Japan (1960 - 2019)

Relationship between inflation and unemployment

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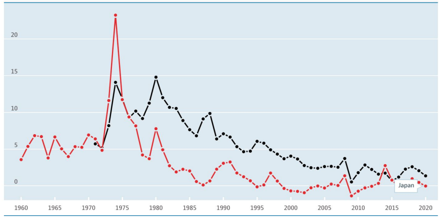
Econometric model context

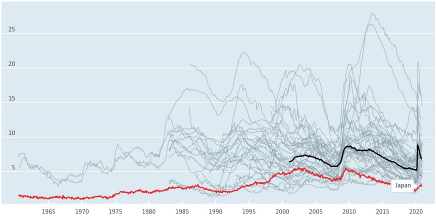
- In order to analyze the inflation rate and unemployment rate relationship in Japan during the time period: 1960-2019. We keep in mind the Phillips curve economic concept, which suggests:
    - There is an inverse relationship between inflation and unemployment.
    - With economic growth comes inflation, which leads to more jobs and less unemployment.
    - in periods of high unemployment, inflation is lower and, in periods of low unemployment inflation is higher.

- Our original linear econometric model will display the relationship between the inflation (CPI) and unemployment rates. Then, we will add an alternative model incorporating the expected inflation rate.

- Before creating the model, we consider important to make sense of the data we are working with.
- From the graphs below, we can infer that the Phillips curve assumptions (listed on the left) are met.



Japan inflation, CPI (1960 - 2019)
extracted from OECD website



Japan unemployment rate (1960 - 2019)
extracted from OECD website

- Additionally, we take into consideration the fact that the error term in the linear model represents exogenous shocks to the world supply.

Alternative model specifications

Our Linear Models

Original linear model:	Alternative linear model:

`## We construct the Linear Model ##`
`## dependent variable: inflation rate`
`## explanatory variable: unemployment rate`
`phillips <- lm(Inflation~Unemployment,data=df_both)`
	`## We introduce an alternative linear model`
	`## dependent variable: inflation rate`
	`## explanatory variables: prior inflation, unemployment rate`
	`phillips_modified = lm(Inflation~Inflation_prior+Unemployment,data=df_new)`

- As displayed, for both, the original linear model and the alternative linear model we use the built-in R function "lm" which is used to fit lit linear models and to carry out regression.
- Both models have inflation rate as the dependent variable and unemployment rate as explanatory variable.
- The difference between our linear models is that the alternative has an additional explanatory variable (prior inflation).
- By adding the inflation rate in the previous t-1 period, "Inflation_prior", we need to be aware that an increase in expected inflation shifts the short-run Phillips curve upward, so that the actual rate of inflation at any given unemployment rate is higher. And, that when the inflation rate decreases, the actual inflation rate at any given level of unemployment will fall by the same amount.
- "Inflation_prior" is taking into account the fact that when workers expect inflation they bargain for higher wage rates, and employers are more willing to grant higher wage rates when they expect to sell their product for higher prices in the future.

Variables, descriptive analysis

Intercept interpretation

- **Inflation rate:** measured by consumer price index (CPI), is the change in the prices of a basket of goods and services typically purchased by specific groups of households. We used it as the dependent variable in both our models. It's data was extracted from the OECD website under "Inflation (CPI)" for Japan during the time period: 1960 - 2019.
  - From the data we can see that from 1960 to 1970 there was an annual growth rate range of [3.6 - 6.9]%. Then, on 1974 there was a peak where the annual growth rate reached 23.2%. From 1981 until now the country we can evidence lower annual growth rates than before, of less than 5%, approaching 0%. Additionally, it must be mentioned that from 1999 - 2012 the annual growth rate was mainly negative (the lowest reported one was -1.4% on 2009). Finally, from 2013 until today there haven't been negative annual growth rates, we can say there is an interval of [0 - 2.8]%, which is relatively low in comparison to the first two decades of our selected time period.
  - Interesting fact: 100 Japanese Yen in 1956 = 605.18 Japanese Yen in 2021 (extracted from inflation.tool.com)

```
> summary(phillips_modified)

Call:
lm(formula = Inflation ~ Inflation_prior + Unemployment, data = df_new)

Residuals:
    Min      1Q  Median      3Q     Max 
-4.0519 -1.3499 -0.2295  0.6581 13.7299 

Coefficients:
                Estimate Std. Error t value Pr(>|t|)    
(Intercept)      4.07454    1.11179   3.665 0.000544 ***
Inflation_prior  0.58677    0.09643   6.085 1.04e-07 ***
Unemployment    -1.01365    0.30923  -3.278 0.001784 ** 
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2.41 on 57 degrees of freedom
Multiple R-squared:  0.6694,	Adjusted R-squared:  0.6578 
F-statistic: 57.71 on 2 and 57 DF,  p-value: 1.997e-14
```

- The intercept in the model shows what will be the inflation rate, given the explanatory variables are equal to 0.
- In our cases, we have seen that the intercept is equal to **4.075**
- With **95%** confidence we can say that the intercept of the model is between **[1.85,6.3]**
- With **99%** confidence we can say that the intercept of the model is between **[1.11,7.04]**

```
> confint(phillips_modified)
                     2.5 %     97.5 %
(Intercept)      1.8482254  6.3008622
Inflation_prior  0.3936722  0.7798652
Unemployment    -1.6328645 -0.3944279
> confint(phillips_modified,level=0.99)
                    0.5 %     99.5 %
(Intercept)      1.111771  7.0373166
Inflation_prior  0.329797  0.8437405
Unemployment    -1.837699 -0.1895937
```

Unemployment rate interpretation

- **Unemployment rate:** indicator measured in numbers of unemployed people as a percentage of the labour force. For this we should keep in mind that a person is considered unemployed if is of working age, without work, available for work, and have taken steps to find work. It's data was extracted from the OECD website under "Unemployment rate" for Japan during the time period: 1960 - 2019.

```
> summary(phillips_modified)

Call:
lm(formula = Inflation ~ Inflation_prior + Unemployment, data = df_new)

Residuals:
    Min      1Q  Median      3Q     Max 
-4.0519 -1.3499 -0.2295  0.6581 13.7299 

Coefficients:
                Estimate Std. Error t value Pr(>|t|)    
(Intercept)      4.07454    1.11179   3.665 0.000544 ***
Inflation_prior  0.58677    0.09643   6.085 1.04e-07 ***
Unemployment    -1.01365    0.30923  -3.278 0.001784 ** 
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2.41 on 57 degrees of freedom
Multiple R-squared:  0.6694,	Adjusted R-squared:  0.6578 
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```

- The coefficient of the explanatory variable shows how does the dependant variable change with respect to a unit change in the explanatory variable.

- The coefficient of the unemployment rate is **-1.014**, so a 1% increase in unemployment will result in **1.014%** decrease in inflation
- The main focus of the Phillip's Model is the negative relationship between inflation and unemployment and, indeed, using the data we have, we can say with **99%** confidence that the value of the unemployment rate is between **[-1.84,-0.19]**, this corroborates the economic statement.

Inflation rate in the previous period (t-1) interpretation

- Calculated from the prior inflation.
- The rate of inflation that people expect.
- The greater the expected rate of inflation, the greater the excess of the prices of indexed securities over those of comparable non-indexed ones.
- Employed only on the alternative linear model.
- It’s data was extracted from the OECD website under “Inflation (CPI)” for Japan during the time period: 1959 - 2018.

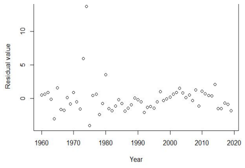
- The inflation rate in the previous period is the other explanatory variable we have in the model.
- The coefficient of the inflation rate in (t-1) shows the influence of the variable on the current inflation. The coefficient is **0.59** which means a 1% increase in the inflation rate in period (t-1) results in an increase of **0.59%** in the current inflation rate.
- With 99% confidence we can say that the value of the coefficient is between **[0.33,0.84]**, so with 99% confidence we can say that the correlation between inflation in time t and in time (t-1) is positive.

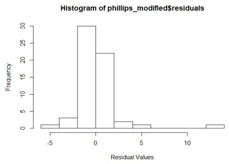
```
> summary(phillips_modified)

Call:
lm(formula = Inflation ~ Inflation_prior + Unemployment, data = df_new)

Residuals:
    Min      1Q  Median      3Q     Max
-4.0519 -1.3499 -0.2295  0.6581 13.7299

Coefficients:
                Estimate Std. Error t value Pr(>|t|)
(Intercept)      4.07454    1.11179   3.665 0.000544 ***
Inflation_prior  0.58677    0.09643   6.085 1.04e-07 ***
Unemployment    -1.01365    0.30923  -3.278 0.001784 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 2.41 on 57 degrees of freedom
Multiple R-squared:  0.6694,	Adjusted R-squared:  0.6578
F-statistic: 57.71 on 2 and 57 DF,  p-value: 1.997e-14
```

Diagnostic checks on our preferred model

Diagnostic checks on “phillips_modified”

	Breusch-Pagan	Breusch-Godfrey	Jarque and Bera
Purpose, testing:	Homoscedasticity	Serial correlation	Normality of the errors and coefficients
P-value	0.02912	0.4571	0.609
Which means:	We reject the null hypothesis which is that the the variance of the errors are homoscedastic. In the graph, we can see that the the variance of the errors is indeed heteroscedastic as the variance is higher in period of economic turmoil.	The error terms are not serially correlated. Thus, the model assumption is satisfied.	We find that the residuals aren’t normally distributed since the Jarque and Bera test yields p-value **<2.2e-16**. We can see this in the histogram. So, as the p-value < alpha, we reject the null hypothesis of normality.






```
	studentized Breusch-Pagan test

data:  phillips_modified
BP = 7.0725, df = 2, p-value = 0.02912
```

```
	Breusch-Godfrey test for serial correlation of order up to
	2

data:  phillips_modified
LM test = 1.5658, df = 2, p-value = 0.4571
```

```
	Jarque-Bera test for normality

data:  phillips_modified$coefficients
JB = 0.36872, p-value = 0.609
```

Significance testing

- We check if the explanatory variables and the intercept are significant. To do so we test the hypothesis that they are equal to 0 against the alternative hypothesis that they are not.
- For the variance of the coefficients we will take into account that the variance of the errors is heteroscedastic, using the **coeftest** method in R with heteroscedastic variance-covariance matrix.

```
> coeftest(phillips_modified,vcoc = hccm) #because of the heteroscedasticity

t test of coefficients:

                 Estimate Std. Error t value  Pr(>|t|)
(Intercept)      4.074544   1.111789  3.6649 0.0005445 ***
Inflation_prior  0.586769   0.096429  6.0850 1.044e-07 ***
Unemployment    -1.013646   0.309228 -3.2780 0.0017842 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

- We get that the intercept, the inflation rate in the previous period and the unemployment rate are all significant since all of their p-values are **<0.001**, which allows us to reject the null hypothesis.

Relevant economic hypothesis of interest in the model parameters

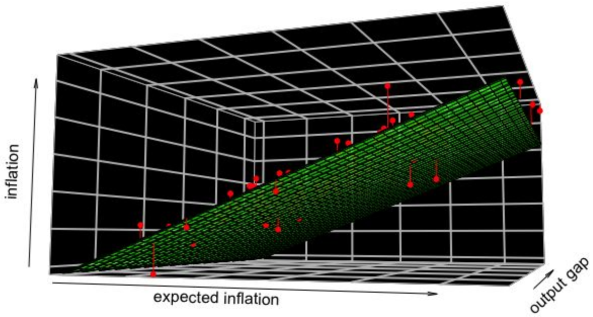
- The New Keynesian Phillips Curve (NKPC) describes a simple relationship between inflation, the expectation hold about future inflation, and real marginal costs.
- <u>As a proxy of real marginal cost we will use output gap</u>

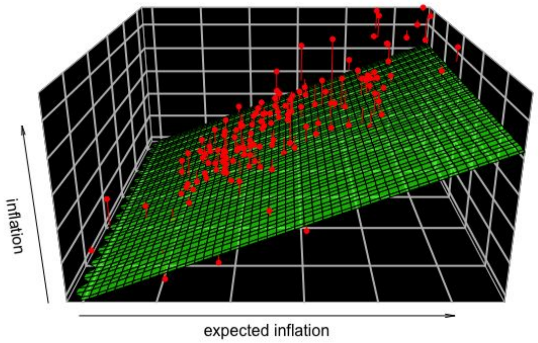
$$\pi_t = \beta E_t \pi_{t+1} + \alpha x_t$$

  - π: inflation (dependent variable)
  - x: output gap (explanatory variable)
  - E: expectation operator
  - Etπt+1: inflation expectation. <u>We will assume persistent expectation</u>: Expected inflation for next quarter = past quarter inflation

We will use data from 1983 to 2019. We were not able to find reliable data on output gap in Japan between 1960 and 2019.

- **With this alternative model the R^2 = 0.81**





Variables, descriptive analysis

Intercept interpretation:

- The intercept in the model shows what will be the inflation rate, given the explanatory variables are equal to 0.
- In our cases, we have seen that the intercept is equal to **0.149**

- With **95%** confidence we can say that the intercept of the model is between **[0.047 , 0.251]**
- With **99%** confidence we can say that the intercept of the model is between **[0.014,0.284]**

Inflation rate in the previous period (t-1) interpretation

- The coefficient of the inflation rate in (t-1) shows the influence of the variable on the current inflation. The coefficient is **0.758** which means a 1 unit increase in the inflation rate in period (t-1) results in an increase of **0.758** in the current inflation rate.
- With 99% confidence we can say that the value of the coefficient is between **[0.647,0.869]**, so with 99% confidence we can say that the correlation between inflation in time t and in time (t-1) is positive.

Output gap (proxy for real marginal cost) interpretation

- The coefficient of the unemployment rate is **0.151**, so a 1 unit increase in unemployment will result in **0.151** unit increase in inflation
- With **99%** confidence that the value of the unemployment rate is between **[0.075,0.227]**

Significance testing

Expected inflation and output gap are both significant at 1% level

```
> summary(NKPC)

Call:
lm(formula = z ~ x + y)

Residuals:
     Min       1Q   Median       3Q      Max 
-1.34654 -0.35041 -0.02625  0.26407  2.28978 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  0.14888    0.05179   2.875  0.00466 ** 
x            0.75806    0.04260  17.797  < 2e-16 ***
y            0.15087    0.02912   5.180 7.34e-07 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.5279 on 144 degrees of freedom
Multiple R-squared:  0.8196,	Adjusted R-squared:  0.8171 
F-statistic: 327.2 on 2 and 144 DF,  p-value: < 2.2e-16
```

Diagnostic checks on NKPC:

	Breusch-Pagan	Breusch-Go dfrey	Jarque and Bera
Purpose, testing:	Homoscedasticity	Serial correlation	Normality of the errors and coefficients
P-value	0.3236	0.6931	Coefficients: 0.006 Residuals: 5e-04
Which means:	The p-value is quite high. Even At the α = 30% level we do not reject the null hypothesis of homoscedasticity of the error terms.	The error terms are not serially correlated. Thus, the model assumption is satisfied.	Both the coefficients and the residuals are normally distributed. Both p-values are very small, meaning we reject the null hypothesis of normality at α = 1% for both.

Bibliography

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