The Research of the Birth Rate in Canada from 1951 to 2022

Zhiyu Chen[1, *], Lin Meng[2] and Siran Luo[2]

[1] Meadowvale Secondary School, Toronto, ON L5N 3B2, Canada

[2] Richmond Green Secondary School, Toronto, ON L4S 2T9, Canada

[3] Nanjing Foreign Language School, Nanjing, 210008, China

*Corresponding author: abirch61974@student.napavalley.edu

Abstract. Although previous studies have shown that Canada's birth rate is in constant decline, many factors are worth investigating. In this study, the ARIMA time series model approach was used to process data from the United Nations World Population Prospects, a system that collects Canadian birth rates from 1995 to 2022. Finally, when the residual model has a sequence relationship, the ARCH/GARCH model is considered for further study, and the conclusion is that the birth rate is still declining due to many factors such as the epidemic situation and living habits, and the birth rate growth is still negative in the next 20 years. However, with more data, Canada's population is still the fastest-growing country among many developed countries. According to the literature analysis, the factors contributing to the low birth rate include the COVID-19 pandemic, women's thoughtfulness and social status, and the improvement of quality of life.

Keywords: Birth rate; Causing factors; ARIMA time series.

1. Introduction

According to Statistics Canada, there has been a downward trend in the birth rate in Canada from 1960 to 2018. In 1960, the total birth rate in Canada was 3.9 births per woman, and in the 1960s and 1970s, the birth rate increased, peaking in 1971 at 3.9 births per woman. However, since 1971, the birth rate has been declining and by 2018 had fallen to 1.5 births per woman [1]. Data show that the number of babies born in Canada last year fell to its lowest level in 17 years, driven by the COVID-19 pandemic and declining fertility rates. Kate Choi, associate professor of sociology at Western University (Canada), says that like many other developed countries, Canada's birth rate has been declining over the past few years, suggesting that the COVID-19 pandemic is affecting family planning for many people [2]. According to Minghui Yu of the Canada Development Report, the social situation in Canada in 2021-2022 is even more complex. At present, Canada's aging problem is worsening, the new generation is unable to make up for the labor shortage, and the future economy is experiencing unprecedented challenges [3].

On February 9, 2022, Statistics Canada released the first results of the 2021 Census. As of the fourth quarter of 2021, the total population of Canada was 38,436,400, an increase of approximately 2.18 million (6.0%) from 2016. In other words, it will be immigration, not births, that will drive Canada's population growth from 2016 to 2021. On the other hand, the COVID-19 pandemic did have a noticeable impact on Canada's population growth curve. the overall population decline in 2021 moderated slightly, but this was largely because 405,000 new immigrants were added to Canada in 2021, the most in history [4]. According to CTV, statistics show that Canada's fertility rate has been steadily declining since 2009. Susan McDaniel, an associate professor of sociology at the University of Victoria, says this shouldn't be cause for concern. Although the total number of births in Canada is declining, the population is still growing. The 2021 census showed that Canada's population grew by 5.2 percent to nearly 37 million, the fastest growth among the G7 countries[5]. TORONTO, Feb. 9 (Xinhua Yu Ruidong) - According to the latest census data released by Statistics Canada on Feb. 9, as of spring 2021, Canada's total population is about 36.992 million. The main factor of population growth comes from new immigrants [6]. According to Statistics Canada, Canada's population continues to grow at the fastest rate among the Group of Seven (G7) industrialized countries.

In the 2016-2021 census cycle, four-fifths of Canada's population growth will come from new immigrants and the rest from natural increase. Canada's largest city, Toronto, has a population of 6.202 million, followed by Montreal and Vancouver [7]. Recently, the Canadian media Global News published data showing that Canada's birth rate has fallen to its lowest level in the last 17 years, with a total fertility rate as low as 1.4. In 2022, the number of registered births in Canada will be 351,679, which is a 5% decline from 2021. Canada has had a growing population since 2009, but fewer babies are being born, with almost precipitous declines by 2021 and 2022[8]. Canada's low fertility rate is the main reason for the country's unprecedented 2021-2023 immigration plan, announced Friday, which aims to admit more than 400,000 new immigrants each year for the next three years. In 2019, Canada's total fertility rate will be 1.47 births per woman over her lifetime. To maintain the size of the population, the fertility rate per woman must be at least 2.1, but Canada has not reached this threshold since 1971. Furthermore, according to data analysis, women's fertility rates are gradually declining [9]. According to the CERI, the total population of Canada in 2021 will be 38,246,100, an increase of 208,900 from the previous year, with a population growth rate (annual percentage) of 0.55%; compared to 2011, the population of Canada has increased by 3,907,000 people. Although the number of births per year in Canada is small, it continues to grow [10].

2. Method

2.1. Data Sources

The data this paper used came from the Macrotrends website, which was compiled from World Population Prospects by the United Nations. It collected the birth rate of Canada from 1995 to 2022.

2.2. Model Protocol

This paper uses the ARIMA time series model to forecast the birth rate of Canada in the next twenty years, from 2023 to 2042. SPSSAU is used to analyze the trend of data. The values of p, d, and q are 0, 1, and 0 respectively. After checking the Ljung-box test, it can be seen that residuals are white noise, so the original assumption cannot be turned down.

2.3. Model Introduction

ARIMA model is used for forecasting data with unfixed features and is influenced by uncertain factors. As a result, data should be first adjusted to a stationary sequence by a difference equation. A combination of AR, MA, and ARMA models helps to get parameters of (p, q).

AR model describes the relationship between current values and previous values. The order, p, can be calculated with this formula:

$$y_t = \mu + \sum_{i=1}^{p} \gamma_i y_{t-i} + \varepsilon_t$$

MA model focuses on the accumulation of errors in some terms. It can effectively remove the random fluctuation when forecasting. The formula of order, q, is shown as follows:

$$y_t = \mu + \varepsilon_t + \sum_{i=1}^{q} \theta_i \varepsilon_{t-i}$$

Put the AR model and MA model together, and the ARMA model (p, q) is obtained. The calculation formula is:

$$y_t = \mu + \sum_{i=1}^{p} \gamma_t y_{t-i} + \varepsilon_t + \sum_{i=1}^{q} \theta_i \varepsilon_{t-i}$$

2.4. Model Testing

Table 1 shows the Ljung-box Q test statistics to check the residuals. Q6 is used to test whether the first six correlations satisfy the white noise. If it is greater than 0.1, the model fits white noise. However, if p is smaller than 0.05, the model does not fit very well.

Table 1. Statistics Table of Q in the Model

Term	Value	*Value of p*
Q1	0.014	0.905
Q2	0.019	0.990
Q3	0.021	0.999
Q4	0.021	1.000
Q5	0.074	1.000
Q6	0.079	1.000
Q7	0.087	1.000
Q8	0.087	1.000
Q9	0.087	1.000
Q10	18.976	0.041*
Q11	18.978	0.061
Q12	18.980	0.089
Q13	18.981	0.124
Q14	18.983	0.166
Q15	19.162	0.206
Q16	19.162	0.260
Q17	19.163	0.319
Q18	19.163	0.382

3. Results and Discussion

Figure 1 shows the raw data on the birth rate in Canada from 1951 to 2022. The birth rate reached its lowest point in the year of 1968 and a maximum in 2004, which is -6.42 and 1.13 respectively. The mean value of these 72 figures is -2.676. Canada does not have a very positive population future. As the figures do not fluctuate about certain values, they can be seen as unstable data. Therefore, the method of first-order difference is required to change them into stable data. If the first-order difference is not effective, then second-order difference is needed.

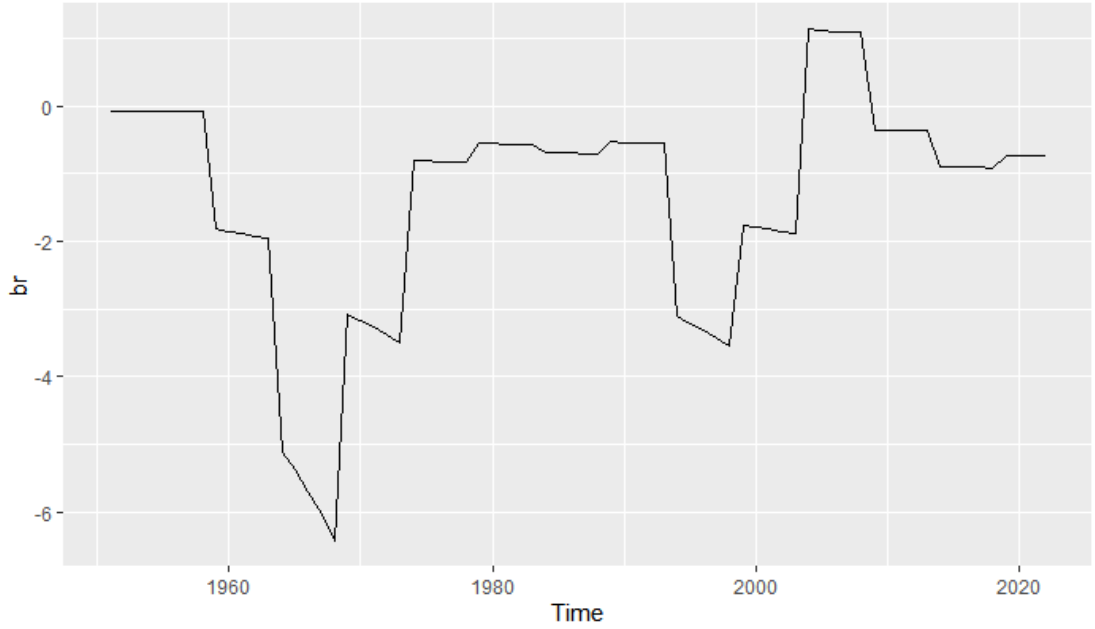

Fig. 1 Birth rate of Canada from 1951 to 2022(original data)

After dealing with raw data, we can see the new graph as shown followed:

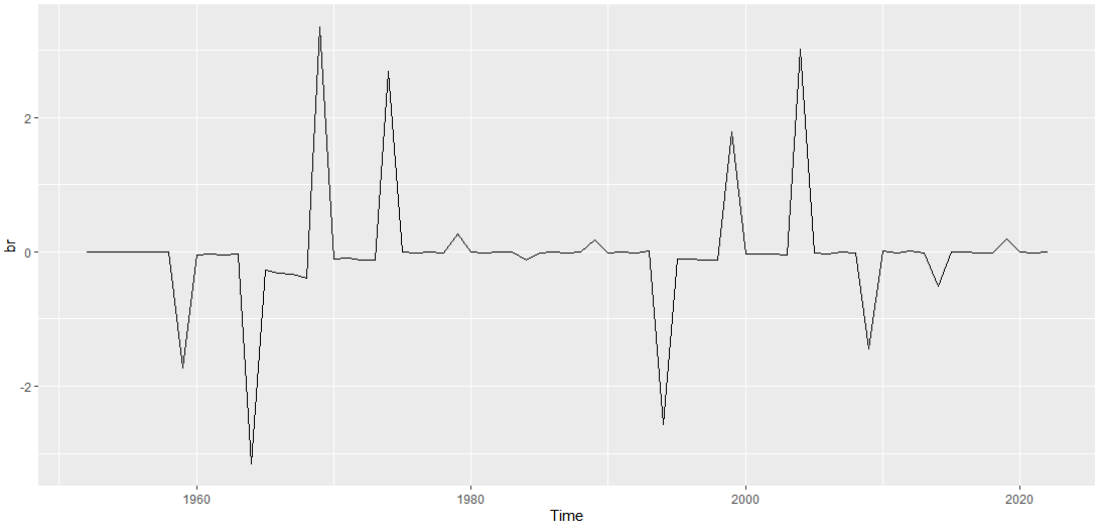

Fig. 2 Birth rate of Canada from 1952 to 2022(after first order difference)

As shown in Figure 2, data are stable and the graph fluctuates at the value of zero. Then ARIMA model can be used to do the prediction. Coefficients must be determined by ACF graph and PACF graph. Here are the graphs and data table:

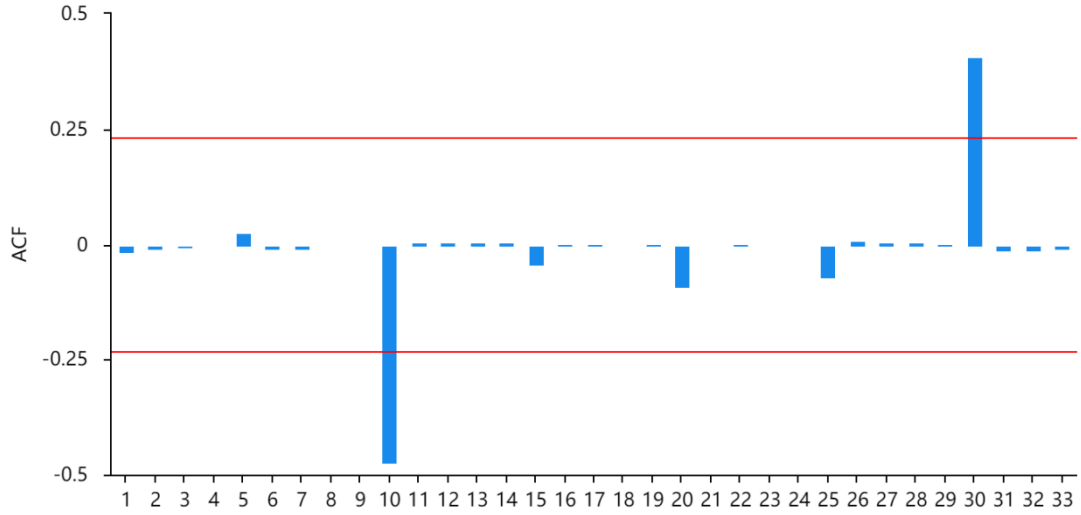

Fig. 3 ACF value for each order

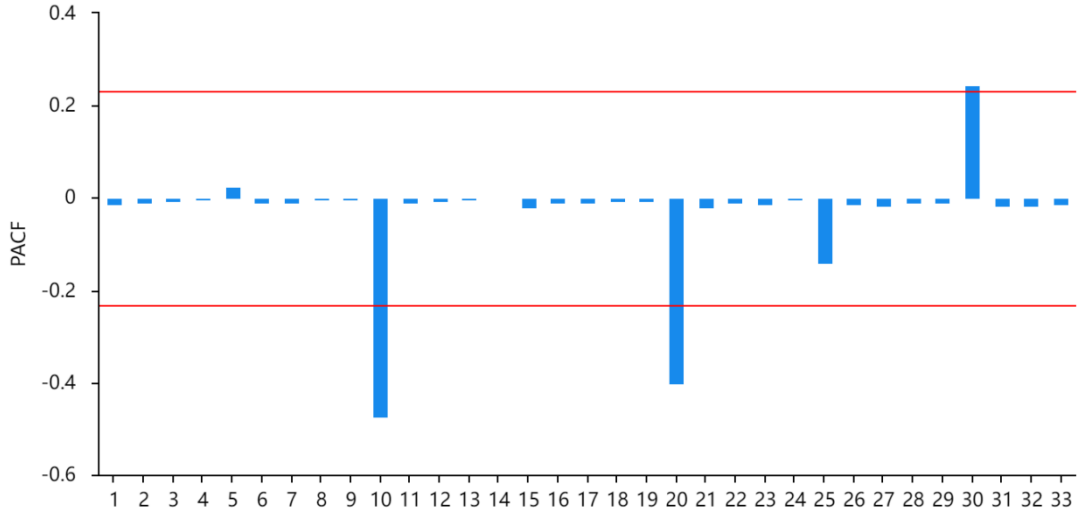

Fig. 4 PACF value for each order

Table 2. Values of different orders

LAGS	Series 1	LAGS	Series 1
1	-0.014	18	-0.001
2	-0.008	19	0.002
3	-0.005	20	-0.091
4	-0.001	21	-0.001
5	0.026	22	0.000
6	-0.009	23	-0.003
7	-0.009	24	-0.001
8	-0.002	25	-0.070
9	-0.001	26	0.007
10	-0.471	27	0.005
11	0.005	28	0.005
12	0.004	29	0.002
13	0.004	30	0.408
14	0.004	31	-0.012
15	-0.044	32	-0.012
16	0.001	33	-0.007
17	0.003		

The x-axis represents the lagged order. These two graphs are used to judge the order of automatic regression, which is recorded by letter p, and order of moving average, which is recorded by letter q. There are four types of situations in total. Firstly, if the ACF graph is truncated at the position of q, which means after certain lagged order, the value of ACF becomes zero, and, the PACF graph is not truncated, then ARIMA model can be simplified to model MA(q). Secondly, if the PACF graph is truncated at the position of p, which means, similar to what is mentioned before, after certain lagged order, the value of PACF becomes zero, and, the ACF graph is not truncated, then ARIMA model can be simplified to model AR(p). The third type is both of two graphs are not apparently truncated, the proper orders for ARIMA model are required. Under normal situations, the most notable order from ACF graph can be used as q, and the most notable order from PACF graph can be used as p. The final situation is, when both of them are truncated, data are white noise. The result is data are improper for setting ARIMA model. According to SPSSAU, the recommended values of p and q are both ten. However, they may not bring about the fittest predicting graph. Coefficients are replaced with nearby numbers like nine, eleven, and twelve and so on. Finally, both p and q are decided to be nine as this prediction fits best.

The forecast of birth rate of Canada in the coming 20 years, from 2023 to 2052, is done with the help of SPSSAU. The result is:

Table 3. Forecast values（20 periods）

Year	Forecast values	Year	Forecast values	Year	Forecast values	Year	Forecast values
2023	0.340	2028	-0.000	2033	-0.139	2038	0.113
2024	-0.814	2029	-0.110	2034	0.875	2039	-0.636
2025	0.111	2030	0.159	2035	-0.180	2040	0.122
2026	-0.214	2031	0.315	2036	0.020	2041	-0.285
2027	-0.273	2032	0.275	2037	0.070	2042	-0.281

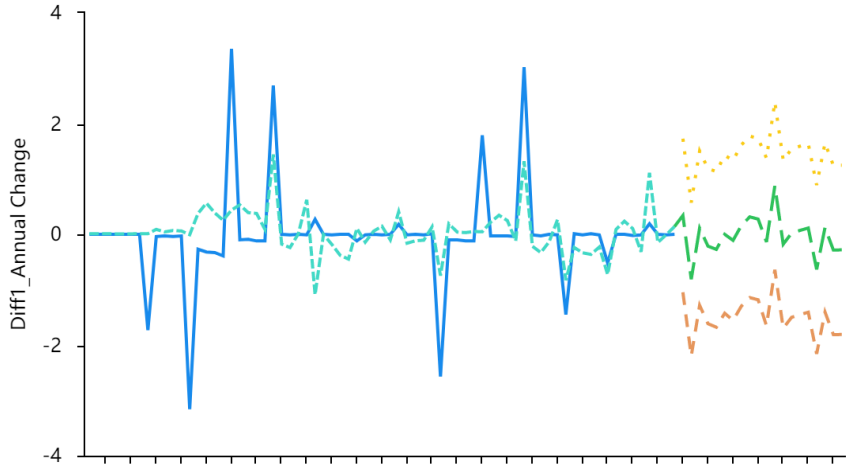

Fig. 5 Forecast values(20 periods)

According to Figure 5, the average birth rate in future 20 years is -2.066, still negative, which means the population is likely to decrease. The year with biggest figure 0.875 is 2034, while the year 2024 has the least birth rate.The blue line is the original stable data and green line is the forecast value. The yellow and orange lines represent the upper limit of 95% and lower limit of 95% of the forecast value. The dotted line over the blue one shows how well the data fitted.

Table 4. LM test

F	0.581	*p value*	0.821
*T *R square*	6.352	*p valu*	0.785

The Table 4 is the Breush-Godfrey LM test. It is used to check whether there is a relationship among residuals series. Firstly, assume H0 is the series without any relationship, and H1 is the series

with relationship. Secondly, use the data provided by LM test, which are F and T*R square. Usually only statistic value F is used. If the corresponding p is smaller than 0.05, then original assumption is rejected, which means there is relationship, vice versa. Eventually, when residual model has series relationship, ARCH/GARCH model can be considered to do further research. In this table, p value is bigger than 0.05, so original assumption is acceptable, which means there is no relationship among residuals series.

4. Conclusion

This study selects a variety of data and focuses on the changing patterns and trends of the birth population in Canada. The conclusion is that in recent years, the birth rate in Canada has shown negative growth, but due to the relatively small original population base in Canada, the total population still grows rapidly despite the negative growth Undeniably, due to the limited access to and amount of literature we obtained, the original population base in Canada is relatively small.

Coupled with the fact that there may be errors in the data we collected and the sample of this model does not cover all years and all births in the country, there may be discrepancies, which may also affect the accuracy of the results. However, this study still has great value and advantages, as well as great reference value. First of all, this study adopts ARIMA time series model, which is innovative. On the one hand, it visualizes the experiment by using the calculation formula and introducing data to visually analyze the changes in the number of births and birth rate in Canada. On the other hand, this experiment does not use a single method for research like many other experiments, but also chooses the ARCH/GARCH model for in-depth research, which makes the data results more comprehensive. Secondly, it will play a positive role for the future Canadian government in terms of national fertility policy planning. In addition to the well-known decline in the birth rate in recent years, it can also take the factors affecting the birth rate as an entry point, such as epidemics, lifestyle changes, etc. Whether these factors are related to the decline in the birth rate deserves attention and consideration, and more literature needs to be sought. This paper is only a rough survey and further research is needed, that is, these findings will point the way for future research on the changes in the birth rate in Canada and the factors that influence it. They will also help to inform the adjustment of the country's future population policy in order to achieve a good and reasonable population size.

References

[1] Wenjing Yao. Master's Theses: Research on the Impact of Digital Economy on Birth Rate, Chinese Master's Theses Full-text Database, 2023-05-01.

[2] Sims E.J.·McCormick J.·Mehta G.·Mehta A. Neonatal screening for cystic fibrosis is beneficial even in the context of modern treatment. J Pediatr. 2005; 147: 306-312.

[3] F. Stephen Bridges·L. Carolyn Pearson. English Journals: Perceptual and Motor Skills, 2004-06-15.

[4] MA Guangming·DING Boying·Central University of Finance and Economics. Journals: Industrial Structure, Residents' Working Hours and Birth Rate, Journal of Audit &Economics, 2023-02-10.

[5] Duoyun Wang. Journals: Research on the necessity, feasibility and potential strategies of increasing fertility rate and delaying retirement in aging society, Contemporary Economic Mangagement, 2023-08-04, 13:31.

[6] GE Run·SHI Xinzheng·Shanghai University of Finance and Economics, Tsinghua University. Journals: How Does Universal Two-Child Policy Affect Fertility Behavior? China Economic Quarerly, 2023-07-30.

[7] Zhike Jia·Yang Gao. Journals: Analysis and reflection on foreign birth support policies, Youth Exploration, 2022-06-14, 10:23.

[8] YU Ye-wen·GONG Liu-tang·Guanghua School of Management, Peking University, School of International Economics and Management BTBU, LMEQF, Peking University. Journals: Population Policy, Fertility and Family Supporting, China Industrial Economics, 2021-05-25, 09:08.

[9] Honglei Wen·Yanyan Zhang. National Science and Technology Books and Documentation Center: Analysis and prediction of the number of births in Canada, 2001.

[10] Transfer boundary. Mobile news: According to data released by Canadian media Global News, Canada's birth rate has fallen to its lowest level in the past 17 years, with a fertility rate of 1.4, 2023-10-15.