Investigating the Relationships between the Output Gap, Inflation and Unemployment

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Abstract

The output gap is an important concept in the study of business cycles. Although it is not directly observable, its computation brings valuable information regarding the state of the economy. The purpose of this article is to investigate the relationships between the output gap and other relevant variables for economic policy, such as inflation and unemployment. The framework used considers eight European Union countries, of which four are old members (Germany, Spain, France and Italy) and four are new members (Bulgaria, Hungary, Poland and Romania). An empirical analysis is going to be performed and the results are going to bring evidence with regard to the type of relationships between variables and their intensity. Moreover, the analysis will allow for cross-country comparisons.

1. Introduction

The output gap, which is the difference between the actual and the potential GDP, is a valuable indicator in the study of business cycles. Its main advantage is that it concentrates a lot of information, as we can formulate relevant statements about the state of the economy in general and that of important variables that are linked to the output gap by simply knowing the values and developments of the output gap.

In a previous study, Ţiţan and Georgescu (2013), investigate the macroeconomic stability using the output gap and obtain several results that underline the importance and usefulness of the output gap for policy analysis in general and business cycles in particular.

In this article, we are interested to see how inflation and unemployment link to the output gap and with each other. We have of course certain expectations derived from the economic theory, and we seek to find empirical evidence that would either confirm or contradict these expectations.

Linked to these expectations is also the issue of timing, since the labour market may react with delay and therefore the influence of the output gap over unemployment and/or inflation may be visible with a certain lag. Inflation, however, may be responding quicker to a change in the output gap compared to unemployment. The analysis using lags is one of the main features of this article.

Bank of Canada (2012) indicates that a positive output gap is usually associated with a boom period and is a sign of economic activity that exceeds capacity, creating pressures on the labour market and on the price levels. A positive output gap is expected to have repercussions towards a lower unemployment and a higher level of inflation. Alternatively, a negative output gap is usually associated with a recessionary period and the pressures would be in the direction of higher unemployment and lower inflation.

The literature on the relationship between inflation and unemployment is very broad and it is possible to consider a setup in which these variables influence each other. However, in our framework we expect the inflation and the unemployment to be correlated, but we consider that they are both influenced by the output gap, and therefore, for the causal analysis, the output gap is always the explanatory variable, while inflation and unemployment are explained variables.

Regarding the relationship between the output gap and inflation, Koske, I. and N. Pain (2008) indicate that "output gaps remain a significant influence on inflation, but their influence is now weaker than in the past, and the usefulness of output gap estimates for real-time inflation projections is limited" (p. 2). Useful information on this topic can be found also in Bouis et al. (2012).

Relevant work is also available with respect to the unemployment and business cycles, for example the model proposed by Christiano et al. (2010). Another relevant study is the one by Hairault et al. (2008), which investigates whether the business cycles can have significant impact on unemployment.

2. Data

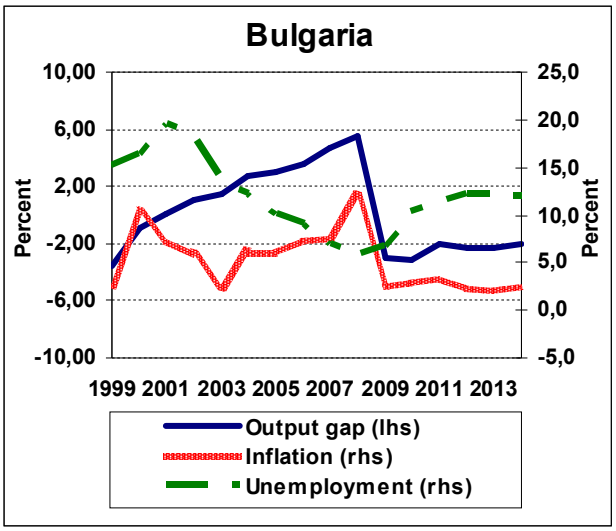
We use annual data for the output gap, inflation and unemployment. The output gap data comes from the AMECO database provided by the European Commission and represents the gap between actual and potential GDP at 2005 market prices. The inflation rate data is calculated based on the HICP index from the AMECO database. The unemployment rate data comes also from the AMECO database and it is based on the Eurostat definition (ZUTN).

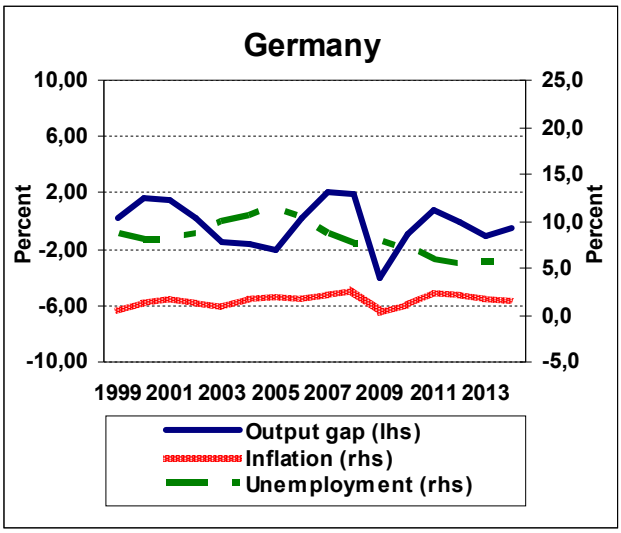
Eight countries from the EU are analysed, four old member states of the EU (Germany, Spain, France and Italy) and four new member states (Bulgaria, Hungary, Poland and Romania). The main period considered is 1999-2014 and includes forecasted values.

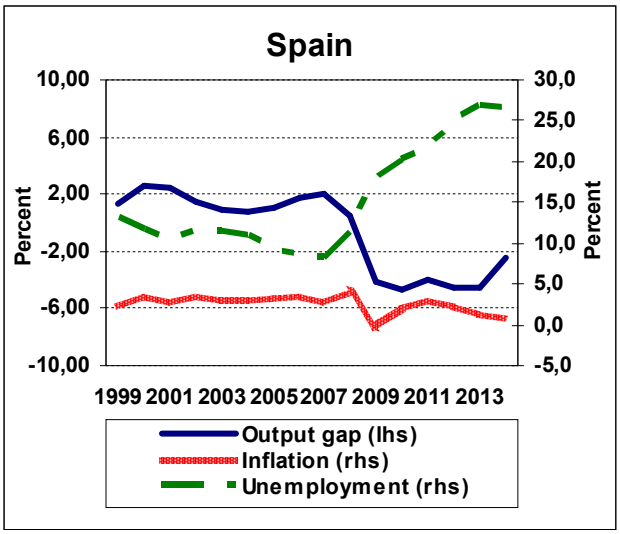
3. Empirical analysis

Exploring the data

The plots below display the data described in the previous section. In each plot, the scale on the left hand side is for the output gap and the scale on the right hand side is for the inflation and unemployment. For all countries, the scale for the output gap is identical, while the scale for inflation and unemployment sometimes fluctuates because of the considerable differences in the levels of these variables among countries.



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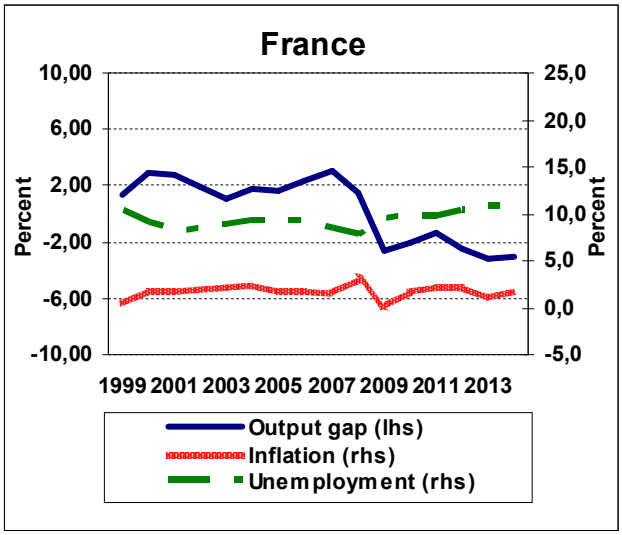
Unemployment (rhs)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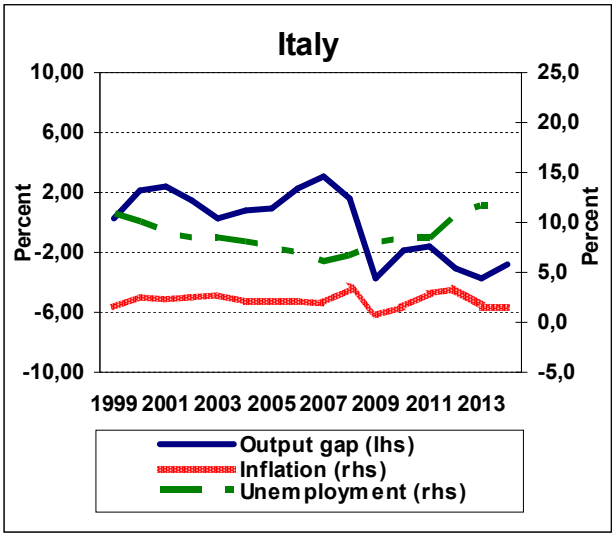
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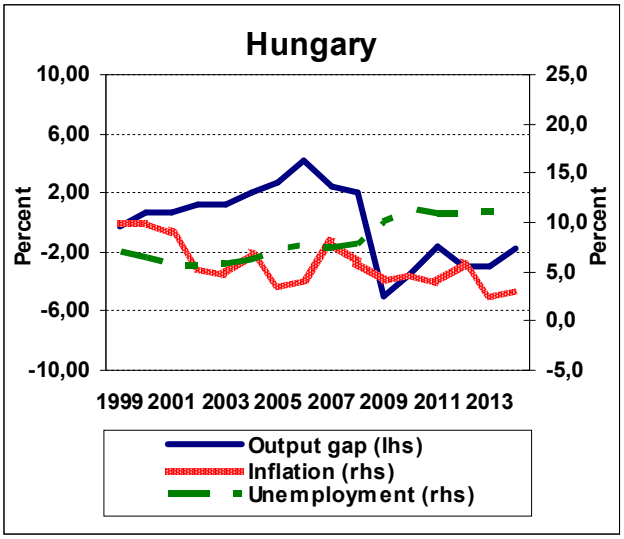
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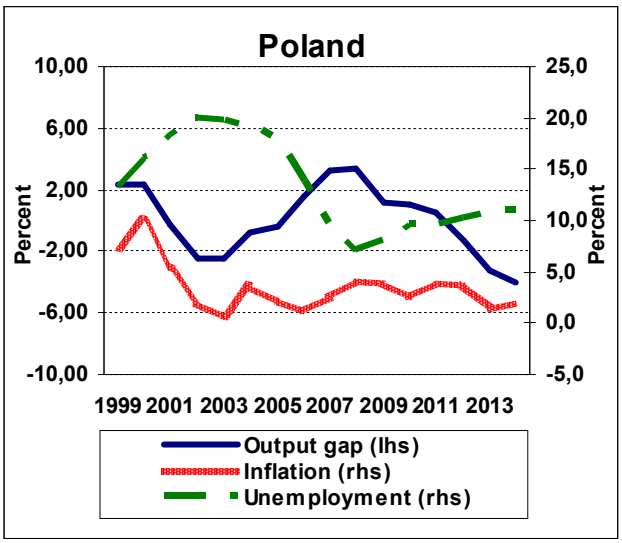
Inflation (rhs)
Unemployment (rhs)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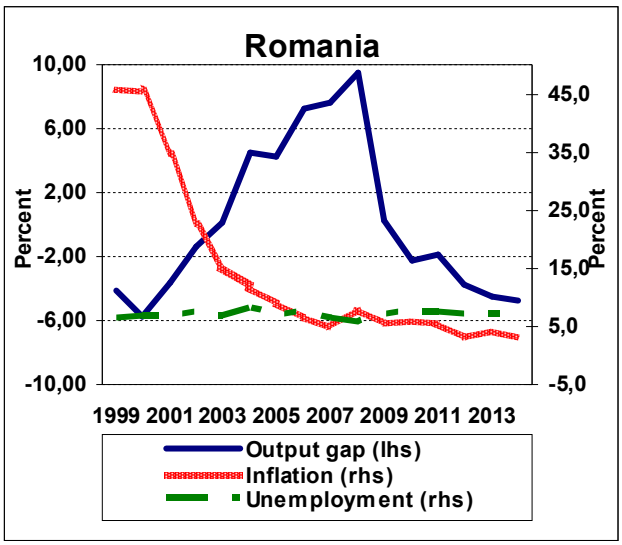
Inflation (rhs)
Unemployment (rhs)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Output gap (lhs)
Inflation (rhs)
Unemployment (rhs)

Correlation analysis

We would like to identify causal relationships between variables, but first we try to look at co-movements by means of a correlation analysis. We try to identify the sign and intensity of the relationships between the output gap, inflation and unemployment.

We consider the relationships Inflation-Unemployment, Output Gap-Inflation, as well as Output Gap-Unemployment. Moreover, the case may be that the output gap can have an impact over inflation and unemployment, but this effect comes with a lag. This would be also visible in the value of the correlation coefficient. Therefore, for the relationships Output Gap-Inflation and Output Gap-Unemployment we also consider three lags of 1 year, 2 years, 3 years.

The whole period is 1999-2014, but when we consider, for example, the correlation of the output gap with 1 year lag with unemployment, we calculate the correlation coefficient for the output gap in the period 1999-2013 and for unemployment in the period 2000-2014. If we consider the 2 year lag, we would have the period 1999-2012 for the output gap and the period 2001-2014 for unemployment. The same logic applies to the 3 year lag and to the lagged relationships between output gap and inflation.

A notation like, for example, Output Gap(-2) – Inflation, refers to a relationship with 2 lags between the variables, where the data used for the Output Gap is 1999-2012, and the data used for inflation is not the whole period, but the corresponding period 2001-2014.

The results of this analysis are available in Table 1 below.

Table 1. Correlation coefficients for different variables across countries

	BG	DE	ES	FR	IT	HU	PL	RO
Inflation - Unemployment	-0.09	-0.16	-0.64	-0.43	-0.21	-0.59	-0.01	-0.25
Output Gap - Inflation	0.72	0.62	0.64	0.29	0.38	0.42	0.52	-0.41
Output Gap(-1) - Inflation	0.32	0.02	0.49	0.15	0.29	0.32	0.59	-0.46
Output Gap(-2) - Inflation	0.29	-0.73	0.33	-0.07	-0.09	0.30	0.40	-0.47
Output Gap(-3) - Inflation	0.26	-0.41	0.38	0.05	-0.20	0.20	0.15	-0.52
Output Gap - Unemployment	-0.33	-0.19	-0.89	-0.74	-0.56	-0.76	-0.36	-0.08
Output Gap(-1) - Unemployment	-0.60	-0.17	-0.92	-0.89	-0.69	-0.69	-0.44	-0.28
Output Gap(-2) - Unemployment	-0.69	0.03	-0.85	-0.73	-0.63	-0.48	0.40	-0.47
Output Gap(-3) - Unemployment	-0.67	0.19	-0.77	-0.64	-0.66	-0.25	0.15	-0.22

The relationship between inflation and unemployment is negative for all countries, in line with intuition. A higher level of inflation is associated with a lower level of unemployment and, respectively, a lower level of inflation is associated with a higher level of unemployment. However, the intensity of the relationship is high for Spain, while for the other countries it is medium or low (for Poland the variables are practically uncorrelated).

The relationship between the output gap and inflation is positive for most countries, which is what we would have expected. The intensity varies from low to moderate and even high (the cases of Bulgaria, Spain and we consider also Germany). However, for Romania the coefficient is negative, which is an unusual result. This could be more clearly explained after the causal dependency analysis, but we can already point out that Romania had a particular situation with respect to inflation. In 1999, at the beginning of the considered period, the inflation rate in Romania was 45.8%, decreasing to 34.5% in 2001, 15.3% in 2003, and the first year with an inflation rate below 10% was 2005. The dis-inflationary process continued, and the inflation rate target for the National Bank of Romania for 2013 is 2.5%, with a variation band of +/- 1 percentage point. Therefore, wider structural issues and changes in the economy may have impacted the Output Gap - Inflation relationship.

Regarding the Output Gap–Inflation relationship with lags, the coefficients either decrease with more lags (the cases of Bulgaria and Hungary), oscillate slightly (the cases of Spain and Poland), or have some or all of the values negative (the cases of Germany, France, Italy and Romania).

For the analysis of the causal relationships, a possibility would be to make a custom model for each country, considering, for example for Poland, the Output Gap(-1) – Inflation model because the correlation coefficient is slightly higher than in the basic model. However, other countries have different particularities, for example the coefficient for Germany becomes strongly negative in the second lag, but then becomes less negative in the third. In order to ensure comparability across countries we are going to consider the same model for all countries, namely the Output Gap-Inflation with no lags, for the causal analysis. Additionally, we are going to consider the Output Gap(-1) – Inflation model for Poland, the Output Gap(-2) – Inflation model for Germany and the Output Gap(-3) – Inflation model for Romania.

The principle used for the selection of the models with lags is that the correlation between variables must be at least as strong as in the case with no lags (the sign can be different).

The relationship Output Gap – Unemployment is negative for all countries, which is a normal result. The intensity across countries is however different. The relationship is strong for Spain, Hungary and France, while the lowest intensity is found in Germany and Romania.

In the case of the Output Gap – Unemployment relationship, the lags are particularly important, because the changes in unemployment do not occur instantly. Intuition indicates also that unemployment has a slower response than inflation to changes in the business cycle. There is evidence of this also in our table, since some of the lags seem to bring considerably "better" coefficients than in the case of the Output Gap - Inflation relationship.

We are going to consider the model with no lags as the base model for all countries for the causal analysis, but for some countries we are going to try to investigate lagged models for which the lags have correlation coefficients at least as strong as in the corresponding base model (sign may change). Therefore, the additional models are Output Gap(-1) – Unemployment for Spain, France, Italy and Poland, Output Gap(-2) – Unemployment for Bulgaria and Romania and Output Gap(-3) – Unemployment for Germany.

In total, for the causal analysis there will be 26 models under scrutiny.

Causal analysis

In the correlation analysis we identified some relationships of co-movement between variables. We would like to test whether next to correlation there is also causality. Based on the correlation analysis we selected 26 cases that we would like to test for statistically significant causality. These individual models are classified in 8 groups of models.

Each time we consider the Output Gap as the explanatory variable. Inflation and Unemployment are explained variables. We use simple regression models with intercept. The obtained groups of models are:

1. $Inflation\_i = \alpha + \beta * Output\_Gap\_i + u_t$, where country i is one of the 8 countries considered.
2. $Inflation\_PL = \alpha + \beta * Output\_Gap\_PL\ (-1) + u_t$, this model is used for Poland, 1 year lag.
3. $Inflation\_DE = \alpha + \beta * Output\_Gap\_DE\ (-2) + u_t$, this model is used for Germany, 2 year lag.
4. $Inflation\_RO = \alpha + \beta * Output\_Gap\_RO\ (-3) + u_t$, this model is used for Romania, 3 year lag.
5. $Unemployment\_i = \alpha + \beta * Output\_Gap\_i + u_t$, where country i is one of the 8 countries considered.
6. $Unemployment\_i = \alpha + \beta * Output\_Gap\_i\ (-1) + u_t$, where country i is one of the following countries: Spain, France, Italy and Poland.

7. Unemployment_i = $\alpha + \beta$ * Output_Gap_i (-2) + u_t, where country i is Bulgaria or Romania.

8. Unemployment_DE = $\alpha + \beta$ * Output_Gap_DE(-3) + u_t, this model is used for Germany, 3 year lag.

The results in Table 2 are obtained. The significance level used is 5%.

Table 2. Models' results

No.	Model	α	t-stat.	p-value	Stat. significant	β	t-stat.	p-value	Stat. significant
1	Inflation_BG = α + β * Output_Gap_BG + u_t	5.0854	9.0720	0.0000	YES	0.7364	3.8401	0.0018	YES
2	Inflation_DE = α + β * Output_Gap_DE + u_t	1.6910	12.4675	0.0000	YES	0.2492	2.9340	0.0109	YES
3	Inflation_ES = α + β * Output_Gap_ES + u_t	2.7597	11.8618	0.0000	YES	0.2528	3.0799	0.0082	YES
4	Inflation_FR = α + β * Output_Gap_FR + u_t	1.7491	9.8214	0.0000	YES	0.0864	1.1160	0.2832	NO
5	Inflation_IT = α + β * Output_Gap_IT + u_t	2.2581	13.2635	0.0000	YES	0.1149	1.5338	0.1474	NO
6	Inflation_HU = α + β * Output_Gap_HU + u_t	5.7150	9.5802	0.0000	YES	0.2498	1.0674	0.3038	NO
7	Inflation_PL = α + β * Output_Gap_PL + u_t	3.5254	6.6623	0.0000	YES	0.5411	2.2848	0.0384	YES
8	Inflation_RO = α + β * Output_Gap_RO + u_t	14.6521	4.2243	0.0008	YES	-1.2065	-1.6728	0.1166	NO
9	Inflation_PL = α + β * Output_Gap_PL (-1) + u_t	3.1120	6.2562	0.0000	YES	0.6271	2.6063	0.0217	YES
10	Inflation_DE = α + β * Output_Gap_DE (-2) + u_t	1.6938	13.7282	0.0000	YES	-0.2682	-3.6505	0.0033	YES
11	Inflation_RO = α + β * Output_Gap_RO (-3) + u_t	8.8376	6.3192	0.0001	YES	-0.5752	-2.0199	0.0684	NO
12	Unemployment_BG = α + β * Output_Gap_BG + u_t	12.0342	12.3865	0.0000	YES	-0.4366	-1.3137	0.2101	NO
13	Unemployment_DE = α + β * Output_Gap_DE + u_t	8.0119	17.1722	0.0000	YES	-0.2142	-0.7331	0.4756	NO
14	Unemployment_ES = α + β * Output_Gap_ES + u_t	14.0783	17.2847	0.0000	YES	-2.0638	-7.1834	0.0000	YES
15	Unemployment_FR = α + β * Output_Gap_FR + u_t	9.4501	58.4281	0.0000	YES	-0.2930	-4.1676	0.0009	YES
16	Unemployment_IT = α + β * Output_Gap_IT + u_t	8.7661	23.2421	0.0000	YES	-0.4196	-2.5282	0.0241	YES
17	Unemployment_HU = α + β * Output_Gap_HU + u_t	8.1731	21.7492	0.0000	YES	-0.6416	-4.3517	0.0007	YES
18	Unemployment_PL = α + β * Output_Gap_PL + u_t	13.4111	12.3582	0.0000	YES	-0.7026	-1.4466	0.1700	NO
19	Unemployment_RO = α + β * Output_Gap_RO + u_t	6.9321	50.2149	0.0000	YES	-0.0086	-0.2998	0.7688	NO
20	Unemployment_ES = α + β * Output_Gap_ES (-1) + u_t	14.4229	19.5726	0.0000	YES	-2.1619	-8.3936	0.0000	YES
21	Unemployment_FR = α + β * Output_Gap_FR (-1) + u_t	9.4860	82.7055	0.0000	YES	-0.3625	-7.0831	0.0000	YES
22	Unemployment_IT = α + β * Output_Gap_IT (-1) + u_t	8.7125	26.1517	0.0000	YES	-0.5192	-3.4726	0.0041	YES
23	Unemployment_PL = α + β * Output_Gap_PL (-1) + u_t	13.6783	12.0946	0.0000	YES	-0.9699	-1.7728	0.0997	NO
24	Unemployment_BG = α + β * Output_Gap_BG (-2) + u_t	11.8738	14.7420	0.0000	YES	-0.8874	-3.3193	0.0061	YES
25	Unemployment_RO = α + β * Output_Gap_RO (-2) + u_t	7.0137	48.2376	0.0000	YES	-0.0268	-0.8915	0.3902	NO
26	Unemployment_DE = α + β * Output_Gap_DE(-3) + u_t	8.0581	13.9151	0.0000	YES	0.2115	0.6366	0.5374	NO

The results in the table allow for an extensive discussion. Firstly, it can be observed that the intercept is statistically significant in all 26 models. This information is quite useful, because in our analysis the intercept has a particular meaning, namely it is the level of the inflation/unemployment given that the output gap is zero.

Secondly, in 14 out of the 26 models, the coefficient of the explanatory variable is statistically significant at the 5% level. From the models with no lags, 8 out of 16 have statistically significant coefficients of the explanatory variable at the 5% level, while from the models with lags 6 out of 10 have such significant coefficients.

Looking at the models with no lags, for the output gap-inflation relationship, the countries for which the relationship is statistically significant are: Bulgaria, Germany, Spain and Poland. In the case of the output gap-unemployment relationship, the countries with statistically significant relationships are: Spain, France, Italy and Hungary.

Considering the models with lags, we can firstly notice that the models with 3 year lags do not display statistically significant relationships. Looking at the models with 1 year lag, we have a statistically significant relationship between the output gap and inflation in Poland, and statistically significant relationships between the output gap and unemployment in Spain, France and Italy. For the models with 2 year lags, there is a statistically significant relationship between the output gap and inflation in Germany and a statistically significant relationship between the output gap and unemployment in Bulgaria.

An overview of the tested models by country is provided in the table below.

Table 3. Tested models overview

	No. of models tested	Stat. significant relationships
Bulgaria	3	2
Germany	4	2
Spain	3	3
France	3	2
Italy	3	2
Hungary	2	1
Poland	4	2
Romania	4	0

In most cases, some of the models selected for testing displayed statistically significant relationships between the explanatory and explained variables. In the case of Spain, all models tested had statistically significant relationships. In the case of Romania, none of the models tested displayed statistically significant relationships. The story of inflation in Romania has been already briefly presented in the correlation analysis section. It is interesting to see why also unemployment seems not to respond to the output gap in the expected way and to try to identify reasons for it. A possibility that is worth investigating is that there may be other factors with greater influence over the unemployment than the output gap, such as migration. In such a scenario, it can be tested whether even in bad times, with negative output gap, the diminished domestic workforce did not enable the unemployment level to raise too much compared to other countries (in the model with no lags, when the output gap is zero the unemployment level would equal the intercept which is 6.9321, the smallest value from all the countries). This kind of testing is however not in the scope of this article.

The evidence found leaves a lot of room for policy discussions and other developments. The evidence gathered from the tested models is somewhat heterogeneous, in the sense that we cannot single out a model for one type of relationship that is good for all countries. Each country has its own particularities and they do not necessarily follow the same pattern closely. However, the fact that evidence was found particularly in the lagged models is of great importance.

When we consider the fact that some effects are present in some cases with a lag of one or two years, this has great implications for policy. If we think about the electoral cycle, for example, some of the effects in the first one or two years may be due to the old administration, while some may not become visible during the current electoral cycle if they haven't been implemented early enough. This is of course an intuitive fact, but it can also be measured and quantified in order to isolate particular measures and their results.

4. Conclusion

The purpose of the article is to investigate on the relationships between the output gap, inflation and unemployment. An empirical study is done which incorporates a correlation analysis part and a causal analysis part. Particular weight is put on using lags so that relationships between variables can be better understood dynamically.

In the correlation analysis part, relationships between the output gap, inflation and unemployment are underlined. The correlations between inflation and unemployment are negative, which is in line with intuition. However, these range from nearly zero to strong correlation.

There is a positive relationship between the output gap and inflation for most countries, with low, medium and high intensities. For Romania the coefficient is negative. Regarding the relationships with lags, they display different behaviours across countries, for example fading out in intensity, or increasing in intensity, changing sign, etc. These results will be used further for the causal analysis part.

In all countries, the relationship between the output gap and unemployment is negative, ranging from low to high intensity. Similar to the relationship between the output gap and inflation with lags, the relationship between the output gap and unemployment with lags displays different patterns across countries and the results are used in the next part of the analysis.

For the causal analysis part, we make a selection of relationships based on the correlation coefficients obtained in the previous part, using an ad-hoc methodology. We model these relationships using simple regression models with intercept, in order to establish causality. In each model, the explanatory variable is the output gap, and the explained variable is inflation or unemployment. We consider 26 models, of which 16 do not have lags (base models) and 10 have lags.

All models have intercepts that are statistically significant at the 5% level, which is an important result considering that in this framework the intercept stands for the value of either inflation or unemployment provided that the output gap is zero.

We obtain 14 out of 26 models where the coefficient of the explanatory variable is statistically significant at the 5% level. For the models with no lags, 8 out of 16 have statistically significant coefficients at the considered significance level, while the same is true for 6 out of 10 models with lags.

The results of the causal analysis allow for a lot of policy discussions. A lot of evidence is available with regard to the impact of the output gap on inflation and unemployment, but this evidence is quite mixed across countries. Each country has its own characteristics and there is no one model that fits all countries. However, the evidence found is valuable, and particularly if we consider the models with lags it is interesting to observe that some of the effects may become visible with a lag of one-two years. This can have great implications over the electoral cycle and design of policies.

References

- Bank of Canada (2012), "The Output Gap", Backgrounders
  http://www.bankofcanada.ca/wp-content/uploads/2010/11/output_gap.pdf

- Bouis, R., B. Cournède and A. Christensen (2012), "Implications of Output Gap Uncertainty in Times of Crisis", *OECD Economics Department Working Papers*, No. 977, OECD Publishing.
  http://dx.doi.org/10.1787/5k95xd7m3szw-en

- Christiano, L. J., Trabandt, M. and Walentin, K. (2010), "Involuntary unemployment and the business cycle", ECB Working Paper No. 1202
  http://www.ecb.int/pub/pdf/scpwps/ecbwp1202.pdf

- Hairault, J.,O., Langot, F., Osotimehin, S. (2008), "Unemployment Dynamics and the Cost of Business Cycles", IZA discussion Papers, No. 3840

- Markku Lanne, Jani Luoto (2012), "Does Output Gap, Labor's Share or Unemployment Rate Drive Inflation?", MPRA Paper No. 41820, Munich Personal RePEc Archive
  http://mpra.ub.uni-muenchen.de/41820/1/MPRA_paper_41820.pdf

- Koske, I. and N. Pain (2008), "The Usefulness of Output Gaps for Policy Analysis", *OECD Economics Department Working Papers*, No. 621, OECD Publishing.
  http://dx.doi.org/10.1787/241172520210

- Macchiarelli, C. (2013), "GDP-Inflation Cyclical Similarities in the CEE Countries and the Euro Area", ECB Working Paper No. 1552
  http://www.ecb.int/pub/pdf/scpwps/ecbwp1552.pdf

- Ţiţan, E., Georgescu, V. (2013), "Investigating Macroeconomic Stability using the Output Gap", Romanian Statistical Review, No. 2
  http://www.revistadestatistica.ro/Articole/2013/RRS_02_2013_a2_en.pdf