Business Data Challenge 2019

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Introduction

In this problem, we are given the dataset consists of firms in 19 different industries across 5 areas in Canada, our objective is to discover the business trend and determine the business cycle over time. In order to quantify the business dynamics measures, five variables are introduced.

By examining the data, we noticed data entries are recorded quarterly starting from 2000 Q1 to 2017 Q3. It is obvious that these data form a time series because data entries are highly correlated, a traditional linear model is not applicable due to the violation of the assumption of independence. Therefore, we decide to use ARIMA(a specific time series model) model to forecast five variables mentioned above.

Methodology

Times Series Analysis

To do the predictions, we decided to apply the seasonal ARIMA model to model our data. For each province's each variable, depending on the behavior of our information set, a S-ARIMA model with optimal parameters will be selected to do the modeling. The optimal parameters for each model will be selected using R-function auto.arima, by choosing the parameters to correspond to the lowest Akaike Information Criterion. Also, auto.arima will also select the appropriate order for integration if the time series is non-stationary. Based on our fitted S-ARIMA models, we are able to do the forecast for future values of those variables such as Entry and Exit for each province, and we will also be able to construct a prediction interval for each future value.

To be more specific, basically, we divided the data set into 95 different subsets based on provinces and industries. Then we train our model and do the forecast for each province's each industry. Then depending on whether the time series data shows a signal of a stochastic trend, the auto.arima function will decide to difference our times series for several times or not, to make the time series stationary. For some subsets of our data, there may exist a signal of the seasonal pattern in the time series, then the auto.arima function will select appropriate seasonal orders for AR and MA parts of our model, which will take into account the seasonality in our time series. For each optimal S-ARIMA model selected by the function auto.arima, we can then forecast the values up to the fourth quarter in 2019.

We implemented the above statistical model with R, you need to have "forecast" library correctly installed, and the dataset imported. The you can run the function "timeseries.predict" and provide the dataset imported, "variable" equals to any one from {"Exit", "Entry", "Opening", "Closing", "Active"}, and "forecast.time" equals to the number of quarters you want to predict since Q3 of the year 2017. The function will save the predicted results in .csv files and the predicted plots in .jpg format. You can find the generated files in Documents if you are a windows user, in #yourusername# folder if you are a mac user.
To view or download the code, please visit https://github.com/carlonlv/Data-Challenge-2019/blob/master/R%20scripts/tsa.r.

Statistical Results

Here are some samples from the results generated by the following codes:

```
timeseries.predict(mydat, variable = "Exit", forecast.time = 9)
timeseries.predict(mydat, variable = "Entry", forecast.time = 9)
timeseries.predict(mydat, variable = "Opening", forecast.time = 9)
timeseries.predict(mydat, variable = "Closing", forecast.time = 9)
timeseries.predict(mydat, variable = "Active", forecast.time = 9)
```

We will discuss about our interpretation from a statistical perspective and an economic point of view.

Some Tables and Forms

This table represents prediction of the number of active companies in retail industry for each area.

Geography	**Industry**	**2017_Q4**	**2018_Q1**	**2018_Q2**	**2018_Q3**	**2018_Q4**	**2019_Q1**	**2019_Q2**	**2019_Q3**	**2019_Q4**
CA	44-45	90401	89020	89069	88667	88773	87444	87445	87018	87152
BC	44-45	13220	12875	12840	12788	12939	12594	12559	12507	12657
ON	44-45	33075	32362	32563	32586	33098	32285	32450	32429	32960
QC	44-45	21430	21048	21120	21093	21128	20644	20669	20646	20703
AB	44-45	10364	10190	10125	10071	10210	10035	9971	9917	10056

This table represents prediction of the number of companies’entry in transportation and warehousing industry for each area.

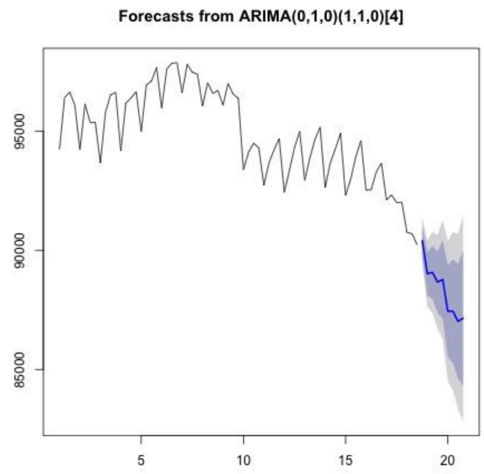
Geography	Industry	2017_Q4	2018_Q1	2018_Q2	2018_Q3	2018_Q4	2019_Q1	2019_Q2	2019_Q3	2019_Q4
CA	48-49	879	761	1063	1068	944	800	1087	1082	952
AB	48-49	127	135	150	147	149	156	166	166	168
BC	48-49	135	118	158	192	160	131	164	196	161
ON	48-49	435	288	494	427	467	295	471	393	452
OC	48-49	87	54	111	122	78	38	85	94	60

To view more predicted data, please visit https://github.com/carlonlv/Data-Challenge-2019/tree/master/tables.

Some Visual Results

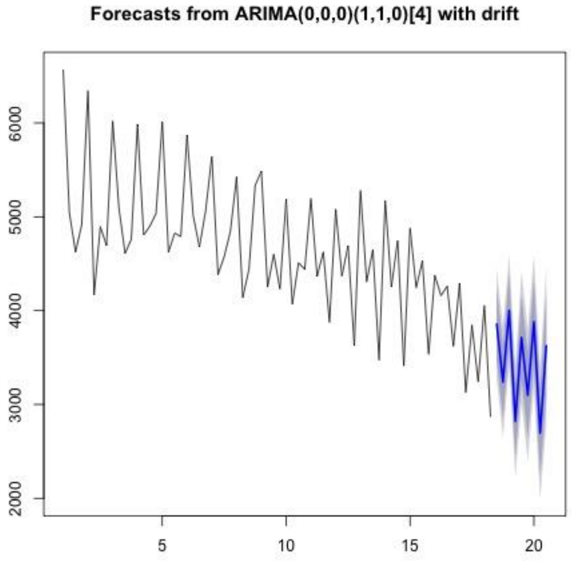
For the plots presented below, we have the number of companies as the y-axis and the number of quarters since Q1 of 2000 as the x-axis. The black fraction of the trend represents the data provided and the blue fraction represents the trend predicted using our statistical models. The grey area represents the variability of our predictions, we are 95% confident that the true value lies within this region.

Number of active firms for retail industry in Canada



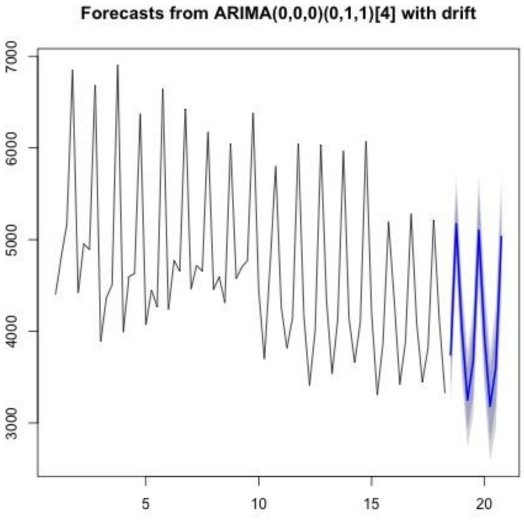
From this plot, we observed a obvious downward trend. Therefore auto.arima decides to difference our time series for once to make it stationary. Based on this model, the number of active firms in retail industry in Canada will decline rapidly in the next few quarters.

Number of opening firms for retail industry in Canada



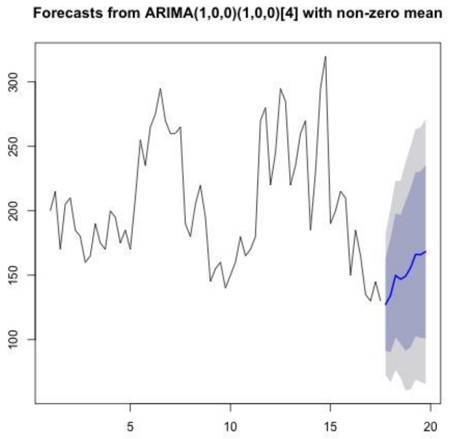
In this plot, there exists obvious downward trend and strong seasonality. Therefore auto.arima differences the time series for once and put a seasonal component into the model. Based on this model, the number of opening firms in the retail industry in Canada will decline gradually and keep oscillating in the next few quarters.

Number of closing firms for retail industry in Canada



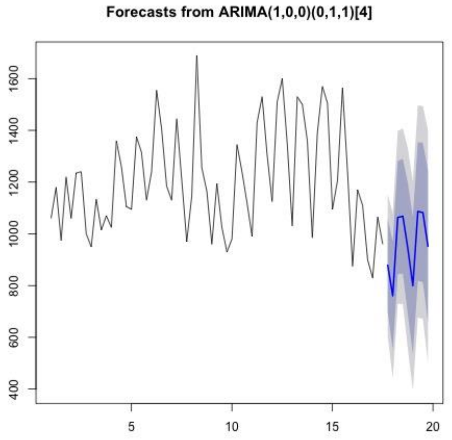
For this plot, there is no obvious trend but has strong seasonality. Furthermore, the variance is quite large overall. Therefore auto.arima generates a seasonal component into the model without differencing the time series too much. Based on this model, we predict the number of closing firms in the retail industry in Canada will keep oscillating in the next few quarters but stay the same on average.

Number of entry firms for transport and warehousing industry in AB



In this plot, we find that the time series looks pretty much like a stationary process. Consequently, auto.arima does not difference our time series, but directly combine a AR(1) model with a S-AR(1) model to fit our data. Based on this combined model, we predict that the number of entry firms for the transportation and warehousing industry in Alberta will increase smoothly in the next few quarters.

Number of entry firms for transport and warehousing industry in CA



From this plot, we can see that this time series looks very stationary. Therefore, auto.arima function gives a AR(1) model to fit our data. Based on this model, we predict that in the next few quarters, the industry is stable, but with some degree of oscillation.

To view more visual results, please visit https://github.com/carlonlv/Data-Challenge-2019/tree/master/plots.

Economics View for the Retail Industry

For example, consider the retailing industry (44-45), we observed that the number of active companies declines over time. Around 2010, there is a sharp decline in the retail industry, it then fluctuates for a while until another sharp decline around 2016. Based on the previous trend of this industry, our time series model predicts further declining in this industry.
In order to explain this scenario, we need to examine the number of opening firms and the number of closing firms. According to the number of opening firms, it is evident there is a significant declining trend in the number of new companies. Unlikely, the number of closing firms is consistent on average and has a minor declining trend. The reasoning behind the sense is very complex, but one possible reason may be the influence of the booming in online shopping during recent years. Since fewer companies enter and a similar number of companies quit, the overall number of active firms is shrinking and this matches our model's prediction.

Economics View for the Transportation and Warehousing Industry

Unlike the retail industry, the transportation and warehousing industry requires more capital investments (i.e. vehicles, warehouses, terminals, etc.), due to the capital has lower liquidity than labor, the length of the market cycle in transportation and warehousing industry is longer than the retail industry. For example, the transportation and warehousing industry in Alberta has a full cycle of approximately 5 years which is longer than a particular cycle for the retail industry. In addition, we observe a new cycle in Alberta is starting from 2017, so more companies will enter the market due to the seasonal effect and this matches our model prediction above.

Conclusions

By doing analysis and predicting data using statistical models, we found that different industries have a significantly different pattern in terms of business trend. For example, the retail industry is experiencing a decline, while the transportation and warehousing industry is pretty consistent. Since the retail industry is relatively labor intensive, and the increase in the minimum wages recent years will make traditional retail companies even harder to generate profits. Due to low efficient retail companies are quitting the market, the expected efficiency of the retail industry will increase in the future and this may lead to a higher consumer surplus. The transportation and warehousing industry is capital intensive, it requires a large amount of resources to build warehouses and transport terminals. Thus, this industry is more stable and has less fluctuation in the long term.

These two industries represent how the business trend can be model and analyze from both statistics and economics perspective. Since our statistical predictions match the economic intuitions, the time series model gives a reasonable forecast for the future.