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Project 6:   
Non-Linear Programming Models

ALY 6050\_Introduction to Enterprise Analytics

# **Introduction**

In project 6 we will look at the history and definition of the Hodrick-Prescott Filter, then apply it to Honeywell stock close prices (from Feb 13, 2018 to May 11, 2018) time series data in practice. We will write an R program to calculate the results, then draw a combined plot to illustrate the relationship between original data and calculated trend. After this project, we will learn the Hodrick-Prescott Filter in theory and understand how to use it programmatically with practical data.

# **Analysis**

## **Perform a research about the Hodrick-Prescott decomposition and provide insights about its historical development**

The technique for filtering trends with a smooth curve from past data has a long history. Some suggest that it started from Leser’s proposal in 1961, which was built on the graduation method developed by Whittaker and Henderson, back in 1923 and 1924. In the 1990s, Robert Hodrick and Edward Prescott brought this into economics and popularized it. Since then, Hodrick-Prescott filter is widely used in macroeconomics and finance, to predict trends by removing cyclical component from time series data, then come up with a smooth curve representation.

## **Interpret each term of the Hodrick-Prescott objective function and discuss a few advantages and disadvantages of this decomposition method.**

The Hodrick-Prescott decompose the data into two part: cyclical component and trend component. The objective function is written as below,

N is the number of samples. is cyclical component, where *t* = 1, …, *N*. is the trend component, for *t* = 1, …, *T*. For the time series *y*, Z is to minimize the objective over all Ts. There are two steps to accomplish this goal. First to minimize the difference between original time series and trend component. Second to minimize the difference between second-order and the trend component. is the smoothing parameter. If 0, then no smoothing is taken place. If the is infinite, then the series would be a linear trend. Normally we use 1600 for quarterly time series, which is also the default setting in R function.

There are 4 advantages of this formulation. First, it is easy to use. In later empirical example that I am going to run, there are only 4 lines of code needed to decompose the trend from the original time series. Second, in the normal decomposition method, there are irregular components added individually. In the HP filter, it has been contained in a cyclical component. Third, because we subsume irregular components in cyclic, the cyclic is considered as residual of the growth estimation. Fourth, the smoothing parameter is determined by empirical investigators.

The disadvantages are as consequences of its advantage. First, HP filter calculates a long run component trend. So it only generates optimal, or even produces extreme second order properties for extreme data. The smoothing parameter is not consistent, which would affect the accuracy in practice.

## **Consider the quarterly time series of Honeywell (HON) stock prices. Apply the Hodrick-Prescott optimization method to decompose the logarithm of the given time series into its cyclic and trend components. Use R to solve the problem.**

The code is written as below,

A screenshot of a cell phone

Description automatically generated

*Figure 1*. R code of hp filter

## **Interpret the results obtained from step 3, above, and discuss the merits of your decomposition, in Word; if any.**

The results are shown as below,

A screenshot of a cell phone

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*Figure 2*. hpfilter results

HP filter uses the natural logarithm of the time series as objective, to make the formula additive. The original time series data from 142 to 156. The trend is a declined non-linear line from 5.030156 to 4.979525. The close stock price of hon is well prepared. Next we could use ARIMA model to perform a forecasting. Sometimes HP filter may not have appropriate solution for the next level forecasting due to the fact that the all the irregular and seasonal trend has been absorbed in cyclical trend, and that may affect the accuracy of the trend calculation.

## **Plot the line plots of the original time series along with its trend component on the same chart.**

The resulting series are plotted in Figure 3.

A close up of a map

Description automatically generated

*Figure 3*. hpfilter trend plots

## **Use the results of your decomposition method and write a summary conclusion of your findings in Word.**

The chart above shows the relationship between the log time series data and trend. The time series data go bumpy up and down. HP filter helped to remove all the noise and provide a simple trend from high gradually to low that both volatility and correlations for all the series.

# **Conclusions**

Hodrick-Prescott filter is a practical tool solving non-linear programming problems. Investigators could use HP filter to separate growth from original time series data that contains cyclical component, irregular values (which are absorbed by cyclical component), and even seasonal component. There are some critical trying to warn people that HP filter is not accurate. First, the decomposition of the series has assumptions. Second, mechanically applied in time series data are not appropriate in this tool. Take one more step to filter the series result and to evaluate the extreme cross correlations are necessary. But, even with different shortcomings and draw backs, Hodrick-Prescott filter still is a widely used decomposition tool in many industries. It is a paradigm for business-cycle estimation at many economic agencies and institutions.

# Reference

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