Econometrics project-1 Estimating Taylor’s rule

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Aim of our study

Predicting the behavior of a Central Bank (CB) has been a challenging task for decades due to many reasons. While the CBs usually have clear main objectives that guide their decisions in their policy decisions many other considerations affect the decision. Among these considerations we could mainly list the political considerations (whether the CB is independent), weights that the CB applies to multiple aims it has, other key macroeconomic variables that affect the key rate (that are usually dependent on the country of choice), and among other possible reasons uncertainty between the exact numerical interactions between key variables.

One of the empirical rule-of-thumb measures used to gauge the relationship has been introduced by John Taylor in 90s to predict the relationship by using a so-called Taylor's rule. Taylor's rule, in its original form predicts the nominal fed funds rate by using inflation and output gap with assigned weights to each one.

Here we will test one of the baseline versions of this equation with one that has additional equations on an interesting CB to see whether the rule has any applicability outside of established and classic CBs that literature used over the decades.

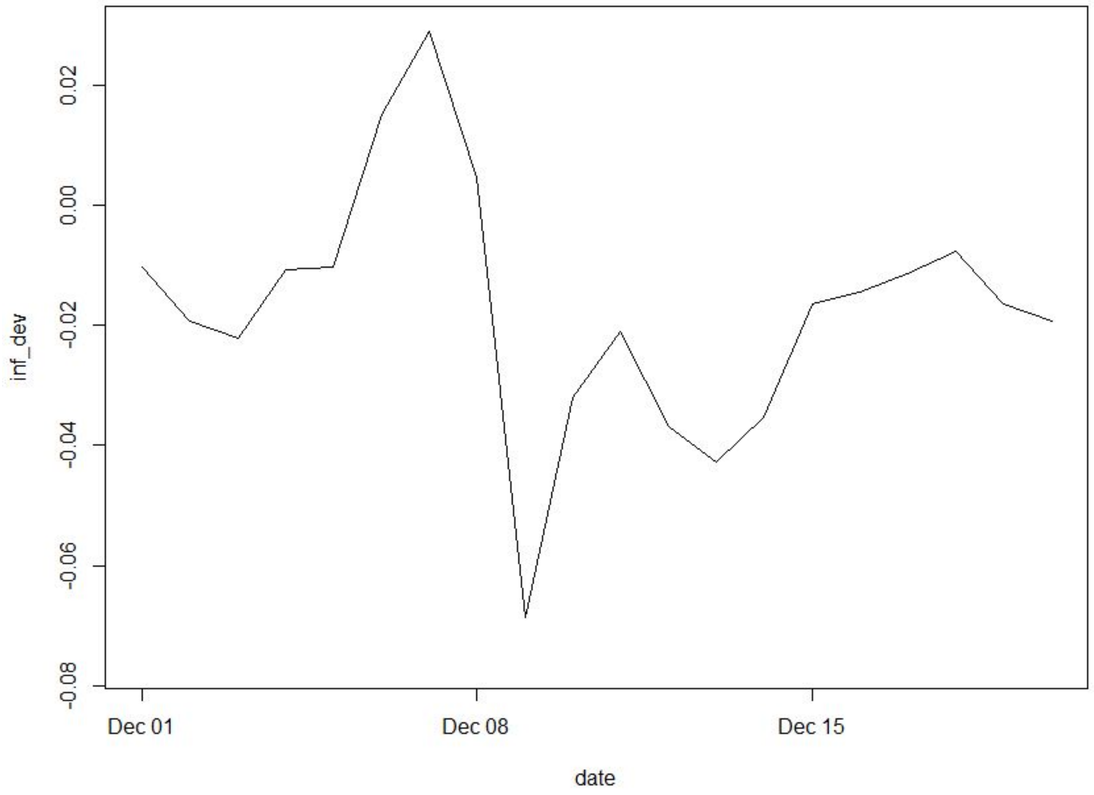
The Set Up

In this study we will take a look at Swedish Central Bank. According to literature and looking To RiksBank's page we can see that contrary to US FED the Swedish CB only targets price target. As such, our baseline for this study will be to look at the classical model for Taylor's rule by taking output gap and deviation from inflation target as explanatory variables. As a next step we looked at the literature to derive a possible easy alternative for the classical Taylor's rule. Looking at Österholm, 2003 and the literature indexed there we concluded that Swedish Central Bank might not take output gap as the goal (as stated on CB's website) and might be rigid in their Monetary Policy, meaning that they might be slow to adjust their rate according to actual economic state.

Firstly, we started looking for data starting from the hardest variable- the output gap. Such data wasn't available widely and we settled on NASDAQ's data derived from OECD data. The data starts from 2001 and ends in 2020, and to avoid erroneous results by interpolation we decided to keep our analysis on annual levels.

Following the previous decision, we extracted yearly inflation data for Sweden for the same periods from OECD. We further, extracted rate data (using 1 week repo rate, parallel to literature) from CB's data archive as the yearly average. For the lagged rates we used annual averages for repo rates lagged by 1 period. Finally, to derive Inflation deviation we used 2% target as it is the target rate for the Swedish CB starting from early 90s.

Descriptive analysis and background



Looking at the graph on the left, we can see that Sweden, parallel to its European peers has mostly stayed way under the official inflation target except for the period before the financial crisis of 2008 and its effects have taken hold. As such, we believe that the second specification where the CB acts slow, and self references its previous rate will be more accurate under the fact that it only targets the price, is unable to produce inflation like its peers and had structural issues post 2008 crisis.

Baseline model

```
Call:
lm(formula = rate ~ deviation + gap)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.023344 -0.012993  0.001417  0.006152  0.028083 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept)  0.019403   0.004681   4.145 0.000677 ***
deviation    0.285671   0.175426   1.628 0.121822    
gap         -0.001390   0.001705  -0.815 0.426169    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.01589 on 17 degrees of freedom
Multiple R-squared:  0.166,	Adjusted R-squared:  0.06789 
F-statistic: 1.692 on 2 and 17 DF,  p-value: 0.2137
```

On the left we can see the results presented to us for the classical Taylor’s rule model. Firstly, we observe that none of the explanatory variables are significant (due to individual p-values). Secondly, we see that the overall model is also insignificant (due to overall p-value). Lastly, we see that the model does a poor job of explaining the variation in our key variable, R squared, where we only have 6% of variation explained. Further, looking at the coefficients we see that the inflation deviation has a positive effect which is consistent with our economic intuition. Lastly, the output gap coefficient has a small negative which is economically insignificant.

Alternative Model

```
Call:
lm(formula = rate ~ deviation + lagged)

Residuals:
       Min         1Q     Median         3Q        Max
-0.0115092 -0.0043344  0.0000648  0.0045192  0.0138284

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 0.006708   0.002347   2.858 0.010892 *
deviation   0.339977   0.071797   4.735 0.000191 ***
lagged      0.837378   0.088766   9.434 3.61e-08 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.006487 on 17 degrees of freedom
Multiple R-squared:  0.861,     Adjusted R-squared:  0.8447
F-statistic: 52.65 on 2 and 17 DF,  p-value: 5.194e-08
```

On the left we can see the output generated from alternative model where the explanatory varibles are 1 week repo rate that is lagged by 1 period, and the inflation target deviation. We had to use the same annual data used in the baseline in order to avoid in bias that could be created by more granular data and to smooth out the short-term effects that data might present us. Firstly, we see that coefficients are significant. Secondly, we see that overall model is significant. Further, wee see that the model explains 84% variation in our dependent variable. Further looking into the numbers wee see that as inflation goes up, the rate also goes up as the economic intuition would suggest. Finally, we see that the lagged rates also have a positive effect on the rates meaning that the rigidity effect is present in our example.

Diagnostics Check

```
RESET test for specification (squares and cubes)
Test statistic: F = 0.878562,
with p-value = P(F(2,16) > 0.878562) = 0.434

Breusch-Pagan test for heteroskedasticity
OLS, using observations 1-20
Dependent variable: scaled uhat^2

             coefficient   std. error   t-ratio   p-value
  --------------------------------------------------------
  const        1.56304      0.354516     4.409    0.0004  ***
  infdev      32.7408      13.2857       2.464    0.0247  **
  ogap        -0.0441375    0.129126    -0.3418   0.7367

  Explained sum of squares = 9.02986

Test statistic: LM = 4.514930,
with p-value = P(Chi-square(2) > 4.514930) = 0.104615
```

```
RESET test for specification (squares and cubes)
Test statistic: F = 0.991076,
with p-value = P(F(2,16) > 0.991076) = 0.393

Breusch-Pagan test for heteroskedasticity
OLS, using observations 1-20
Dependent variable: scaled uhat^2

             coefficient   std. error   t-ratio   p-value
  --------------------------------------------------------
  const         1.43153     0.351321     4.075    0.0008  ***
  w            28.0231     27.0860       1.035    0.3154
  lagged      -51.1053     26.5151      -1.927    0.0708  *

  Explained sum of squares = 5.67215

Test statistic: LM = 2.836076,
with p-value = P(Chi-square(2) > 2.836076) = 0.242189
```

Above you can see the RESET and BP test outputs for the baseline model and below you can see the corresponding tests for the alternative model. Firstly, we look at the RESET test. Both models give us insignificant outputs. Meaning that the model specification is correct, and the models are indeed linear. Second test is partially significant across the models. The meaning behind it is that both models violate the homoskedasticity assumption for our model specification. Here we did not test for normality, as it was assumed at this point due to small sample size.

Conclusion

As a result of our study, we see that the reaction function for the Swedish CB does is more likely to not take the output gap (or alternatively full employment) into consideration. The CB is more likely to consider inflation deviation and be rigid in its decisions like their European peers. The models that we have developed support he statement.

Despite positive results, the results should be interpreted with caution and further studies with better sources of data could be conducted. Firstly, and most importantly, output gap is a hard to measure variable and publicly available data does not provide for a wide enough sample size. Due to this we have a small sample size where some outliers could have had outsized effects on the results. The sample size also prevents us from empirically testing for the normality of data. Our models only fulfill the linearity assumption further fail to satisfy homoskedasticity assumption and the only main assumption that could be credibly proved is linearity.

ANNEX 1- R code

```
 Swedish.dataaaaaaa <- read.delim("C:/Users/macbook pro/Desktop/Swedish data.txt")

>   View(Swedish.data)

> date <- as.Date(Swedish.data1])

> deviation  <- as.double(Swedish.data [,5])

> plot(date, inf_dev, type = 'l')

> gap <- as.double(Swedish.data[,7])

> rate <- as.double(Swedish.data [,6])

> regs_res =  lm(formula = rate ~ gap + deviation)\
```

- summary(reg_res)
- Bptest(regs_res)
- Resettest(regs_res, power= 2:3) (regression, extraction, and diagnostics were repeated for the alternative specification of our model)