Panel Data Regression Analysis

Unemployment Rate In US & UK

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Executive Summary

The general notion of Unemployment rate is that it is affected by the global economic trends such as GRP (Gross Domestic Product of the country), inflation rate and the stock market performance of the country. These factors are considered as the pillars of the economy which has the straight association in influencing the nation's performance. It makes sense to think that when a country's economy is doing well, the unemployment level will be lower as more people are employed due to the increase in the demand of products and more money. However, when the economy takes a hit, that is when the levels of unemployment rate tend to increase. This trend has been evident from the Global Financial crisis of 2008.

In order to understand this trend that occurs of lower unemployment rate during the booming economy and higher unemployment rate during the economic depression, we tried to analyze the 3 variables of inflation, GDP and the stock market in explaining their effect in the unemployment rate across the years.

We made a panel data analysis of 2 countries, namely US and UK, to explain the models on fixed effects, mixed effects and pooling models in explaining the variance of these . The key findings of our regression analysis suggest that inflation is inversely associated to unemployment rates which GDP and stock market are positively associated in determining the unemployment rate of the country.

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1. Problem Significance

“Too big to fail!” This statement has become synonymous with the worst global financial crisis since the great depression. While governments and banking institutions scrambled to lessen its impact, the global unemployment rate continued to rise until it peaked at 11.4%, and 9.6% in the United Kingdom (UK) and United States respectfully. The lack of employment opportunities meant that many college graduates in 2008 were either out of a job or simply unable to land one. According to new research from the MIT Sloan School of Management and State Street Associates, “there’s a 70% chance that a recession will hit in the next six months”. If this is true, college graduates will once again find themselves in an impossible situation.

This study will examine the impact that various economic factors have on the unemployment rate. In addition, this study will assess the association of these economic factors on the US and UK. The results of this study will help college graduates to understand and be cognizant of just how important these macro economic variables are in influencing employment opportunities both domestically and abroad.

2. Data Sourcing/Preparation

The data was collected from various reliable sources: Unemployment rate for the US was collected from Federal Reserve Economic Data (FRED), while unemployment rate for the US was collected from the Office of National Statistics; inflation rate and GDP rate for both countries were gathered from FRED; stock market index for both countries were taken from Yahoo Finance. We have gathered data from different sources and combined them into one dataset.

Variables	Column Names	Description	Source
Country	country	Two levels: US and UK	-
Year	year	Time period 1985 - 2018	-
Unemployment rate (%)	unemp	Average annual unemployment rate for US and UK respectively	ONS(UK), FRED

Inflation rate (%)	inf	Average inflation rate for US and UK respectively	FRED
GDP rate (% change)	gdp	Average annual gross domestic product for US and UK respectively	FRED
Stock market index	snp	US: S&P 500 yearly index	Yahoo Finance
		UK: FTSE 100 yearly index	Yahoo Finance

Table 2.1

This dataset includes 68 observations of 6 data attributes. The data contains unemployment rate, inflation rate, GDP rate, and stock market index of both the US and UK across 34 years (1985 – 2018). Therefore, there are a total of 34 observations each for the US and UK. For the stock market index, S&P 500 was chosen to represent the US market, while FTSE100 was chosen to represent the UK market. We were only able to obtain monthly stock market index, so we summed up the monthly index for each year and computed the yearly average. The other variables are almost self-explanatory.

Figure 2.2

```
> str(d)
'data.frame':   68 obs. of  6 variables:
 $ country: chr  "UK" "UK" "UK" "UK" ...
 $ year   : num  1985 1986 1987 1988 1989 ...
 $ inf    : num  6.1 3.4 4.1 4.2 5.8 8.1 7.5 4.6 2.6 2.2 ...
 $ unemp  : num  11.4 11.3 10.4 8.6 7.2 7.1 8.9 9.9 10.4 9.5 ...
 $ s.p    : num  1315 1607 2029 1802 2195 ...
 $ gdp    : num  4.2 3.14 5.3 5.76 2.57 0.74 -1.09 0.37 2.53 3.89 ...
```

3. Hypotheses (Rationale for Variable selection)

We decided to investigate the impact of economic factors like the GDP, the general market performance and inflation on unemployment rate in a country. Each of these variables are highly likely to have an association with the unemployment rate in a country. The beta values for each of these variables would indicate the level and direction of association.

1. $H_{1a}: \beta_{inflation} < 0$

   Traditionally the widely held notion is that there exists an inverse relationship between inflation and unemployment rate. Higher inflation rate will have an exponential effect on prices, rapidly eroding the consumer buying power. This in turn will slow the economy down, will reduce GDP, and will increase unemployment rate.

2. $H_{2a}: \beta_{GDP} < 0$

   Okun' Law (1962), states that if the unemployment rate falls to 1%, then the output will be increased by 3%. Therefore, to avoid losses from unemployment, the economy should expand continuously. Our alternate hypothesis is that there exists an inverse association between GDP and unemployment rate.

3. $H_{3a}: \beta_{Market\ Performance} < 0$

   If the rate of unemployment is high, we hypothesize that the market performance would also be adversely affected. Lower number of jobs would reflect a poorly performing market. Our hypothesis is that there is a negative association between general market performance and unemployment rate.

4. Descriptive Analysis/ Visualization

Figure 4.1 below shows summary statistics of the unemployment rate, inflation rate, stock market index, and GDP for both the US and the UK across the 34 years (1985 – 2018). The summary statistics include sample size, average, standard deviation, minimum value, 25th quartile, 75th quartile, and maximum value.

UK

```
> stargazer(uk[c("inf","unemp","s.p","gdp")],type = "text")

================================================================================
Statistic N    Mean     St. Dev.     Min    Pctl(25)  Pctl(75)     Max
--------------------------------------------------------------------------------
inf       34   2.900      1.776     0.400     1.800     3.475     8.100
unemp     34   7.100      2.087     4.100     5.325     8.475    11.400
s.p       34 4,606.112 1,822.602 1,314.800 3,027.300 6,219.900 7,367.100
gdp       34   2.351      1.814    -4.250     1.898     3.395     5.760
--------------------------------------------------------------------------------
```

US

```
> stargazer(us[c("inf","unemp","s.p","gdp")],type = "text")

================================================================================
Statistic N    Mean     St. Dev.    Min    Pctl(25) Pctl(75)     Max
--------------------------------------------------------------------------------
inf       34   2.685      1.061    1.000    1.875     3.225     5.000
unemp     34   5.965      1.486    3.900    4.900     6.900     9.600
s.p       34 1,069.869 658.473  186.850 453.640  1,366.185 2,709.980
gdp       34   4.888      1.858   -0.800    4.225     6.300     7.800
--------------------------------------------------------------------------------
```

Figure 4.1

In Table 4.2, we can see that the mean annual unemployment rate in the US was lower than that of the UK across the 34 years. The mean inflation rates were not much different from each other. Mean GDP rate of the US and the UK are 4.89% and 2.35% respectively. Realize that the mean stock market index for UK and US are significantly different. This is because the scales for the two markets are different.

Mean of US	Variables (1985 – 2018)	Mean of UK
5.97%	Unemployment rate	7.10%
1069.87	Stock market index	4606.11
2.69%	Inflation rate	2.90%

4.89%	GDP rate	2.35%

Table 4.2

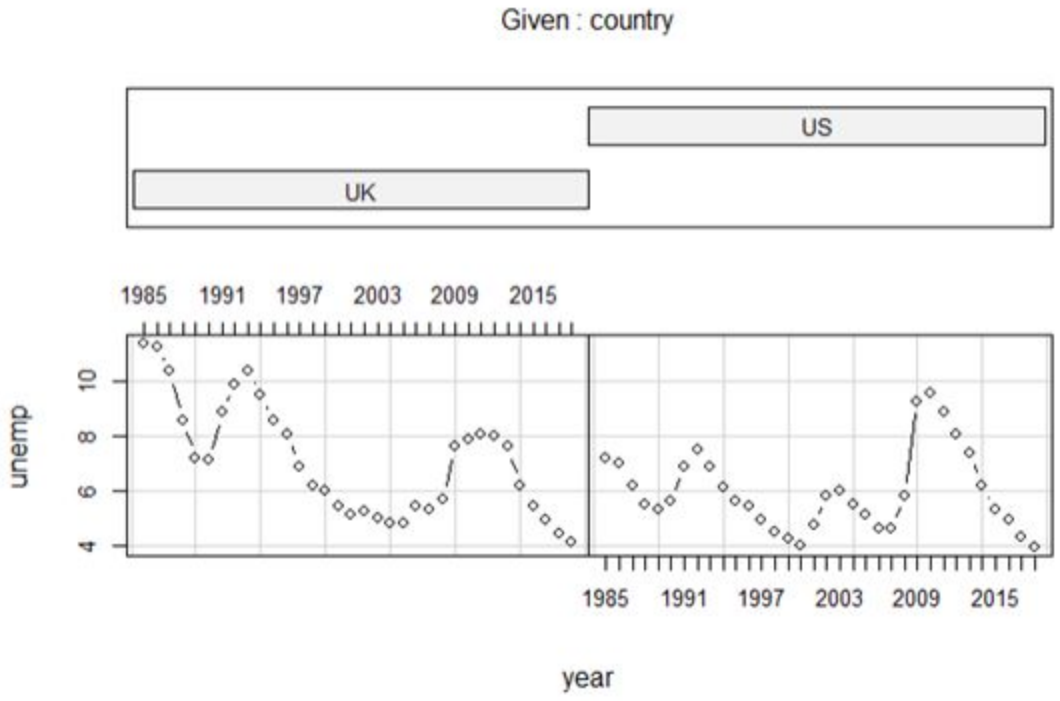

Figure 4.3

Figure 4.3 displays the unemployment trend for both the UK(left) and the US(right). From the graphs, we can see that there is a similar pattern between the two countries – the upward and downward patterns are similar.

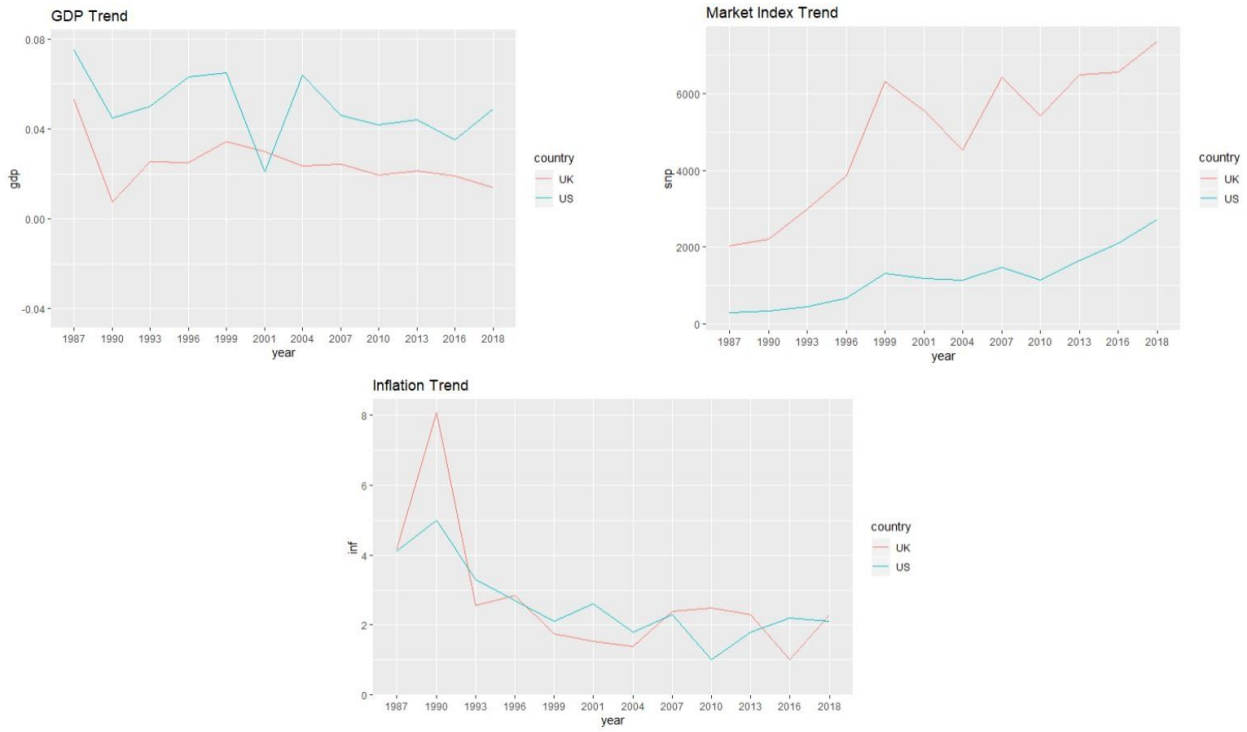

Figure 4.4

These three visualizations depict the trends for inflation rate, stock market index, and GDP for both the countries in our analysis. The GDP visualization shows the annual percentage change throughout the 34 years. The dip in 2001 for the US was due to its economy shrinking in the 3rd quarter. During that 3rd quarter, the US was facing a slight recession. The trends for both US and UK are upward in the long run, which financial analysts expect that the market index is always going up in the long term. Lastly, the inflation rates for both US and UK have downward trends overall.

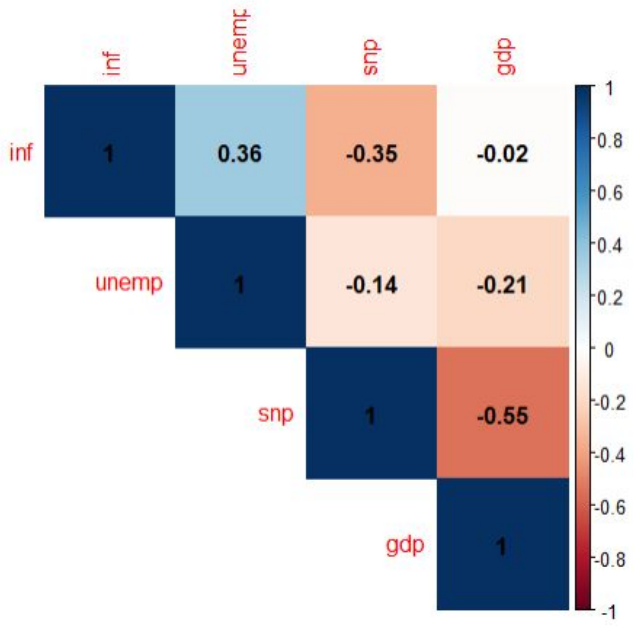

Figure 4.5

From the correlation matrix in Figure 4.5, it is shown that inflation rate and unemployment rate are positively correlated to each other; stock market index and GDP rate are negatively correlated to unemployment rate. However, the correlation matrix did not take into account that the dataset is panel data.

5. Models

Based on the hypothesis formulated and the descriptive analyses, the following models have been considered:

Since our dependent variable is continuous and our data has the characteristics of panel data, we have considered the pooled and mixed effects models.

5.1 Model 1

Unemployment Rate = f (Inflation Rate, GDP, Market Performance)

Where *f = Pooled effects model.*

5.2 Model 2

Unemployment Rate = f (Inflation Rate, GDP, Market Performance)

Where *f = Fixed effects model (one way)*

5.3 Model 3

Unemployment Rate = f (Inflation Rate, GDP, Market Performance, I(Inflation Rate*GDP))

Where *f = Fixed effects model (one way) with interaction*

5.4 Model 4

Unemployment Rate = f (Inflation Rate, GDP, Market Performance)

Where *f = Fixed effects model (two way)*

5.5 Model 5

Unemployment Rate = f (Inflation Rate, GDP, Market Performance)

Where *f = Mixed effects*

6. Quality Check

The models are compared below

	Dependent variable:				
	unemp				
		panel linear			linear mixed-effects
	(1)	(2)	(3)	(4)	(5)
inf	0.359**	-0.230	-0.317	-0.374	-0.154
	(0.161)	(0.154)	(0.191)	(0.226)	(0.146)
gdp	-0.274**	-0.190**	-0.314*	0.088	-0.184
	(0.118)	(0.093)	(0.183)	(0.171)	(0.146)
snp	-0.0002	-0.001***	-0.001***	-0.001***	-0.001***
	(0.0001)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
I(inf * gdp)			0.038		
			(0.048)		
Constant	7.042***				10.618***
	(0.987)				(1.963)
Observations	68	68	68	68	68
R2	0.197	0.472	0.477	0.519	
Adjusted R2	0.159	0.438	0.435	-0.074	
Log Likelihood					-128.087
Akaike Inf. Crit.					272.175
Bayesian Inf. Crit.					289.931
F Statistic	5.220*** (df = 3; 64)	18.753*** (df = 3; 63)	14.133*** (df = 4; 62)	10.789*** (df = 3; 30)	
Note:					*p<0.1; **p<0.05; ***p<0.01

Seeing that we have a panel data sample the pooled model cannot sufficiently explain variations in our data and the output is inconsistent.

The fixed effects model is a better fit to our data.

The mixed effects model does show significant terms for varying slopes of GDP across the countries but since we have only two panels of observations, we cannot model random effects and hence the results of the mixed effects model aren't reliable.

The fixed (one way) effects model without an interaction term is the model we will use to explain our results as it has a reasonable R squared value and does not drop half the number of observations to estimate the parameters unlike the two ways model.

Hypothesis	Null Rejected/Fail to reject	Significance	Inference
H1	Fail to reject	no	From the model,based on our data we see that inflation does not seem to be associated with the unemployment rate across the two countries
H2	Null rejected	yes	From the model, based on our data we see that for one unit increase in GDP over the average value of GDP for a country the unemployment rate reduces by 0.19 per cent.
H3	Null rejected	yes	From the model, based on our data we see that for one unit increase in MarketIndex over the average value of MarketIndex for a country the unemployment rate reduces by 0.001 per cent.

7. Insights

Based on our statistical analysis, we can derive the following insights from our data:

1. Contrary to the popular belief that inflation and unemployment are in inverse relation, our data model rejects the hypothesis which explains this relation. A better explanation for this is that sensitivity of inflation to slack in the economy—the Phillips Curve—is lower than it was several decades ago. Estimates of the Phillips Curve suggest that in the past, inflation was strongly linked to how much slack was in the economy: as the unemployment rate declined, wage and price pressures increased. However, more recently, estimates suggest the Phillips Curve is essentially flat, so prices are less responsive to slack. This change could be due to trends in labor market bargaining or competition particularly from abroad that makes firms less willing to increase prices. This explanation would indicate that we're less likely to see inflation generated by lower slack, such as that indicated by low unemployment rates

2. The unemployment rate fell from 9.1 percent to 8.3 in 2011, but real GDP grew only 1.6 percent. That is much lower than its average growth of 2.6 percent since 1985. This puts forth the idea that the unemployment rate can improve only so much given the modest growth of economic activity. This is based on an empirical relationship sometimes referred to as Okun's law, which is essentially a simple rule of thumb that associates the growth rate in real GDP to changes in the unemployment rate observed around the same time. Part of the explanation for this effect has to do with the fact that we will always have some level of unemployment even in good times, due to natural churning in the labor market. As the economy goes through a long expansion, unemployment will stabilize at this lower level, and additional growth may not necessarily generate additional reductions in the unemployment rate. The upshot is that the rate may not go below that level. As a result, further GDP growth will not necessarily manifest itself as a further decline in the unemployment rate.

3. The unemployment rate usually rises during business recessions and falls during business expansions. Many economists argue that sectoral shifts account for a large portion of the cyclical variation in unemployment. When an economy is hit by an adverse shock, e.g., a sharp increase in crude oil prices, then production resources—including labor—will move from more adversely affected sectors to less adversely affected sectors. Because of the presence of industry-specific skills and the time-consuming nature of the job search, the process of transferring workers across industries tends to be slow and involves spells of unemployment. Therefore, an increase in intersectoral shifts leads to higher unemployment by increasing the amount of labor reallocation. Stock market dispersion is a good proxy for the volume of intersectoral shifts. Because stock prices are equal to expected discounted future cash flows, when stock prices in a sector go up (down), the sector is likely to experience increased (decreased) cash flows and thus demand more (less) labor input in the future. As hypothesized, the two variables (employment and SNP) tend to move in the same direction, with a correlation coefficient of 0.14. In particular, stock market dispersion appears to provide a good explanation for the movement of the labor market in the past few years.

Annexures

R Code:

```
rm(list=ls())

library(rio)

library(moments)

library(corrplot)

library(car)

library(plm)

library(stargazer)

library(corrplot)

library(plotly)

library(ggplot2)

library(dplyr)

library(lattice)

d <- import("Unemployment.xlsx")

if(!require(FSA)){install.packages("FSA")}

if(!require(psych)){install.packages("psych")}

if(!require(lme4)){install.packages("lme4")}

if(!require(lmerTest)){install.packages("lmerTest")}

if(!require(nlme)){install.packages("nlme")}

a <-pdata.frame(d, index=c("country","year"))

summary(a)
```

```
# Pooled Effects Model

pooled <-plm(unemp ~ inf + gdp + snp, data=a, model="pooling")

summary(pooled)


# Fixed Effects Model

fixed_w <-plm(unemp ~ inf + gdp + snp, data=a, model="within")

summary(fixed_w)

summary(fixef(fixed_w))


#Fixed Effects with interaction

fixed_wi <-plm(unemp ~ inf + gdp + snp+ I(gdp *inf) , data=a, model="within")

summary(fixed_wi)

summary(fixef(fixed_wi))


#Fixed Effects two ways

fixed_w2 <-plm(unemp ~ inf + gdp + snp , data=a, model="within", effect="twoways")

summary(fixed_w2)

summary(fixef(fixed_w2))


#Mixed

library(lme4)

mixed = lmer(unemp ~ inf + gdp + snp +(1+ snp|country),data=a)

summary(mixed)
```

```
#Comparing

stargazer(summary(fixef(fixed_w)), type = "text", summary = FALSE, title = "Intercept for Within one way ")

stargazer(summary(fixef(fixed_w2)), type = "text", summary = FALSE, title = "Intercept for Within Two way ")

stargazer(pooled,fixed_w,fixed_w2,type='text',summary=FALSE)

pFtest(fixed_w, pooled)

plmtest(fixed_w, effect = "individual")

plmtest(fixed_w2, effect="twoways", type="bp")

pFtest(fixed_w, fixed_w2)

plmtest(fixed_w2,)

AIC(fixed_w, fixed_w2, pooled)


#Mixed effects

model = lmer(unemp ~ inf + gdp +snp + (1|country),

        data=d,

        REML=TRUE)

summary(model)

fixef(model)

ranef(model)

coef(model)
```