2022

Utilize ARDL Boundtest to Study Economic Growth Challenges in Singapore

Long Ta
lta@conncoll.edu

Utilize ARDL Boundtest to Study Economic Growth Challenges in Singapore

Long Ta

May 14, 2022

1 Introduction

Singapore's economy is an interesting story. After its expulsion from the Kingdom of Malaya in 1965, the country faced many challenges: The aftermath of the Second World War left most of Singapore's infrastructure was destroyed; there was a high level of unemployment given the destruction of infrastructure; the country's small land size / population prevents it competing with neighboring countries in cheap labor manufacturing. Through a series of policy changes, Singapore people income has grown an average 8% annually since its independence, and the country rises from having been torn by the Second World War to become one of the most developed countries in Asia and is known as one of the 4 "Tigers of Asia."

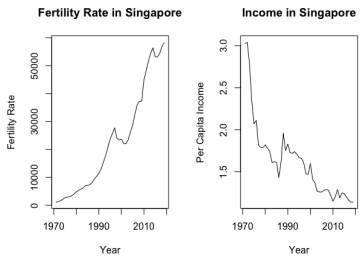


Figure 1: Fertility Rate and Income in Singapore between 1970 - 2019

.

In studying the potential challenges that face the economic growth of Singapore in the future, I resort to the ARDL Bound Test approach to Cointegration to test for long run relationship between variables representing social challenges and Singapore's economy performance factors.

2 Literature Review

Manu Bhaskaran (2014) argues that even though Singapore's economy has performed relatively well until 2014, there are challenges that it will face in the long term that can hamper growth. Among which a changing demography, represented by an aging population and lowering fertility rate is cited as a concerning factor for Singapore's long term economic growth (Bhaskaran, 290).

As the population of Singapore grows older, the labor force shrinks because of an increase in people in the retirement age, which in turns requires more labor into elder health care. Furthermore, an aging population is also less attractive to the foreign employers, who want a dynamic workforce with a surplus of young employees. Eileen Tang, in a publication in 1974's Southeast Asian Affairs also shared the same concern about Singapore's labor force, stating that the country needs to depend on an external labor supply for the economy to grow (Tang, 234-240). Tang also raises a point about gender participation (Tang, 238): the economic growth rate depends on the labor force, which in turns relies on the participation of all genders alike.

From the readings of Tang and Bhaskaran, I am interested in learning about the long-run relationship between economic growth in Singapore with the change in this country's demography since its inception. By using time series analysis as a metric to determine the relationship, I will be able to confirm the existence of such relationship through quantitative methods

3 Dataset

All time series are taken from the World Bank's "The World Bank Open Data," an open database that contains key information about each country over time. The data is collected in 48 years between 1971 – 2019 and is reported annually.

Three variables will represent social challenges in Singapore, including: Fertility Rate; Population Density; Dependency Ratio (Percentage of Population in Working Age versus Retirement Age). I also expand on this research by adding another variable representing gender equality in the labor force: The percentage of women in the labor force. Because of data collection limitation, we only have observations between 1990 - 2019 for this variable. Another two variables will represent Singapore's economic growth rate: GDP, which represent the total amount of output an economy produces over a period of time, and the Per Capita Income (PCI). All time series variables will be checked for trend / seasonality / variances prior to further analysis.

4 Methodology

The ARDL Bound test is a test for cointegration based on the original ARDL model. This test was developed by Pesaran et al., and is a more efficient method of testing for cointegration among time series variables. It is more efficient because the test functions with a mixture of I(0) and I(1) variables, and it also performs with a smaller sample size than existing tests (Abu, 137 - 138). It consists of 2 parts: the ARDL Model and the Bound Test

4.1 Cointegration

In the past, economist used linear regression models for time series. The variables in question are treated without its time property. However, these variables can be correlated because of a random error or an unknown third factor. The natural order of time can also cause correlation among observations. This could lead to misleading judgement of relationship among time series (Spurious Regression).

To solve this problem, in 1987 Granger and Engel created the idea of cointegration to confirm the relationship between two variables. The idea is for 2 integrated series, if there exists a parameter α such that

$$\epsilon_t = y_t - \alpha x_t$$

Then these two series are bound to not move away from the other in the long run, or the linear combination of these 2 series is stationary. There we may say that these two time series variables are cointegrated.

4.2 The ARDL Model

The Auto-Regressive Distributed Lag Model (ARDL) is of the form:

$$Y_t = \alpha + \sum_{i=1}^{p} \phi_i Y_{t-i} + \sum_{j=0}^{q} \beta_j X_{t-j} + \epsilon_t$$

- Y_t is the value of the dependent variable record at time t
- Y_{t-i} is the value of the dependent variable record at the m period before t
- X_{t-j} is the value of the dependent variable record at the n period before t

- β and ϕ are the coefficients for the lagged independent variables and the lagged response variable
- p and q are lagged terms, respectively
- ϵ_t is the disturbance / random term

.

In essence, the ARDL model is a type of time series model that can be broken down into 2 components: Auto-Regressive and the Distributed Lag. The prediction variable of concern is a function of its own past values (Auto-regressive) and of other variables' past values (Distributed Lag). The number of the lags of the dependent and independent variable generates an ARDL(p,q) model.

4.3 The Bound Test

The ARDL Bound Test tests for the existence of cointegration of variables by computing a F-statistics test among the coefficients for long run variables. We assume one variable is a dependent variable while others are independent. To conduct the test, we need to make sure that all concerned variables are I(1) or I(0) variables, and our model is dynamically stable. Next, we modify the ARDL model to the form

$$\Delta Y_t = \alpha + \sum_{i=1}^{p} \phi_i \Delta Y_{t-i} + \sum_{j=1}^{q} \beta_j \Delta X_{t-j} + \gamma_1 Y_{t-1} + \gamma_2 X_{t-1} + \epsilon_t$$

.

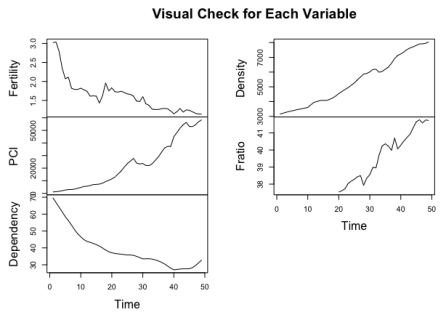
With Y be the assumed response variable, X be the predictor; Δ is the differencing operator and $\gamma_1 Y_{t-1}$ $\gamma_2 X_{t-1}$ are terms representing long-run correlation of these variables. We then conduct. an F-test on the long-run coefficients γ_1 and γ_2 under the null hypothesis that H0: $\gamma_1 = \gamma_2 = 0$. Pesaran et al. (1999) Provided a p-value table for the bound, with assumptions that if the p-value of the F-test is lower than the bounds, reject H_O and conclude there is cointegration. If the p-value of the F-test is higher than the bounds, conclude there is no cointegration. If the p-value of the F-test is between the bounds, the result is inconclusive and we need to resort to other studies.

5 Application

The names for each variables are:

- Per Capita Income: PCI
- Dependency Ratio: Dependency
- Population Density: Density
- Fertility Rate: Fertility
- Percentage of Women in the workforce: Fratio

A visual plot for each time series show that they all exhibit trend, which requires at least 1 level of differencing. The plot is as follow:



We then conduct an Augmented Dickey Fuller test (ADF test) for each variable to determine if the respective series contains a unit root. The result shows that all series (with the exception of Fertility rate) has at least one unit root. In order to transform the data, we take the first difference on each variable and on each variable's log transform value, then perform the ADF test again. Our result shows that Density and LogPCI, the variable represents the log transformed PCI variable, are stationary after differencing. As a result, we shall conduct the ARDL Bound Test on a combination of 3 variables: LogPCI, Density and Fertility because only these 3 variables are either I(0) or I(1) variables.

Two hypotheses are generated based on our 3 variables, given the original scope of our research:

1. Does Fertility Rate have a long-term impact on Per Capita Income?
2. Does Population Density have a long-term impact on Per Capita Income?

.

Which implies 2 tests have to be conducted, the first with Fertility as the predictor and LogPCI as the response, and the second with Density as the predictor and LogPCI as the response. For each case, we generate an Auto ARDL Process for model selection based on AIC. We found that an ARDL(2,0) model is appropriate for each case. We then conduct the Breusch-Godfrey test for serial correlation of order up to 1 to test for residuals correlation and found that no serial correlation exists in both model. From that, we decided to conduct the Bound F-Test for Cointegration on each ARDL model.

6 Findings

The result of our F-Test are as followed:

```
            t1
method      "Bounds F-test (Wald) for no cointegration"
alternative "Possible cointegration"
statistic   0.6947596
null.value  numeric,2
data.name   "d(PCI) ~ L(PCI, 1) + Fertility + d(L(PCI, 1))"
p.value     0.8854224
tab         data.frame,2
            t2
method      "Bounds F-test (Wald) for no cointegration"
alternative "Possible cointegration"
statistic   3.680729
null.value  numeric,2
data.name   "d(log_PCI) ~ L(log_PCI, 1) + Density + d(L(log_PCI, 1))"
p.value     0.2117236
tab         data.frame,2
```

Give the high p-value (at confidence interval = 10%), we came to the conclusion that neither Fertility Rate or Population Density cointegrate with LogPCI

7 Conclusion

From the result of our ARDL Bound F-test, we conclude that neither Fertility Rate or Population Density has long-term impact on Income Per Capita. This result contrasts with Bhaskaran and Tang's idea that either of these factor are related to Singapore's economic growth and they can be hampering the country's growth in the long term. One potential explanation for the non-existence of cointegration between Income and Fertility rate is that there since Singapore relies heavily on foreign labors, they can replace the needs for domestic labor with foreign workers. For Population Density and Income Growth, we can explain that Singapore's high level of urbanization level has always been the country's

characteristic, and that the increasingly crowded living space may not strongly affect its economic growth in the long run. However, we must acknowledge the existence of multiple other factors that can influence growth in Singapore, such as income inequality, the participation of women in the labor force, cost of living, and others.

To extend on this research, we can incorporate more variables for consideration. The Gini Coefficient, which measures income inequality across households is a good candidate for our research. The current dataset does not include the Gini Coefficient report from before the year 2000, which requires more data mining. We can also investigate on the back impact of Income on Fertility Rate. A popular phenomenon is that women who are more educated and have higher income often have a lower fertility rate than those who are not (Schultz, 2005). This is interesting because more resources to raise up children does not always lead to more children being conceived in household. Applying the ARDL Bound test method into this case in the context of Singapore can reveal interesting findings about Singaporean women's choices in conceiving children, thus helping with answering why the Fertility Rate in Singapore has been decreasing recently.

References

Abu, Nurudeen (2017) : Does Okun's law exist in Nigeria? Evidence from the ARDL bounds testing approach, Contemporary Economics, ISSN 2300-8814, University of Finance and Management in Warsaw, Faculty of Management and Finance, Warsaw, Vol. 11, Iss. 2, pp. 131-144, https://doi.org/10.5709/ce.1897-9254.232

Bhaskaran, Manu. "CHALLENGES FACING THE SINGAPORE ECONOMY." Southeast Asian Affairs, 2014, pp. 290–302, http://www.jstor.org/stable/44112079. Accessed 8 May 2022.

Kleanthis Natsiopoulos and Nickolaos Tzeremes (2021). ARDL: ARDL, ECM and Bounds-Test for Cointegration. R package version 0.1.1. https://CRAN.R-project.org/package=ARDL

Pesaran, M. Hashem, et al. "Bounds Testing Approaches to the Analysis of Level Relationships." Journal of Applied Econometrics, vol. 16, no. 3, 2001, pp. 289–326, http://www.jstor.org/stable/2678547. Accessed 22 Apr. 2022.

Tang, Eileen P. T. "SINGAPORE: CHALLENGES OF GROWTH." Southeast Asian Affairs, 1974, pp. 232–77, http://www.jstor.org/stable/27908227. Accessed 8 May 2022.

Schultz, T. Paul, Fertility and Income (October 2005). Yale University Economic Growth Center Discussion Paper No. 925, Available at SSRN: https://ssrn.com/abstract=838227 or http://dx.doi.org/10.2139/ssrn.838227