decrease in the birth rate. In the heatmap, we can observe that the color changed dramatically as the average color changed from yellow to red with some purple regions.

In 2021, the heatmap's color changed to navy and purple. Seoul has the darkest color compared to any other region in South Korea. Now, Seoul, Busan, and Incheon have the lowest birth rate, and Jellanam-do, Gangwon-do, and Gyeongsangbuk-do record the highest birth rate. Seoul has recorded a birth rate of 0.63, and Jellanam-do has recorded a birth rate of 1.02. This means that people in South Korea are planning not to have a single number of children, and the only region that plans to have a child is Jellanam-do, with a birth rate of 1.02. In 2021, it was hard to observe a pattern in regions with high or low birth rates. The economic environment in each region was researched to determine the reason behind this.

Overall, the birth rate has decreased dramatically since 2000. According to the last graph, Seoul showed the greatest difference with about 0.5 decrease in birth rate, and

Gyeongsangbuk-do show the least decrease in birth rate (about 0.4). According to the change in the birth rate graph, we can observe that the range of difference in the birth rate for the capital region is 0.5~0.48. These regions have the largest decrease in the birth rate in South Korea. The range of change in the birth rate of the metropolitan region is 0.46 ~ 0.44, which shows less decrease than the capital region but decreased more than that of the rural area, which recorded a 0.44~0.4 reduction in the birth rate. This indicates that a region with a lower birth rate is the region with a large number of households and an area where the economic environment is developed.

iii) Unemployment Rate

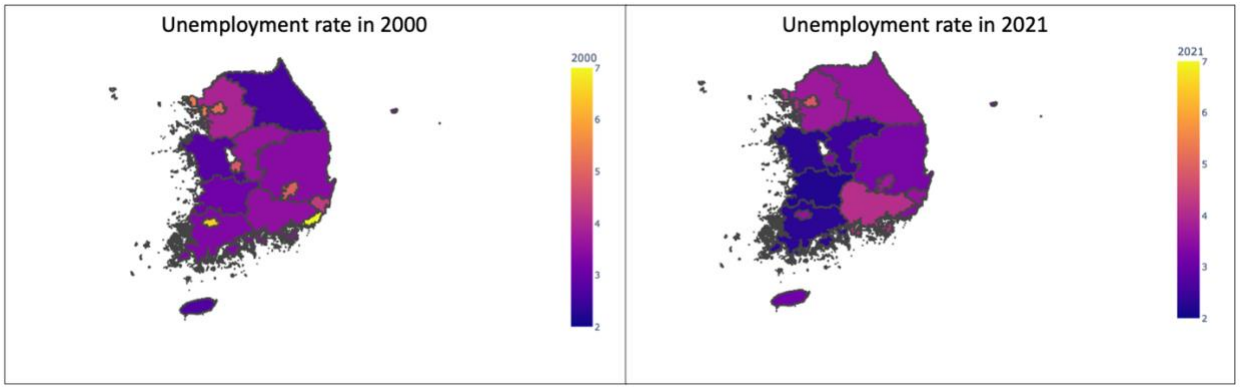


Figure 11 Unemployment rate of South Korea

According to the unemployment rate heatmap, in 2000, Busan and Gwangju had the highest unemployment rate, with 7.0% and 6.5%. Most regions in South Korea have an unemployment rate smaller than 5%. However, in 2021, the unemployment rate decreased for all regions except Seoul. Seoul became the region with the highest unemployment rate of 4.8%, and other regions had unemployment rates smaller than 4.0%. From figure 8, we can observe that South Korea's population is concentrated in Seoul. Therefore, the unemployment rate in Seoul is obviously high due to the relatively competitive labor market. In general, most regions show a decrease in the unemployment rate but Gyeongsangnam-do and Gangwon-do increase merely. The decrease in the unemployment rate means an economic expansion as all productive resources are efficiently utilized.

However, even though the unemployment rate has generally decreased, the change in the unemployment rate has negatively influenced the birth rate. According to figure 10, Gyeonggi-do, Incheon, Seoul, and Jeju-do show a significant decrease in the birth rate. Still, Seoul, Incheon, and Gyeonggi-do have an unemployment rate above 3.7, meaning that the capital region had the highest average unemployment rate. Surprisingly, in consecutive order, Daegu, Ulsan, and Gwangju also showed a relatively high unemployment rate than other regions, with a rate of 3.6. However, most rural regions showed an unemployment rate between 2.2~3.6. Since the high unemployment rate implies a recession in local economics, we can observe a rapid decrease in the birth rate in a region with a competitive labor market. A large number of households implies that more people are competing for better jobs, which leads specific regions to have fewer children.

iv) Employment Rate

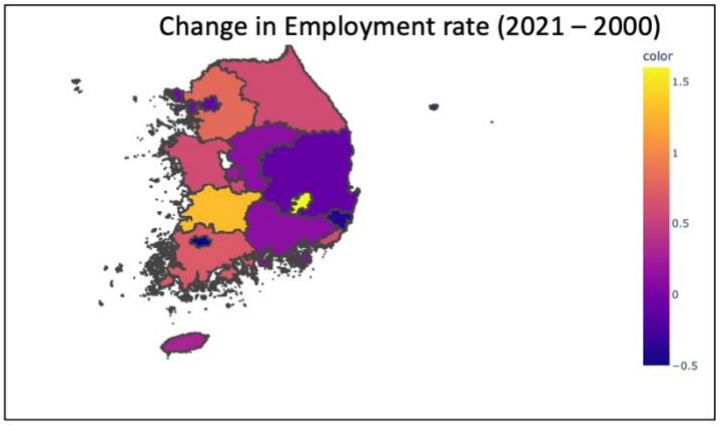


Figure 12 Change in Employment rate

The trend in the employment rate follows the general trend of the birth rate. In this graph, most regions show an increase in employment rate, but Seoul, Incheon, Gwangju, and the southeastern part (except Daegu) show a decrease in employment or a mere increase in the employment rate. Other than that, most regions' employment rate has increased by more than 0.5%. Similar to the unemployment rate heatmap, the capital and metropolitan regions showed the least employment rate increase. Surprisingly, the graph shows that the metropolitan area had less increase in employment rate than the capital region. According to the graph, only Gwangju and Ulsan showed a decreased employment rate. In this graph, Daegu and Gyeonggi-do can be marked as an outlier. Even though Daegu is a part of the metropolitan region and Gyeonggi-do is a capital region, they showed a high increase in employment. However, on average, the metropolitan area showed the least increase in employment rate, and the rural area showed a relatively high increase in employment.

According to this figure 12, the area with an increase in the employment rate showed a decline in the birth rate. Compared to the result of the unemployment graph, this graph also showed a similar trend: an increase in the employment rate resulted in a rapid decrease in the birth rate. This implies that a region with better economic development resulted in a reduction in the birth rate.

v) Income

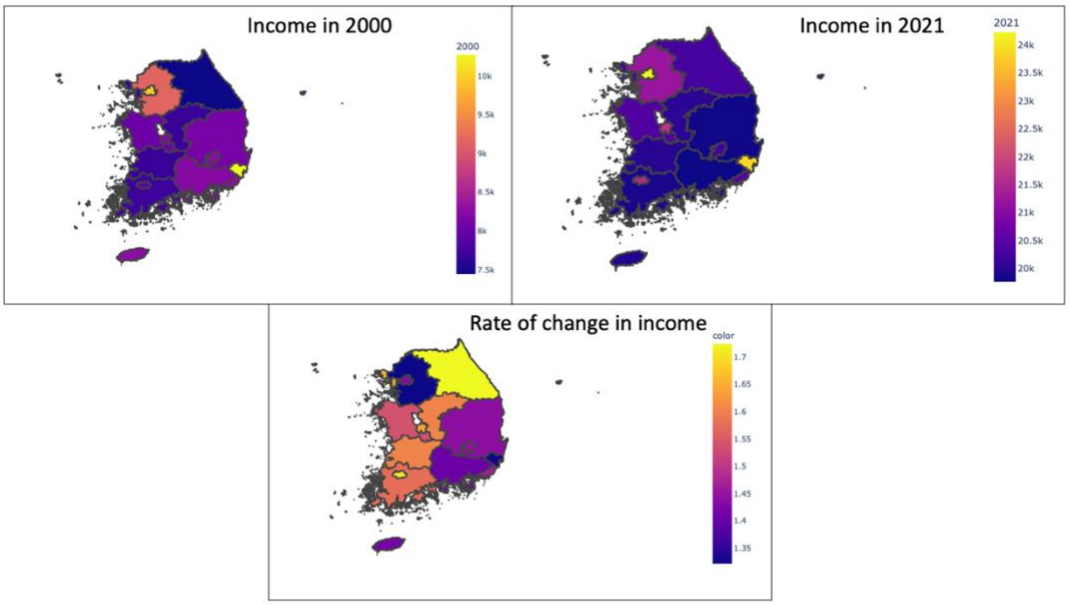
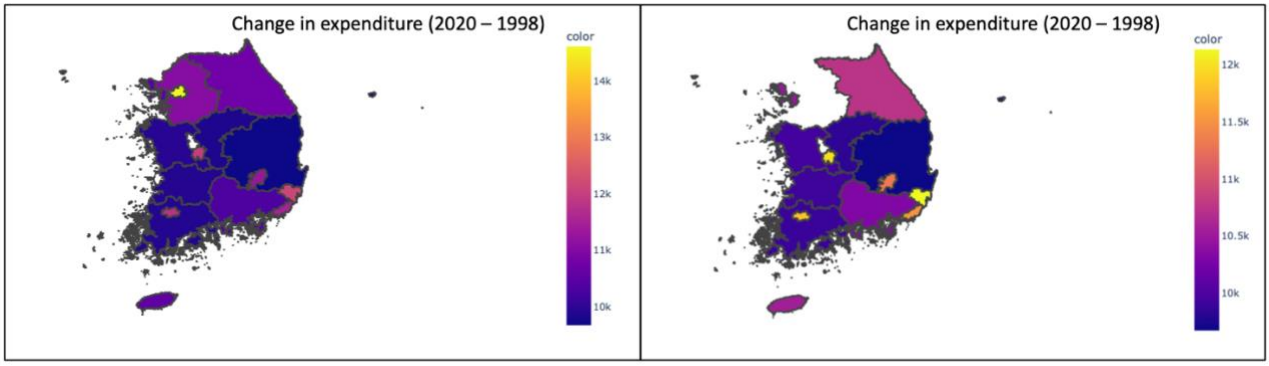


Figure 13 Change in income in South Korea

Income is an essential economic variable that can measure the households' socioeconomic status. More income results in more household consumption, and people can afford more goods and services as their income increases.

In 2000, the income of Seoul, Gyeonggi-do, and Ulsan was incomparably higher than in other regions. These regions are known as the most developed region in South Korea, and as a result, they have the highest income than other regions. In 2021, Seoul, Ulsan, Gwangju, and Daejeon recorded the highest income, and compared to other regions, the graph clearly shows the large gap between the developed region and other rural regions. To determine the rate of change in income, I set income in 2000 as a base year, subtracted the base year from income in 2000, and divided it by the base year. However, except for Incheon and Gwangju, capital regions and metropolitan regions had a relatively low increase in income than the increase in income of rural areas. Since the developed regions had high incomes in 2000, their income might not be changed that much. Still, a mere increase in income and a decrease in income imply that households in developed regions have difficulty in spending money. These might have influenced the birth rate of the capital regions and metropolitan regions as households can't afford as much as before.

vi) Household Expenditure



As time passed, households tended to spend more on household expenditure. As people earn more income, the inflation rate will increase, forcing them to spend more money than they did. According to the graph above, Seoul's household expenditure increased significantly from 1998 to 2020. For better visualization, I excluded data for the capital region. In the second graph, we see that expenditure in the metropolitan region (Daegu, Daejeon, Ulsan, Gwangju, and Busan) also changed significantly. However, other than these regions, the changes in household expenditure are similar. According to the graph, we can imply that as people's household expenditure increased, those regions experienced a low birth rate. People tend to save some of their expenses by not having a child.

Based on the result, the economic development of a specific region hindered people from having a child. Although the income has increased, a relatively high unemployment rate, decrease in employment rate, and increase in household expenditure caused a reduction in the birth rate of the capital region and metropolitan region. From this comparison, we can conclude that household expenditure influenced the birth rate more than income. Even though the income has increased, the market experiences a increase in the inflation rate as the income increases. This cause people to use more money to afford the same as before. Regardless of the rise in income, people's expenditure will also increase, but having the same services and goods.

vii) Educational expenditure

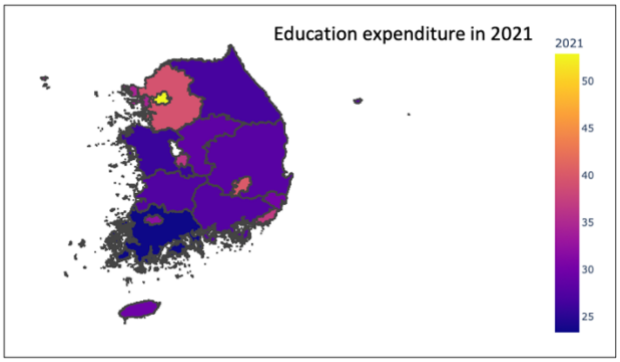


Figure 14 Educational Expenditure in South Korea

The data used in this graph is the average cost of private education for elementary, middle, and high school students. According to the figure above, Seoul has the highest average

cost of private education. Then, Daegu and Daejeon require a high cost for the child's education. In general, the capital region requires the highest average cost of private education. Their average cost is 422,000 won for the capital region. The average cost for a metropolitan region is 350,600 won for the metropolitan region. Lastly, the average cost for the rural region is 271,000 won. The average cost of education is lower than the expected value. This is because this cost is average for elementary, middle, and high school students. Since elementary and middle school students don't have to take much private education, the average value gets lower. Still, this value is a crucial element as it can compare the educational expenditure of each region. Based on the data, the higher education cost in certain regions causes that region to have a lower birth rate. If households have children, their expenses will increase more heavily due to an increase in education expenditure. Since educational expenditure is the most crucial element for raising a child, it is undeniable to spend money on educational expenditure. For these reasons, an increase in expenditure might be evidence to prove why some regions' birth rates are low. More education costs put pressure on household consumption, and it causes the household to have less number of child.

viii) House price

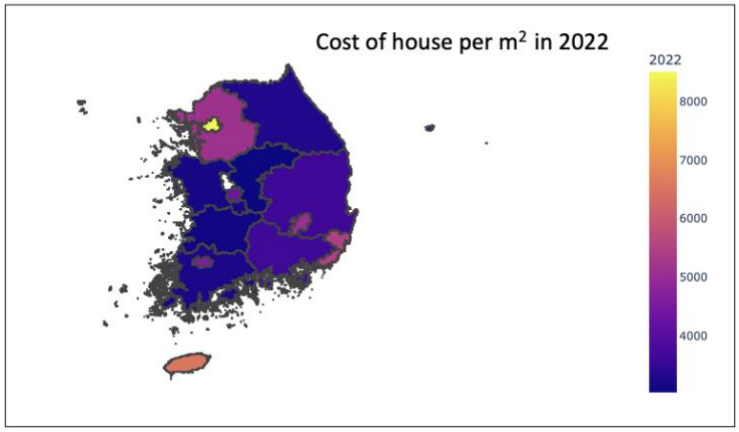


Figure 15 House price in South Korea

The variable used to determine the relationship between house price and the birth rate is the cost of the house per m^2 in 2022. The house price in Seoul is incomparably high compared to other regions. The number of households determined from the previous graph is 5,492,783 households. This shows that about 5,492,783 households are paying a large amount in house prices than households living in other regions. This indicates that most South Korean households spend a lot on house prices. An outlier in this graph is Jeju-do. Since Jeju-do is famous for tourism and has a high value of land, the cost of a house in Jeju is high. Jeju-do is more suitable for having a hotel, private holiday cottage, and buildings than a real house for people. This is why Jeju-do's house price is much higher than in other regions. As shown in the figure above, the house price for the capital region is high. Since the capital region is the most socially and economically developed area, the house price is high, as expected. Then, the metropolitan area's house price, and lastly, the rural area has the lowest house cost per m^2. This shows that households living in the capital region and metropolitan region are experiencing high pressure in paying the bill for their house. This pressure led to a decrease in

the birth rate. As the households living in a specific region has to pay more for the house, they can't spend their money on other unnecessary expenditure. Thus, these people decided to have fewer children, which led to a decrease in the birth rate.

3) Time series graph of South Korea

In this section of graphical analysis, the time series graph of South Korea will show the observed trend in change of each economics variables. Over the past years, South Korea's economy has developed greatly and led to economic prosperity. However, the economic development in South Korea shows indirect relationship with the birth rate. The analysis of this time series graph will explain how economic growth influenced the birth rate to decrease. Each socio-economic variables are crucial in raising a child and the general change in the variable over time implies how the variable has influenced the birth rate of South Korea.

i) Birth rate

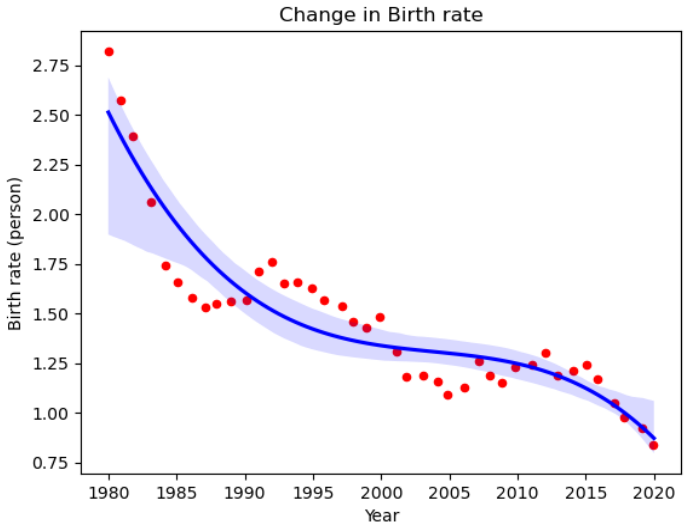


Figure 16 Change in Birth rate

This time series graph shows the average birth rate data of South Korea from figure 10. Since 1980, the birth rate has declined rapidly. South Korea's birth rate was 2.82 in 1980 and rapidly decreased until 1995. After then, it decreased at a slower rate until 2010. In 2010, the birth rate decreased similarly to that in the 1980s. Since the 1980s, the GDP of South Korea has kept increasing as the government's policy targeted economic growth. After the Korean war in the 1950s, the South Korean government implanted various economic plans to help large enterprises, build roads for transportation, and focus on creating jobs for people.

However, the sudden increase in GDP and economic development led to a rapid increase in GDP per capita, and as a result, the unemployment rate started to increase regardless of government policies. In the 1980s, the average inflation rate was 9.2% which was a relatively high inflation rate compared to the 1990s and 2000s. This increase in the inflation rate and unemployment rate greatly influenced people's economic status, leading to people deciding to have a less number of children. Although in 1997~2001, South Korea experienced a huge economic crisis called the "International Monetary Fund" crisis. During this time, lots of cooperation faced bankruptcy, and people lost their jobs. Since 2000, the aftermath of the IMF

incident has led to 'future anxiety,' leading to a decrease in the birth rate. In the 2000s, there was a slight increase in the birth rate, but in 2015, South Korea experienced a rapid decline in the birth rate, recording 0.82 in 2020.

ii) GDP per capita

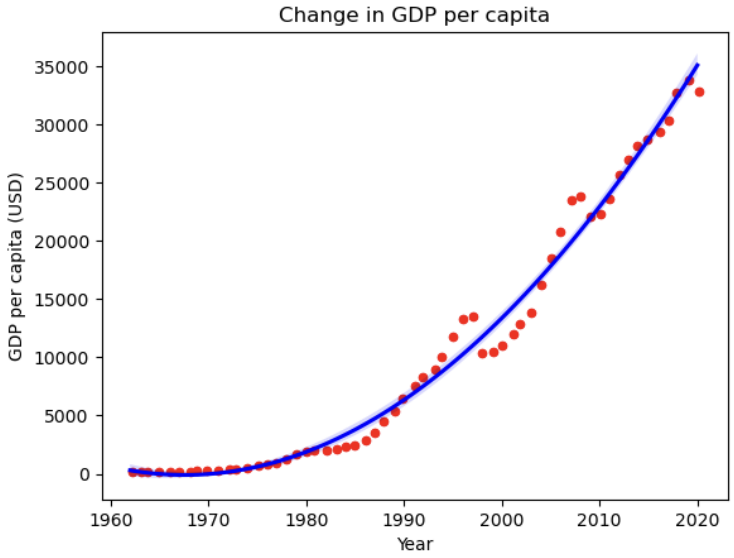


Figure 17 Change in GDP per capita

The increase in GDP per capita refers to economic expansion. GDP per capita measures the economic output produced by each person. While GDP measures the net output created by a country, GDP per capita is an efficient tool that shows the growth of every people. South Korea had a mere increase in GDP per capita until 1985, but from 1990, the GDP per capita increased rapidly. Although in 1999 and 2010, there was a decrease in GDP per capita. In 1999, due to the IMF crisis, the GDP per capita decreased as people lost their source of income. Other than that, South Korea has experienced huge economic development, and people could have a more stable socio-economic status than before. Compared to the GDP per capita in 1990, South Korea's current GDP per capita has increased by 7 times greater.

iii) Income (USD)

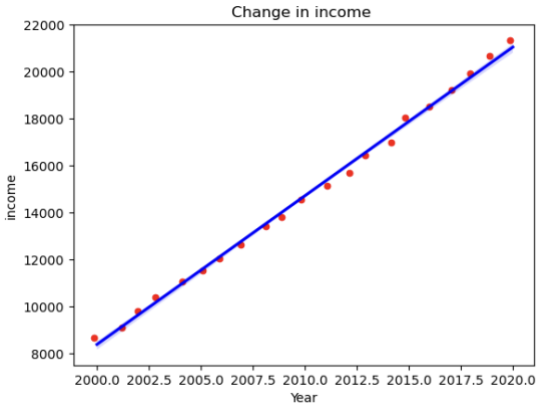


Figure 18 Change in Income

As the GDP per capita increased, the income also raised significantly. Since 2000, the income has grown steadily; compared to 2000, the current income is about 2.8 times greater than before. The increase in income shows overall growth in the economy of South Korea, and this increase in income causes people to spend more for a better quality of life. However, this increase in income leads to more consumption and can increase the interest rate. Since the rise in income raises the demand for money and the supply is constant, the interest rate increases as people get higher incomes. Ultimately, the rise in consumption and interest rate will cause inflation, which limits the benefits of raised income. Still, this steady increase in income shows the economic development as people are earning more than the past.

iv) Educational Expenditure

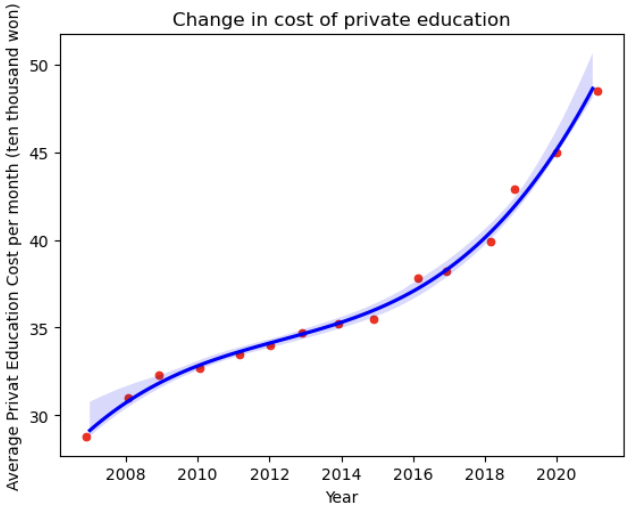


Figure 19 Change in Educational Expenditure

According to KOSTAT, 75.5% of students have experienced a private education. South Korea's personal education business is large, and South Korea is well-known for providing private education for students. According to the graph above, the cost of average private education has increased by 1.8 times. The graph shows an average private education cost, but the real value might be higher than the value shown in the graph. Since most private education is provided for high school students, the data related to elementary and middle school students might lower the average. This variable could be the most essential variable that proves the decrease in the birth rate. Educational expenditure takes up a huge percentage of expenditure for raising a child, and an increase in educational expenditure might hinder people from having a child. As the graph shows, this rapid increase in educational costs might influence the birth rate to decrease. This variable might show why South Korea is an outlier of OECD countries. Since South Korea's private education business is more significant than other OECD countries, South Koreans might feel pressure on educational expenditure.

v) Household Consumption

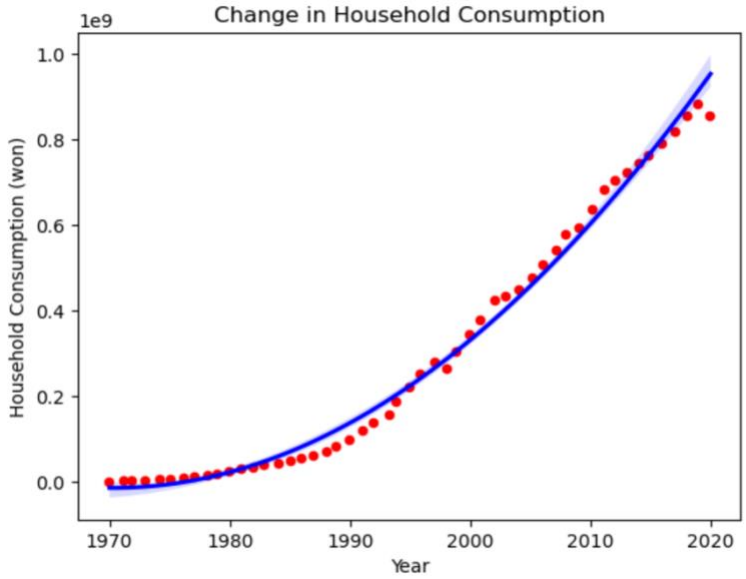


Figure 20 Change in Household Consumption

Household consumption represents the consumed goods and services needed for living. As income increases, people begin to consume more goods, ultimately increasing interest rates and inflation rates. As the figure shows, household consumption has increased since the 1970s. Until the 1990s, household consumption increased slowly, but after the 1990s, household consumption increased rapidly. The amount of average household consumption in 2020 is 10 times greater than that of the 1970s. This rapid increase can explain why the increase in income couldn't enhance people's quality of life. As people earn more money, society requires people to consume more goods and services. The increase in interest rate will lead to an increase in the inflation rate, which causes people to use more money for a stable life. As shown in the figure, people are spending much more money faster than the rate of increase in income.

vi) Housing price index

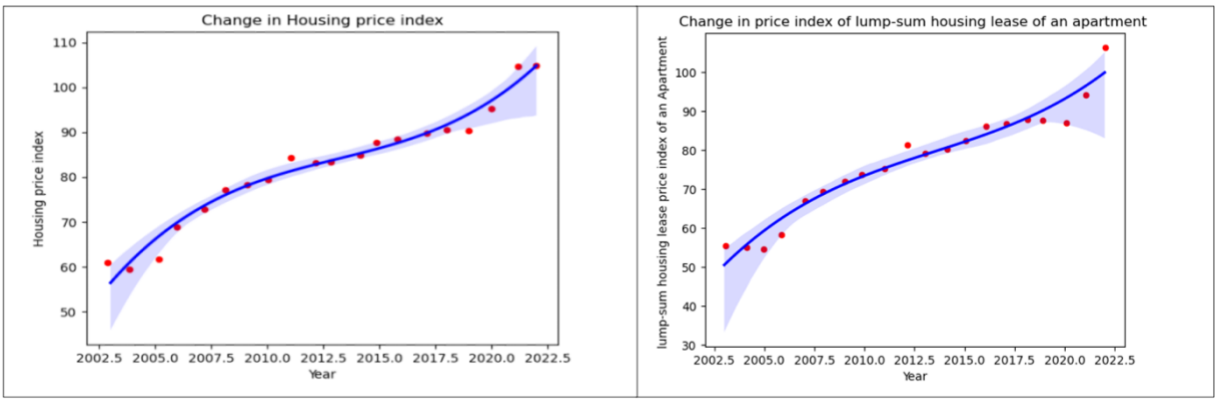


Figure 21 Change in Housing Price Index

The figure on the left is a graph showing house price index in South Korea and the figure on right is a graph that shows the price index of lump-sum housing lease in South Korea. Most of South Koreans use this lump-sum housing lease system for their household. Instead of paying

monthly rental fee, the customer deposits same amount of money as the market value of the house. The general trend of housing market is that the price is increasing. Both figures show corresponding trend. It increased in slow rate until 2012, but from 2012, the price of house increased in a greater rate. In 2008 to 2012, the global economic crisis led decrease in demand of house. Specifically, South Korea recorded the lowest number of trading volume of house. Then, after the reactivation of the house market, South Korea's house price increased rapidly. According to the figure, in 2020, the price of house increased dramatically. The increase in price of house gives more pressure to people. As the number of family member increases, it requires better quality of house and as having a child requires house with higher cost, this increase in house price might have caused people to not have a child.

vii) Income vs Household Consumption

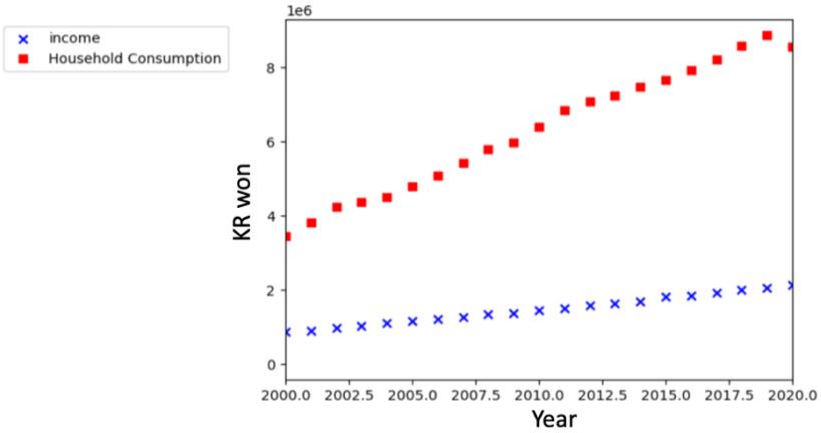


Figure 22 Income vs Household Consumption

The graph above is a comparison graph between income and household consumption from 2000 to 2020. This figure will enhance my assumption made in figure 21. As stated, the household consumption increase is much faster than the increase in income. Since the slope of the red dots is stiffer than the blue dots, this represents that household consumption is increasing faster than income. Not only the rate of change but the difference in the amount of money is also great. This graph shows that household consumption is almost 3~4 times greater than the income value.

viii) Income vs House Price

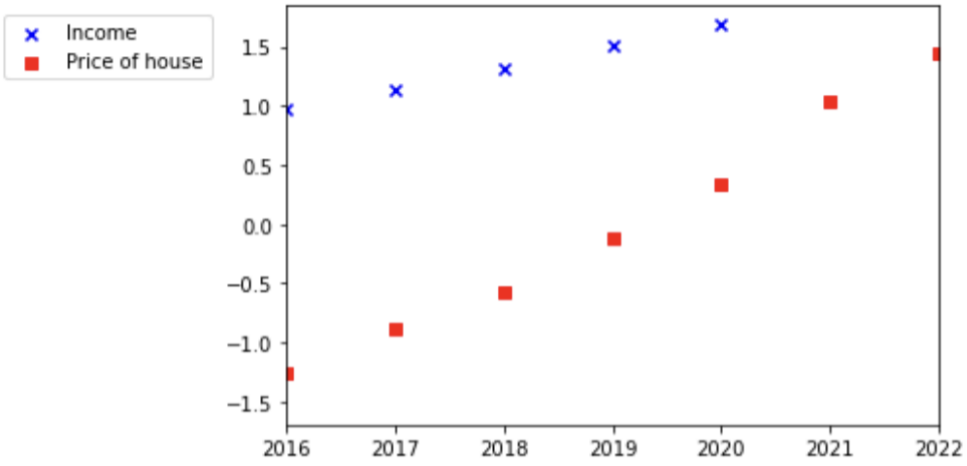


Figure 23 Income vs House Price

This graph is drawn to compare the change in income and the house price. Since the monetary gap between price of house and income is large, I had to use standardization for better comparison. For a better comparison, I used standardization by subtracting every data sample from the mean value, then dividing those sample by standard deviation. In this way, it can clearly show the difference in the rate of change. As shown in the figure above, while the increase in income is mere, the rise in house price is stiff. Similar to the income vs household consumption figure, the increase in revenue is not helping citizens. Relatively radical increases in house prices and household consumption are hindering people from affording a better life as house prices and household consumption are essential in living. This comparison proves that the income increase does not show a direct economic growth of households.

ix) CPI

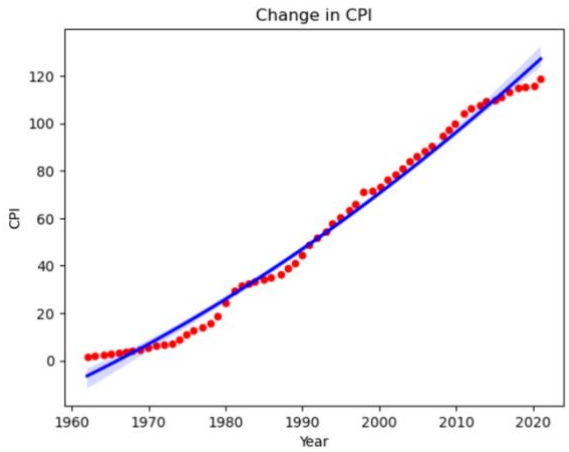


Figure 24 Change in CPI

CPI is an essential economic measurement that can be used to show the inflation rate. CPI is a price index that shows the price of the average market basket of goods and services purchased by customers. The faster rate of change in CPI represents an increase in the inflation

rate. From the 1960s to the 1980s, the increase in CPI was not radical, but after the 1980s, South Korea's economy started to develop with government policies. This caused people to earn more money, and the inflation rate began to increase as people spent on goods and services. The essential trait of this graph is that this graph implies that the increase in income or other monetary value is not always beneficial. An increase in income causes the inflation rate to increase, and a high inflation rate hinders the benefits of an increase in income.

x) Unemployment rate and employment rate

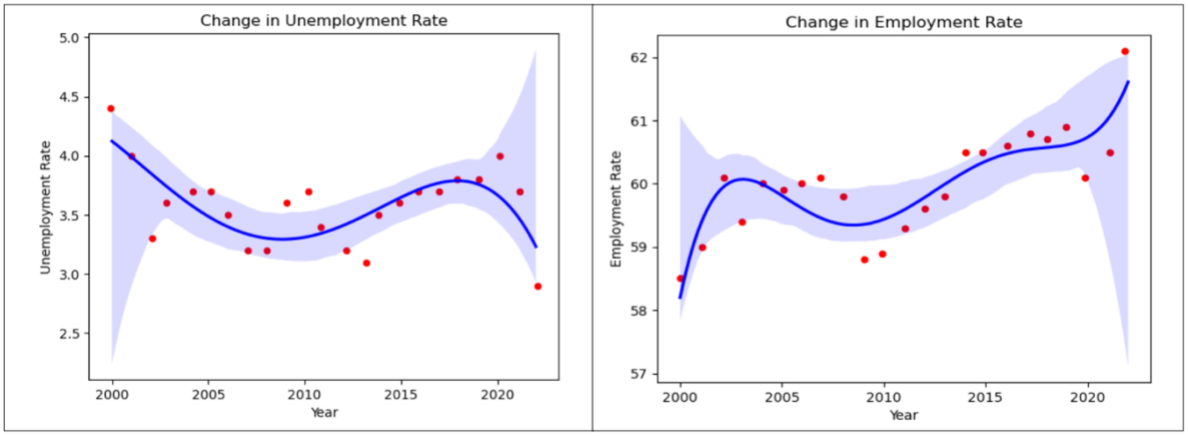


Figure 25 Change in Unemployment Rate and Employment Rate

The average unemployment rate in South Korea over 20 years is about 3.5%. Since 2000, the unemployment rate has gradually decreased by about 1.5%. Although, in 2008, due to the global economic crisis, the unemployment rate slightly increased, eventually, the unemployment started to decrease again due to economic expansion (growth). For the employment rate, there was about a 3.5% increase in the employment rate. Same for unemployment, in 2008, the employment rate decreased heavily, but since then, employment has started to rise again. Coherently, in 2020, the unemployment rate increased, and the employment rate decreased. This phenomenon is due to COVID-19, and as many companies dismissed workers or people sought this term as an opportunity to change jobs, there was some change in the rate. Ultimately, the decrease in the unemployment rate and the increase in employment illustrate economic growth.

xi) Labor force participation rate

(1) Total

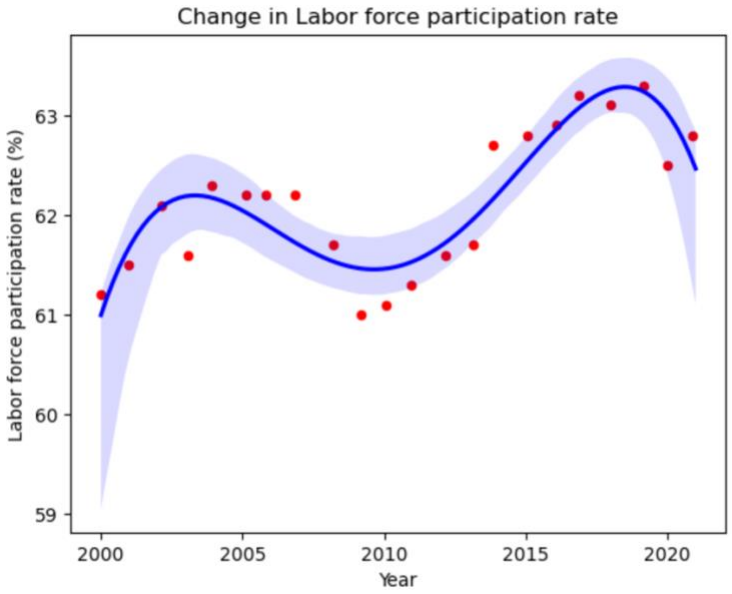


Figure 26 Change in Labor force participation rate (total)

In general, South Korea's total labor force participation rate increased. From 1998 to 2000, the IMF economic crisis caused South Korea to have a high number of unemployed workers. Since then, the labor force participation rate has increased as the economy has started recovering. However, the labor force participation rate decreased in 2005 and expanded again in 2012. Ultimately, the percentage of the labor force participation rate increased until 2018, but the recent trend shows that the labor force participation rate is decreasing. Although the labor force participation rate has increased, an increase of only 1% is not ideal and means that economic growth was insufficient.

(2) Male

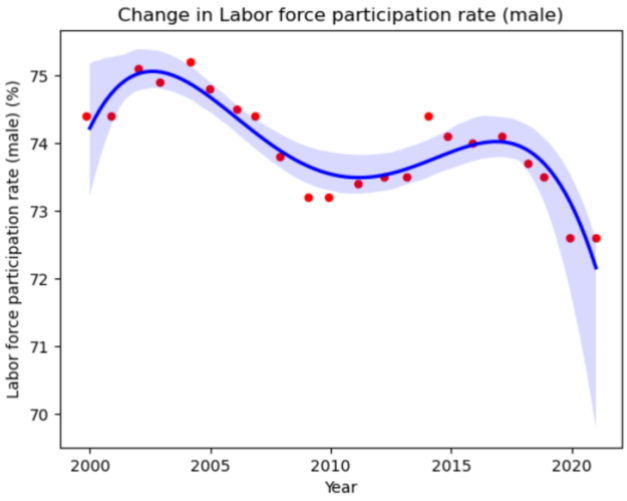


Figure 27 Change in Labor force participation rate (male)

Surprisingly, the percentage of men joining the labor force has decreased by about 2%. In 2000, about 74.3% of male workers participated in the labor force, but with a constant decrease, in 2020, only about 72.5% of male workers left in the labor force. Since most of the labor force was male, this trend shows that the number of men joining the labor force is much less than the number of men leaving the labor force. This indicates that the circulation in the labor force, the switch between old and new workers, is failing.

(3) Female

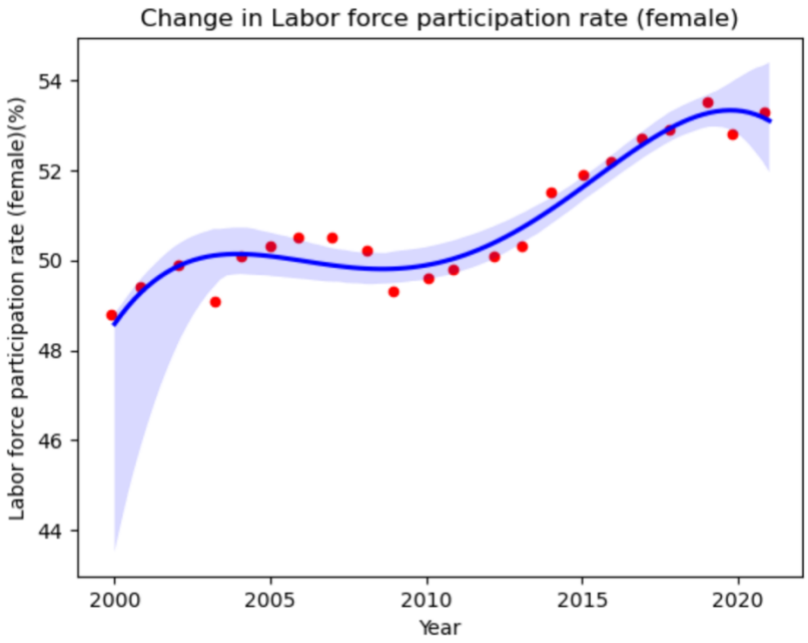


Figure 28 Change in Labor force participation rate (female)

An increase in the female labor force participation rate has been selected as a possible obstacle to decreasing the birth rate. An increase in the female labor participation rate means more female citizens are willing to work, not just nurture a child. As a result, the higher demand for work caused people to not have a baby. Raising a child and working in employment have been seen as an opportunity cost to each other (Doepke, 2022). In this graph, female workers' labor force participation rate increased by about 5%. In figure 26, about 2% of males' labor force participation rate decreased, but about 5% increased for females. This shows that more female workers are joining the labor force rather than leaving.

(4) Comparison

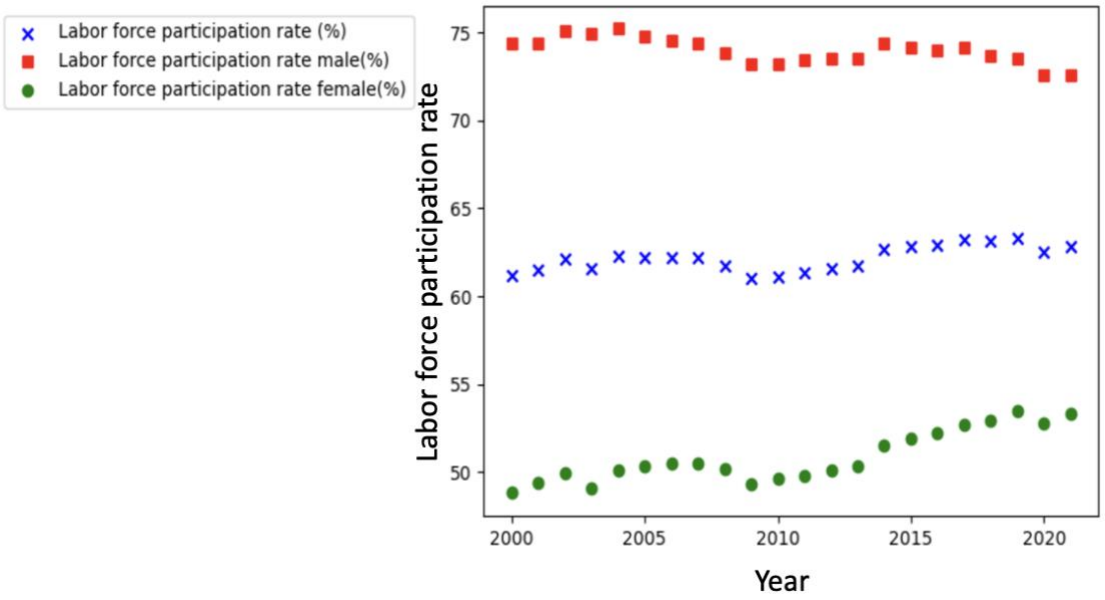


Figure 29 Change in Labor force participation rate (comparison)

The figure above clearly compares the labor force participation rate of the total labor force, male and female workers. As discussed above, the overall percentage of labor force participation rate has increased by about 1% which is below expectation. Male labor force participation decreased by 2%, indicating a failure of labor circulation. Lastly, the female participation rate has increased by about 5%. The figure clearly shows that the female labor force participation rate is the only one that shows a clear increasing trend. As Doepke stated, these trends can be a reason behind decreasing birth rate. As more female workers tend to join the labor force, they are paying more for the opportunity cost, which is not having a child.

xii) Women quitting job for childcare

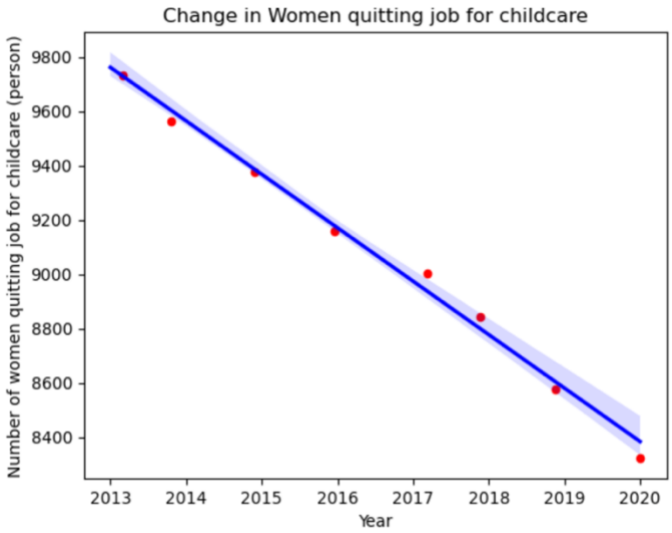


Figure 30 Change in Women quitting job for childcare

Traditionally, the mother oversaw taking care of the household and child. As women become mothers, they usually give up working and raising a child. The opportunity cost of becoming a parent can be related to the household production theory, as mentioned in the introduction. For their child, people are using their goods and services to foster children. The household's production is consumed by the household, not by other consumers, and they are using their income for production. However, to foster their child, people are giving up their source of resources and still have to use their products (income) for their child. However, as shown in the figure, women tend to remain employed. Since 2013, the number of women quitting a job for childcare has decreased continuously. This can be both the result and reason behind reducing the birth rate: not having a child will not make women quit a job and forgoing a source of resources for a child is unnecessary for them.

xiii) Average age of becoming a mother

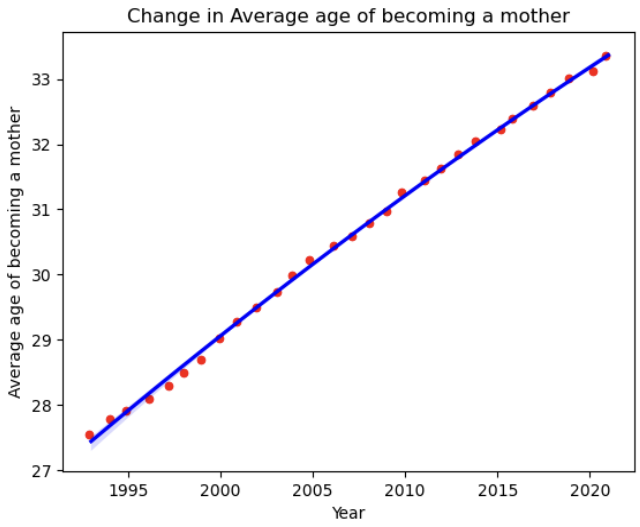


Figure 31 Change in Average age of becoming a mother

This unique graph is about a change in average age of becoming a mother. In 1995, the average age of mother of an infant was about 27. However, with a steady increase, in 2020, the average age of mother became over 34. This change shows that the social norm is thinking of late marriage or not trying to have a child earlier. This graph shows the real problem in South Korea that Koreans are not thinking of having a child.

xiv) Childcare support & policy (cooperation vs government)

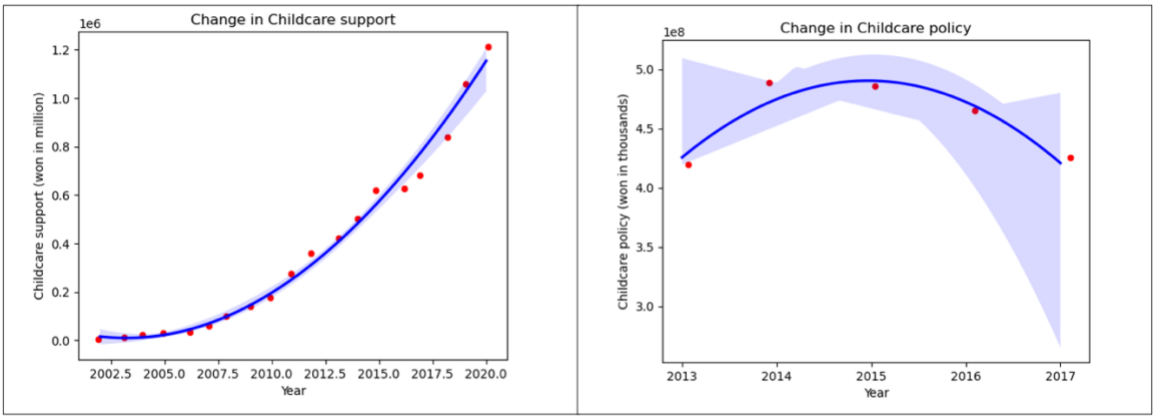


Figure 32 Change in Childcare support and policy

The left figure is a graph about childcare support from cooperation, and the right figure is a childcare policy constructed by the government. Surprisingly, while the cooperation supports employees, the government's childcare policy is not helping people who have a child. Since 2007, the cooperation has increased the amount of childcare support in a high rate. The government increased childcare support greatly in 2014 but after 2014, the government decided to support citizens less. While the government is asking for a higher birth rate and encouraging people to have a child, their policy is not helping people at all. The citizens are having a more challenging time due to inflation and higher household consumption; the reduced childcare policy won't let people have a child.

IV. Statistical Analysis of the birth rate vs economic variables

1) General OLS model – The general OLS model is used to determine the coefficients of linear regression equation which represents the relationship between independent variables and dependent variables. For this honors thesis, the independent variables will be Apartment CPI, Household Expenditure, CPI, Women labor force participation rate, Annual Income, and Employment rate.

2) Fixed Effect model – When using panel data in an analysis, there can be a categorical predictor which divides the observations into groups such as countries, schools, years, etc. In this context, fixed effects are assumed to be constant across individuals and random effects may vary. In other words, Fixed effect measures the effects assuming the same condition across all observations that these conditions don't change or change at a constant rate over time. Therefore, this honors thesis will use fixed effect model with a panel data set including 5 countries to observe these effects in addition to OLS models.

a) General OLS Model Regression Analysis

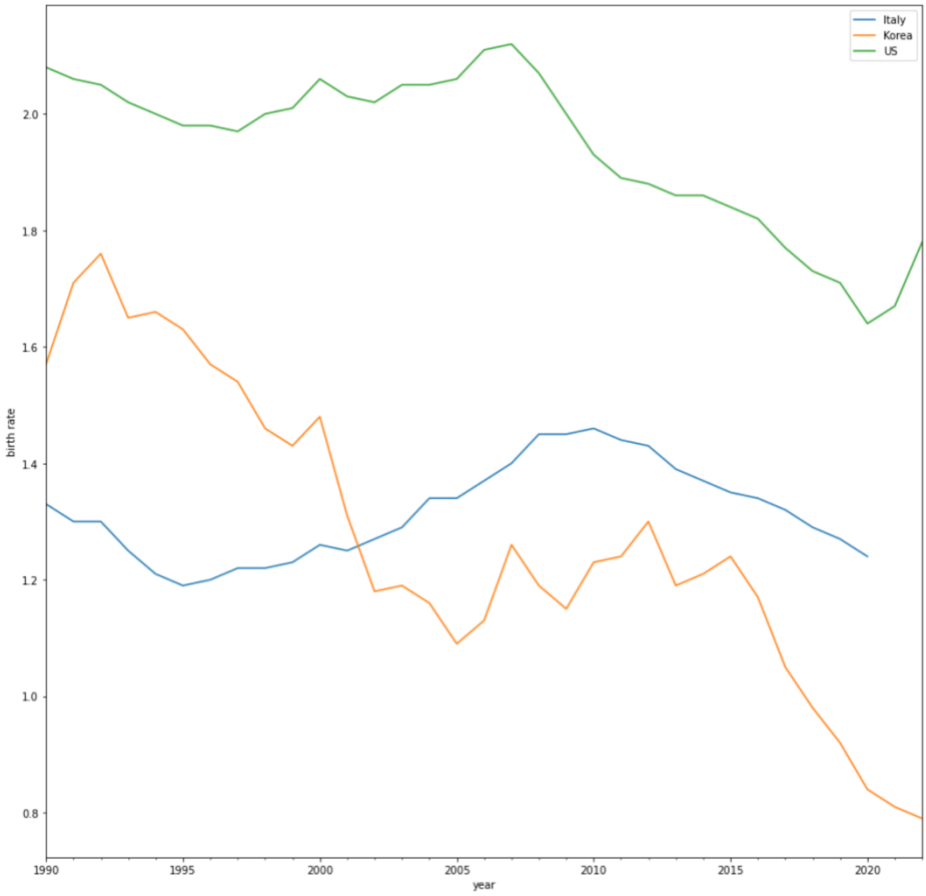


Figure 33 Birth rate graph of Korea, United State, and Italy

I decided to compare the relationship between birth rate and six variables in three different countries. Based on the statistical analysis, I will determine which variables influenced the birth rate of each other the most and compare the ranking of the variables to each other. I chose to pick two other countries from Europe and North America. This selection was based on two main reasons: 1) Most OECD countries are in Europe and North America, so selecting countries from these two continents could best present the OECD countries 2) I tried to choose one country that overcame the birth rate dilemma, and one other country experiences a sudden decrease in the birth rate. According to the data from World Bank, I determined that the United States and Italy perfectly matched my standard.

As I mentioned in the introduction, Doepke mentioned that the United States started to show an increasing birth rate trend and exemplified it as a country that overcame the birth rate dilemma. In the graph, we can easily observe that United States' birth rate started to increase in the mid-1990s, and starting in 2018, it began to increase again. Also, when the birth rate in the United States decreased, it had a much slower rate of decrease of birth rate. I wanted to compare the statistical analysis of South Korea and the United States to show how each variable influenced differently on the birth rate. By this comparison, I can conclude that some variables are more influential to the birth rate.

Italy was recognized as a country that overcame the birth rate dilemma, but now it is recognized as Europe's South Korea as its birth rate is decreasing at the fastest rate in Europe. Since 1995, the birth rate started to increase until 2010, which shows a similar trend in the United States. However, recently, while the United States birth rate started to increase, the birth rate in Italy is decreasing at a fast rate, and it is still decreasing rapidly. By comparing Italy, I wanted to compare if they share variables that influenced relatively greatly on the birth rate. Since they are experiencing a decrease in the birth rate recently, the result might answer which variables are more influential to the birth rate.

Equation for OLS:

$$Y = \beta_0 + \beta_{aptcpi}X_{aptcpi} + \beta_{expenditure}X_{expenditure} + \beta_{cpi}X_{cpi} + \beta_{womenemp}X_{womenemp} + \beta_{annincome}X_{annincome} + \beta_{emprate}X_{emprate} + \epsilon$$

Equation for Fixed Effect Model:

$$Y = \beta_0 + \beta_{aptcpi,it}X_{aptcpi,it} + \beta_{expenditure,it}X_{expenditure,it} + \beta_{cpi,it}X_{cpi,it} + \beta_{womenemp,it}X_{womenemp,it} + \beta_{annincome,it}X_{annincome,it} + \beta_{emprate,it}X_{emprate,it} + \alpha_i + \epsilon_{it}$$

where

i = country
t = year
α_i = time-invariant variables

Table 1. Estimation Result for South Korea, Italy, and US (Regular Regression)

Variable	OLS (South Korea)	OLS (Italy)	OLS (United States)	Fixed Effect Model (Country fixed)
Apartment CPI	-0.1679*** (0.0013)	-0.0421*** (0.0011)	-0.0041** (0.0017)	0.0012*** (0.0003)
Household Expenditure	-1.2328*** (0.0499)	0.0002 (0.0004)	-0.0005 (0.0000)	0.00004* (0.00002)
CPI	-0.0054*** (0.0020)	-0.0684*** (0.0045)	-0.0007 (0.0108)	-0.0060*** (0.0020)
Women Labor	-2.3309*** (0.0022)	-0.1192*** (0.012)	0.0453 (0.1287)	0.03357*** (0.0079)
Annual Income	0.0001 (0.0001)	0.0005 (0.0006)	0.0002 (0.0000)	-0.00001*** (0.000003)

Employment Rate	-0.0692* (0.0081)	-0.0145 (0.0106)	-0.0206*** (-0.0097)	0.0005 (0.0057)
Constant	-0.9982*** (0.0822)	1.5027*** (0.2660)	1.11 (0.9602)	.1659 (.3607)
Number of observations	23	23	31	124
Standard errors in parenthesis				

The result of the regular multiple regression for South Korea suggests that Apartment CPI, Household Expenditure, CPI, Women Labor, and Employment Rate were significant. The Apartment CPI, Household Expenditure, CPI, and Women Employment Rate were significant at 1% level, while Employment Rate in general was significant at 10% level. As our dependent variable, Birth Rate, shows a downward trend, most of the independent variables used showed an inverse relationship with the dependent variable.

From the beta value, we can notice that the Women employment rate (-2.3309) had the largest magnitude of impact on the birth rate compared to other significant variables. This suggests that as more women jumped into the job market in the last couple decades, the birth rate was largely affected. Household expenditure CPI (-1.2328) had the second highest magnitude, followed by APT CPI, Employment Rate and CPI. Annual income did not have a significant impact on birthrate, indicating that even though annual income has generally increased, its effect was not different from zero. The beta value suggests that the increase in women labor force participation rate and increase in the expenditure caused South Korea's birth rate to decrease the most.

In the case of Italy, Apartment CPI, CPI, Women Labor were significant factors that influenced birth rate. All significant variables were significant 1% level. Household Expenditure, Annual Income, and Employment Rate were not significant. Similar to the results of South Korea, Women Employment (-0.1192) had the largest negative impact on birthrate in Italy, followed by CPI (-0.0684) and Apartment CPI (-0.00684). Although the case of Italy showed a greater number of insignificant variables, it is evident that the increasing burdens from the rise in consumer price and women starting to have careers did impact the birthrate in Italy. Compared to South Korea, the beta values are relatively all small, but it is same that the women labor force participation rate has the highest beta value, meaning that for both countries, the women labor force participation influenced the birth rate the most. One thing to mention is that while South Korea's expenditure was the second highest value, the CPI was the second highest value for Italy.

For United States, as evident in the general trend, the decline in the birthrate is not as severe as that of the other two countries of interest. The results of the regression analysis support the trend, as many of the variables were not shown to be significant factors of birthrate. Only Apartment CPI (-0.0041) and Employment Rate (-0.0206) indicated a significant relationship at 1% level. While Women Employment Rate was significant in both South Korea and Italy cases, it was not a significant factor in the United States and the standard error value was high as well. This could imply that when women jump into the job market, there are social restraints that hinder women from giving births in Korea and Italy, while the impact is not

gender specific in the United States. The general Employment Rate was shown to be significant. Also, the intercept was not significant for only the case of United States, indicating that there was no average impact of the independent variables.

Figure 34 Women Labor Force Participation Rate for South Korea, Italy, and US

As shown in the figure 34, the women labor force participation rate for South Korea and Italy has been increasing steadily. However, for United States, the women employment rate has been decreasing since early 2000s and unlike South Korea and Italy, the birth rate started to increase. Also, while the women labor force participation rate for United States and Italy is high, that of South Korea is just starting to increase. Based on the graph, we can imply that it is true that the increase in women labor force participation rate influences the birth rate to decrease. This could be also explained by the beta value of Women labor force participation rate as South Korea recorded the highest (-2.3309), Italy recorded second highest (-0.1192), meaning that the labor force participation rate influenced South Korea the most, and United States the least. Thus, by comparing the OLS regression model, I hypothesize that the women labor force participation rate influenced the birth rate the most and to verify my hypothesize, I am going to use fixed effect model.

b) Fixed Effect Model Regression Analysis

There are 4 main reasons for using Fixed Effect in a similar setting as this thesis:

1) To control unobserved heterogeneity: Fixed effect models allow the elimination of unobserved heterogeneity. Unobserved heterogeneity might lead to omitted variable bias, degrading the accuracy of our estimates. In the fixed effect model, the time invariant variables eventually disappear, eliminating the unobserved heterogeneity. OLS estimation does not account for the time invariant unobserved factors.

   The Fixed Effect Model regression eliminates the control unobserved heterogeneity by using a time demeaned result which is expressed by tilde. This result is determined by subtracting the average regression equation from regression equation. In this case, the regression equation is a birth rate equation with various explanatory factors.

$$Y = \beta_0 + \beta_{aptcpi,it}X_{aptcpi,it} + \beta_{expenditure,it}X_{expenditure,it} + \beta_{cpi,it}X_{cpi,it} + \beta_{womenemp,it}X_{womenemp,it} + \beta_{annincome,it}X_{annincome,it} + \beta_{emprate,it}X_{emprate,it} + \alpha_i + \epsilon_{it}$$

$$\overline{Y} = \beta 0 + \beta aptcpi,it\overline{Xaptcpi,it} + \beta expenditure,it\overline{Xexpenditure,it} + \beta cpi,it\overline{Xcpi,it} + \beta womenemp,it\overline{Xwomenemp,it} + \beta annincome,it\overline{Xannincome,it} + \beta emprate,it\overline{Xemprate,it} + \alpha_i + \epsilon it$$

   However, when determining the average birth rate equation, we divide the sum of explanatory variables by 1/T, when T is time.

$$\frac{1}{T}\sum_{t=1}^{T} Xit$$

   However, since α_i is time invariant variable, the mean value of α_i divided time is still same as α_i because the time can't influence the value of α_i. Thus, when subtracting the average birth rate equation to the original birth rate equation, the α_i value cancels out because we are subtracting the same value. The subtracted values are shown as the equation with tilde. Since the α_i value are the same for both original regression and average regression, so we can cancel the α_i values out.

$$\widetilde{Y} = \beta 0 + \beta aptcpi,it\widetilde{Xaptcpi,it} + \beta expenditure,it\widetilde{Xexpenditure,it} + \beta cpi,it\widetilde{Xcpi,it} + \beta womenemp,it\widetilde{Xwomenemp,it} + \beta annincome,it\widetilde{Xannincome,it} + \beta emprate,it\widetilde{Xemprate,it} + \alpha_i + \epsilon it$$

   Since the Fixed Effect Model uses the time demeaned result, it eliminates the time invariant error that could happen when OLS estimator is used.

2) To improve precision: Fixed effect models gives more precise estimates by accounting within-group correlation. This allows more accurate standard errors, improving the precision of the estimates.

3) Handling unbalanced panel data: Fixed effects model can handle unbalanced panel data. Sometimes, the data used for each variables have different number of samples. By using the fixed effect model, we can increase the sample size and handle the unbalanced panel data to get more accurate result. In each of the OLS analysis, only 23 and 31 samples were used, which are small sample sizes for OLS estimation. By using panel data, we can get more accurate results.

4) To handle endogeneity: The endogeneity happens when the x variable in regression model is correlated with the error term and arises when there is a two-way causality between outcome and independent variable. The fixed effect models can address endogeneity problem, resulting in better outcome.

Among the possible reasons for using Fixed Effect Model, the main reason for using the fixed effect model is due to the nature of the data and the samples. When using OLS analysis, the evaluation of the variables needed to be done individually for each country. As a result, the sample sizes became too small. Although the variables indicated significance, the small sample sizes mean that the result is not fully reliable. Therefore, this research combined the dataset for all the countries of interest as a panel dataset. This increased the sample size to over 100 samples, which could provide reliable analysis results. In the OLS regression analysis, it has determined that the women labor force participation rate was significant for South Korea and Italy. Through the fixed effect model regression, I want to verify my hypothesis that the women labor force participation rate influenced the birth rate because the fixed effect model regression will give me the beta value that proves whether the variables are related if we fix the countries.

For the fixed effect models, I thought adding two more countries from North America, Europe, or Asia would improve statistical results as it provides more samples. I decided to add Canada and Japan for my statical analysis for two main reasons.

First, I added Canada because it has a similar economic trend to South Korea. Canada's GDP per capita of households is similar to South Korea, and other economic variables are similar to South Korea's. However, Canada's rate of change of birth rate has been steady since the 1990s. Since 1990, only 0.43 births per woman has been decreased. I thought including a country with a similar economic background to South Korea, but a different birth rate trend might be a good data sample to create a more precise and accurate statistical analysis without bias. Thus, I decided to add Canada for our fixed effect and random effect model.

Second, I added Japan because of their situation and geographical reason. Although Japan's birth rate is better than South Korea, Japan is experiencing population aging. This unbalance in society is causing slow economic regression, and the birth rate has also been recognized as their problem. Also, since Japan is right next to South Korea, they share a similar culture, social norms, and economic development. Thus, I chose Japan, which has similar traits and problems to South Korea but shows a better birth rate than South Korea.

The main reason behind adding Canada and Japan to the Fixed Effect Model is for more samples. The OLS regression model only runs statistical analysis of an individual countries' data on variables. Since the Fixed Effect Model is used to determine the average beta value and the average relationship between economic variables and birth rate, I decided to add two more countries for more precise and accurate measurement of the beta value. The beta value of Fixed Effect Model of 5 countries will show better beta value than just running that of 3 countries. Thus, I decided to run Fixed Effect Model with Canada and Japan as well. However, I did not included Canada and Japan for OLS regression Model because I chose countries for OLS regression based on their birth rate trend and to compare beta values with that of South Korea.

In the Fixed Effect Model, the countries and years were fixed. The models analyzed the impact of the independent variables in South Korea, Italy, the United States, Japan, and Canada. According to the result of the Fixed Effect Model, all values except employment rate showed a significance but the beta values for Apartment CPI and Annual Income was too low to indicate any significant impact on birthrate. Thus, the only variables that is notable to mention in this regression analysis are Apartment CPI, CPI, and Women Labor Force participation rate.

Apartment CPI, CPI, Women Employment, Employment Rate were significant factors that impact birthrate in the countries of interest. The Apartment CPI and Women Labor were significant at 1% level and CPI at 10%. Surprisingly, the fixed effect model regression showed different result with the individual OLS results. While the Apartment CPI, CPI, and Women Labor Force participation rate had negative beta value for individual regression, when I ran those data into the fixed effect model regression, the beta value for Apartment CPI (0.0012) and Women Labor Force participation (0.03357) had positive beta value, meaning that when we view this panel data as one dataset, then the Women Labor Force participation rate and Apartment CPI showed direct relationship with the birth rate. This result shows that the analysis that I found through OLS regression and Fixed effect model regression are different as the beta value of each variable (relationship between dependent variable and independent variable) showed opposite result. This indicates that although on the global level, when we consider the effect across the countries, Women Employment did not have a significant relationship in the decrease of birth rate, but according to the result of the OLS, it was a special and unique characteristic of Korea, where as Women Employment increased, the birthrate fell.

c) Statistical Analysis

The Variance Inflation Factor (VIF) is a test used to assess the degree of multicollinearity between predictor variables in a regression model. Multicollinearity occurs when two or more predictor variables are highly correlated with each other, which can lead to unreliable regression coefficients.

The VIF measures how much the variance of the estimated regression coefficient for each predictor variable is inflated due to the presence of other predictor variables in the model.

The formula for VIF is as follows:

$VIF = 1 / (1 - R^2)$

where R^2 is the coefficient of determination obtained from regressing the predictor variable of interest against all the other predictor variables in the model. The coefficient of determination (R^2) obtained from this regression analysis represents the proportion of variance in the predictor variable of interest that is explained by all the other predictor variables in the model. This value is then used to calculate the VIF for the predictor variable of interest.

In simpler terms, the R^2 value measures the strength of the relationship between the predictor variable of interest and the other predictor variables in the model. It tells you how much of the variability in the predictor variable of interest can be explained by the other predictor variables in the model. The higher the R^2 value, the stronger the correlation between the predictor variable of interest and the other predictor variables, and the higher the VIF value will be.

A VIF value of 1 indicates that there is no multicollinearity between predictor variables, while a VIF value greater than 1 indicates some degree of multicollinearity. A commonly used rule of thumb is that a VIF value greater than 5 indicates significant multicollinearity, and a value greater than 10 indicates severe multicollinearity.

If the VIF test reveals the presence of multicollinearity, it may be necessary to remove one or more predictor variables from the model or to combine them into a single variable. This can help improve the accuracy and reliability of the regression coefficients and predictions.

The following is the VIF test result of this thesis.

Variable	VIF	1/VIF
Employment Rate	7.53	0.13
Household Expenditure	4.51	0.22
CPI	3.54	0.28
APT CPI	3.12	0.32
Women Employment	2.75	0.36
Annual Income	2.43	0.41

Here, all variables showed VIF level under 5 except for Employment Rate. With such high VIF level, employment was indeed insignificant in the Fixed Effect Model. In fact, with such multicollinearity, the employment rate variable could be excluded from the analysis entirely. Fortunately, one of our key variables, women employment rate did not result in a high level. This indicates that while Employment Rate is correlated with many of the variables in the analysis, Women Employment was not, most likely just with Employment Rate. As all the other variables were shown to be below 5, which means that the model used in this study is robust.

I used the heteroskedasticity test to verify whether the variability of variables is unequal to the range of values of the second variable. It is essential to check whether the data is experiencing heteroskedasticity or not. If the data is experiencing a heteroskedasticity, it means that the estimated standard error is wrong. Therefore, we cannot rely on the data's confidence intervals, hypotheses tests, and p-value. After running the heteroskedasticity test, I got a p-value of 0.94. Since the resulted p-value is smaller than 0.05, we can reject the null hypothesis and state that the Fixed Effect Model is not experiencing heteroskedasticity. Ultimately, the regression is experiencing a homoskedasticity, which means that we can rely on the regression.

		0	1
0	Lagrange multiplier statistic		125.000000
1	p-value		0.939772

Heteroskedasticity test

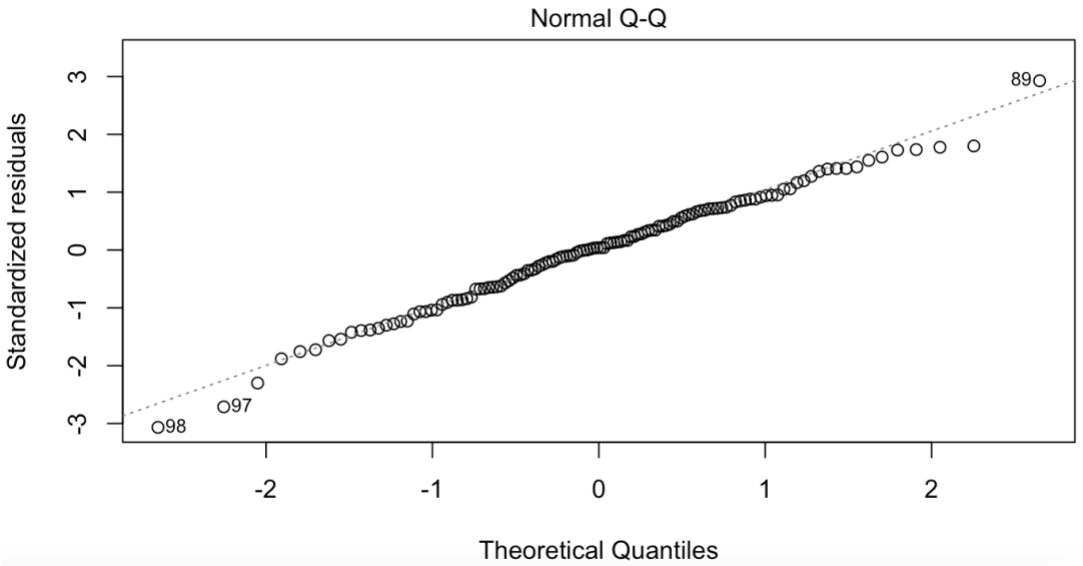


Figure 35 Normality Test

The normality test determines whether the data used for the regression has been drawn from a normally distributed population. The normality test is necessary to determine whether the data is suitable to do hypothesis test. In this case, I run R to draw a Q-Q graph for normality

test. The Q-Q test is a plot to test whether the data is experiencing normality or not. By plotting their quantiles on x and y axis, this graph can compare two probability distributions. In this case, since most dots are lying on the regression line, so this Q-Q plot implies that the sample used for the regression is showing a normality. Therefore, the data was suitable to do hypothesis test.

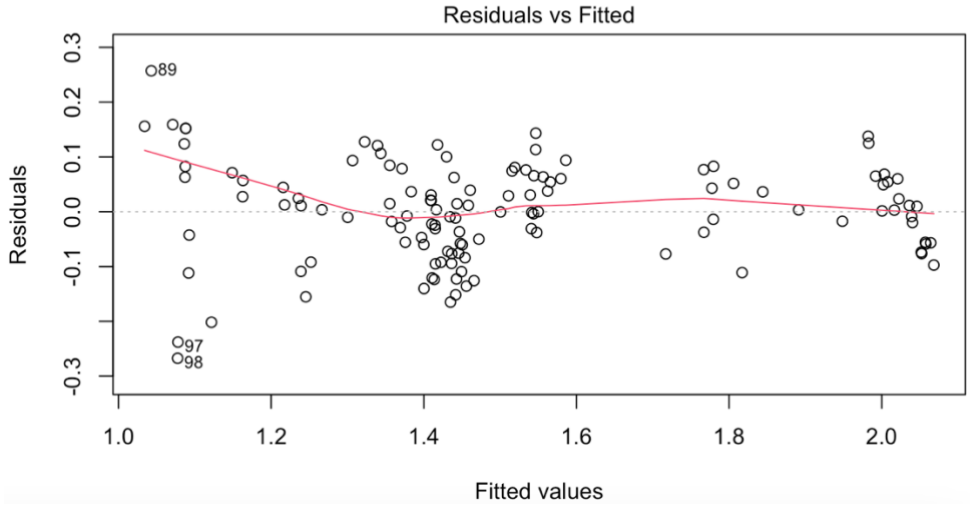


Figure 36 Linearity Test

The linearity test is used to analyze the variance for the linear regression for each level of the predictor variables. If the relationship between predictor variables and outcome variable is not showing a straight-line relationship, then we might not be able to use the model as the accuracy will be reduced. In this case, the linearity test was run by R by plotting the fitted values and residuals to determine the variance between two values. For the dots plotted on the left, the difference between residuals and fitted values were great, but as the graph continues, the graph started to show the linearity. Therefore, in this case, a strong linearity is not shown but it is still having a modest linearity.

V. Conclusion

Graphical Analysis – Heatmap

Surprisingly, among six economic variables used to compare regionally, five variables had an inverse relationship with the birth rate. However, the unemployment rate was the one variable with a positive relationship. However, since the decrease in the unemployment rate represents economic expansion, although the unemployment rate and birth rate have a positive relationship, it means that the decrease in unemployment (economic expansion) resulted in a lower birth rate. Ultimately, we can see that while all six economic variables showed a sign of economic expansion, the birth rate in each region kept decreasing.

For the heatmap, I divided it into three main groups: 1) Capital (3), 2) Metropolitan (5), and 3) Rural region (8). Although all variables showed a negative relationship with the birth rate, some variables showed a different trend from each other. For instance, while the change in household expenditure, educational expenditure, and house price was more significant in the capital region, the change in income, employment, and unemployment was more significant in the metropolitan region. Compared to the change in birth rate, which showed the greatest difference in the capital region, we can imply that the change in birth rate followed the trend of household expenditure, educational expenditure, and house price. Coincidently, all these variables are related to the consumption needed to raise a child in a household, for the variables that showed a more dramatic change in the metropolitan region are associated with the salary of a household. From this, we can imply that consumption relates to the birth rate more than another economic variable as capital regions' birth rates decreased more greatly.

Graphical Analysis – Time Series Graph

Since 1980s, South Korea' birth rate decreased dramatically. During 1990s, the rate of decrease slowed a little bit, but starting 2010s, the birth rate started to decrease again with a faster rate. Surprisingly, the GDP per capita and average income of households also increased in a fast rate. The birth rate dilemma is a word to describe a phenomenon where birth rate decreases even though there is economic expansion. While other OECD countries are now overcoming this dilemma, South Korea is still showing this dilemma which has been a severe problem. From these time series graph, I divided this graphical analysis mainly into two parts: 1) Income vs Expenditure, 2) Change in labor force participation rate. For the variables, the economic expansion led to decrease in birth rate which was similar to the trend shown by the heatmaps. However, the main point was will increase in income influence birth rate more or will increase in expenditure increase influence birth rate more?

Based on the comparison graph, the rate of increase of income was much slower than the rate of increase of expenditures and price of house. Although the GDP per capita and average income increased, the CPI, expenditure, and house price (which are all related to increase in consumption) influenced household's economy more. This was one thing that I wanted to determine through graphical analysis as it shows that people are not only earning more but also, they are paying more.

The other trend I wanted to discuss was the change in the labor force participation rate. In the time series graph, the employment rate increased, and the unemployment rate decreased, ultimately leading to the same result. However, while the average labor force participation hasn't changed much, the labor force participation rate between females and males showed an inverse relationship. While the female labor participation rate increased dramatically, the male labor force participation rate decreased. From this, we can notice that more women are entering the labor force while the men's labor force is constantly falling. This is because in the labor force, there were more men, but now the trend is changing, and more women are entering the labor force. By comparing the labor force participation graph and birth rate, we

can postulate that increase in women entering the labor force has a relationship with South Korea's constant decrease in the birth rate.

Through the analysis of the heatmap and time series graph, I was able to construct a hypothesis that could be answered by statistical analysis: 1) The increase in consumption/expenditure has a more significant influence on the birth rate than economic expansion 2) The increase in the women labor force is the major change that caused a decrease in the birth rate.

Statistical Analysis – General OLS model

The general OLS regression shows the coefficients of linear regression to determine the relationship between independent variables and dependent variables. In this research paper, the general OLS regression model for South Korea, Italy, and United States was used. According to the OLS estimation result for South Korea, the beta value of women labor force participation rate (-2.3309) was the greatest, then Household Expenditure, and Apartment CPI recorded high beta value. All of these beta values were negative meaning that increase in women labor force participation rate, household expenditure, and apartment CPI have an indirect relationship with the birth rate. For Italy, the beta value of women labor force participation rate (-0.1192) was the largest, then CPI and Apartment CPI. Same as the regression result of South Korea, all beta values were negative, meaning that the variables had inverse relationship with the birth rate. Lastly, for United States, the beta value of women labor force participation rate (0.0453) was the highest, then Employment rate and Apartment CPI. One thing to notice is that the beta value of women labor force participation rate was positive meaning that United States' women labor force participation rate has direct relationship with the birth rate. This shows that the United States' birth rate dilemma has been solved and the birth rate crisis is not critical as other countries. However, still, for South Korea and Italy, where the women labor force participation rate is increasing, the birth rate is still decreasing in a rapid rate.

Statistical Analysis – Fixed effect model

The main reason why I used fixed effect model is to verify my hypothesis that women labor force participation rate showed the strongest indirect relationship with the birth rate. However, the result for fixed effect model regression showed exact opposite with general OLS regression models. Since the general OLS model is not applicable in comparing the beta values of each country, I had to use fixed effect model and random effect model to determine the effectiveness of independent variables on dependent variables.

While the beta value of Women Labor Force participation rate for South Korea was -2.3309, and that of Italy was -0.1192, the beta value for fixed effect model was 0.03357. This means that when we run individual OLS regression, it showed that the women labor force participation rate had indirect relationship with the birth rate but when we ran the data as a whole, using fixed effect model, it resulted that the women labor force participation rate had weak, direct relationship with birth rate (beta value = 0.03357). This result rejected my hypothesis that the women labor force participation rate has strong, indirect relationship with the birth rate.

However, since the main topic of this thesis paper is South Korea, I want to compare the result of general OLS regression of South Korea to the fixed effect model regression. While the fixed effect model regression result showed positive beta value for Apartment CPI and Women labor force participation rate, the OLS regression for South Korea showed strong, negative beta value for Apartment CPI and Women Labor force participation rate. This makes South Korea as an outlier, and it is true that South Korea's birth rate is counted as an outlier as well. Thus, I thought that comparing results of countries and result of South Korea can give answer to the radical decrease in birth rate of South Korea.

Table 2. OLS regression of South Korea vs Fixed Effect Model Regression

Variable	OLS (South Korea)	Fixed Effect Model (Country fixed)
Apartment CPI	-0.1679*** (0.0013)	0.0012*** (0.0003)
CPI	-0.0054*** (0.0020)	-0.0060*** (0.0020)
Women Labor	-2.3309*** (0.0022)	0.03357*** (0.0079)

For a better comparison, I made a table that compares the important data. I excluded those variables with low significant level, high standard error, and low beta values to only compare important variables. The beta value of CPI for both South Korea and fixed effect model was similar to each other. The beta value of single OLS regression for South Korea was -0.0054, and that of fixed effect model was -0.0060, meaning that the influence of CPI on birth rate of various countries was similar to the influence of CPI on birth rate of South Korea.

However, while the fixed effect model showed weak, positive relationship of Apartment CPI and Women Labor force participation rate with birth rate, South Korea showed strong, positive relationship between Apartment CPI and Women Labor force participation rate with the birth rate, meaning that these two variables showed totally different relationship with birth rate in South Korea only. Then why is this relationship only shown in South Korea?

According to the *Analysis on Rapid Decline of Birth Rate in Gyeonggi: Reason and Aftermath* and '서울시의 주택문제와 부담가능한 임대주택 정책제언' written by Dr. Park, this phenomenon is caused by the social norm of South Korea. The majority of population in South Korea are willing to live and are currently living in capital region for economic reasons. Seoul, a capital of South Korea, is more centralized than any other region in South Korea. For the household, they all want to live in Seoul due to their development in services and for educational reason. All of the top universities are ranked in the center of Seoul and the educational expenditure in Seoul is incomparable with other region. For the household who raise their child, they all want to live in capital region for their child's educational reason. This caused house market to be more competitive with higher demand of house, causing a rapid increase in house as well.

Also, the South Korea's low interest rate are causing house price to increase as well. According to Dr. Hwang, a president of South Korea Economists association, mentioned that the South Korea's interest rate is too low and allow people to get loan easily. This causes the demand of house in Seoul to increase, causing house price to increase. Due to the severe increase in house price and as they can't afford living in Seoul, more people are tending to not have a child in their household.

For South Korea, the Women Labor Force participation rate showed the largest negative beta value with -2.3309. For other country, the fixed effect model shows that the beta value is 0.03357 which has totally opposite value with that of South Korea. While the beta value of South Korea is showing a strong, indirect relationship with birth rate, the beta value from fixed effect model shows a weak, direct relationship with birth rate, meaning that while the women labor force participation has no significant relationship with birth rate of other countries, the women labor force participation of South Korea has a significant relationship with birth rate.

This unique relationship between two variables in South Korea was followed by the change in women employment market trend. According to Dr. Shin's research paper, she mentioned that in recent 20 years, the enrollment of women to tertiary school and number of women looking for job increased greatly. As women tend to achieve higher degree and seeking for a job, the opportunity cost of having a child increased greatly, leading to the decrease in birth rate in South Korea. Dr. Shin compared this phenomenon to other countries and claimed that South Korea is more vulnerable for these changes than any other countries due to the ongoing gender inequality problem. According to Yang's research, he used graphs to illustrate the gender inequality happening in South Korea. The female labor force participation rate, female higher education enrollment rate, and gender wage gap of South Korea are lower than average OECD countries. However, Yang stated that although the values are much lower than the average of OECD countries, the rate of increment of these variables of South Korea is higher than the OECD countries (Yang, 2021).

Dr. Shin compared this phenomenon to other countries and claimed that South Korea is more vulnerable for these changes than any other countries. As an Asia country, South Korea's social norm was recognized as one of the most conservative social group, meaning that women couldn't get the same opportunity as men did. Dr. Shin claimed that while other OECD countries already overcame this gender inequality issue and South Korea just started to experience the change in social trend, South Korea is showing the faster rate of change and different social phenomenon than other countries.

In conclusion, although the beta value of fixed effect model regression implies a weak, direct relationship between women labor force participation rate and apartment CPI with birth rate, South Korea's unique change in social trend and economic situation made South Korea to function as outlier. Still, the strong, positive beta value implies that South Korea's birth rate is mainly influenced by women labor force participation rate and Apartment CPI.

VI. Future Reference

In the future, if I could design this analysis again, I would also like to include social variables. At first, I only chose economic variables as this thesis is mainly about utilizing data science on the economic question. However, if I could design this analysis differently, I would include social variables or survey data because the birth rate can also be influenced by those variables as well. One thing that discouraged me was the availability of the data. The statical data I could find was mainly from the 1990s, and the data from the year before the 1990s was not available. If I could gain more data from the past, I think the statistical analysis could be more significant. The only problem I had was not able to find enough accurate data that I was looking for.

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