INVESTIGATING MACROECONOMIC STABILITY USING THE OUTPUT GAP[1]

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Abstract

The purpose of the article is to illustrate the importance of the output gap in analysing macroeconomic stability in general and business cycle dynamics in particular. Ten EU countries are considered, with five old members and five new members. For all ten countries the data for the period 1999-2014 is used, but for four countries, namely France, the United Kingdom, Italy and Spain additional data is available that goes back to 1965, such that the whole period 1965-2014 is covered, which allows for a particular analysis. An empirical analysis is performed with regard to the behaviour of the output gap for different countries over time. The results obtained allow for relevant comparisons and highlight the usefulness of this indicator as a tool in the study of business cycles.

Keywords: output gap, potential output, business cycles, density, simulation

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The movement of the economy is in principle of cyclical nature, alternating boom and recession periods. From the perspective of the policy maker it is desirable to have a growth path that is as smooth as possible. A valuable indicator of this smoothness, though it is a partial one and does not summarize all information regarding the business cycles is the output gap.

There are various possible definitions of the output gap, but a simple one would be that it is the difference between the actual and the potential output, thus reflecting the drift of the economy from its level that implies equilibrium.

A positive output gap reflects an economy working over potential, which generally corresponds to a boom period, while a negative one illustrates a situation in which the factors are not fully employed and is, in general, associated with recession. It is true however that an economy can have a negative output gap even after the technical recession phase is over. In our analysis we consider the moment when the output gap gets back to zero from

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negative territory to be the end of an economic cycle and the beginning of the next one.

In the following we investigate the behaviour of the output gap for selected countries over time and try to gather useful evidence that can help design policies for a smoother growth path.

The literature on potential output and the output gap is generous, as the topic is very relevant, especially in times of economic turmoil.

The Bank of Canada (2012) defines the output gap as the difference between the actual and the potential output, while the potential output is defined as "the maximum level of goods and services an economy can produce on a sustained basis with existing resources (labour, capital equipment, and technological and entrepreneurial know-how) without generating inflation pressures". The Bank of Canada (2012) underlines the importance of the output gap as a source of inflationary pressures: "When demand for goods and services presses against the economy's capacity to produce, this tends to put upward pressure on prices. When demand is weak, it tends to push prices down. Put another way, when the rate of inflation *consistently* comes in higher than expected, it is typically a sign that demand for goods and services is pushing against the limits of capacity. When the rate of inflation consistently comes in lower than expected, it is generally a sign of weak demand and of spare or unused capacity".

The Bank of Canada has an inflation rate target of 2 percent. Its approach with regard to excess or insufficient demand is stated in the same document: "when demand is expected to exceed potential down the road (positive output gap), the Bank will typically raise interest rates to cool down demand and inflation pressures. When demand is expected to fall short of potential (negative output gap), the Bank will lower interest rates to boost demand and prevent inflation from falling below 2 percent." From this example we can already see how policymakers design ways to counter the volatility of the growth path, trying to make it as smooth as possible.

On the measuring of the output gap, the Bank of Canada underlines the difficulties arising from the fact that the potential output and the output gap cannot be observed directly: "Potential output and the output gap can only be estimated: for example, potential can be thought of as the product of trend labour input and trend labour productivity. Such estimates, however, are subject to considerable uncertainty, especially when the economy is coming out of a deep recession, during which major structural changes often take place".

On the measurement of the potential output and as a consequence the measurement of the output gap, there is a lot of available literature. In the case of Romania, Gălăţescu et al. (2007) estimate the potential output growth rates. For this, they use univariate and multivariate methods, such as: production function, filters with unobservable components, structural vector autoregressions.

Altăr et al. (2010) estimate the potential output and the output gap for Romania for the period 1998-2008. They identify the contribution of the production factors to the potential output. They also aggregate the results obtained by filtering methods in a consensus estimate.

There is also literature available dealing with concerns over the quality of the estimates and projections. Koske and Pain (2008) investigate on these topics. Marcellino and Musso (2010) explore the reliability of real-time estimates of the output gap for the euro area.

The quality and reliability of the estimates from the European Commission may be also an issue, considering the fact that the variables are estimated and not directly observed and that some of the values represent forecasted values of such estimates.

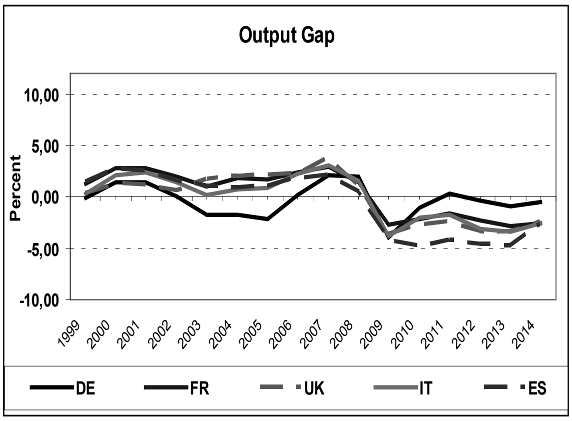
The data used are from the AMECO database of the European Commission and represent the gap between actual and potential gross domestic product at 2005 market prices, in percent. There are large differences in the levels of the output gap across countries, because of the differences in output. The fact that the output gap is expressed in percent insures comparability.

There are ten EU countries under scrutiny, five old members (Germany, France, UK, Italy and Spain) and five new members (Bulgaria, Czech Republic, Hungary, Poland and Romania). The frequency of the data is annual. The period is 1965-2014 for France, UK, Italy and Spain and 1999-2014 for the rest.

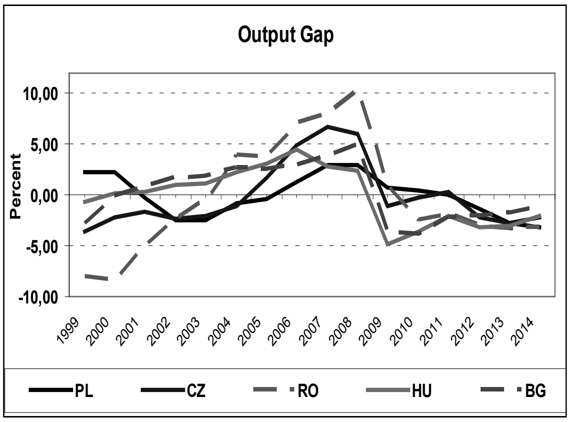
The data represent estimates of the European Commission (EC) and therefore the last values up to 2014 represent the EC view on future output gap developments. Also for the "historical" data, the output gap is not directly observable but calculated. For the purpose of this study we will mainly consider the period 1999-2014 for all countries, and 1965-2014 respectively, for the four countries with available data.

The graphs below plot the output gap series for the ten countries, divided in two subgroups, the old member states and the new member states, for the period 1999-2014.

Old member states



New member states



The pictures are scaled in the same way, to ensure comparability. It can be easily spotted that the output gap moves within a much tighter interval for the group of old member states, while the new member states display a higher volatility. Romania in particular has the highest amplitude of the variation, displaying both the minimum and the maximum.

The pictures also indicate more co-movement in the group of more advanced economies, while the emerging economies group is less compact. This is an indication of the stronger integration and synchronisation of business cycles among the group of old members compared to the group of new members.

These aspects can be further investigated by means of correlation matrix analysis.

The matrix for the output gap for the period 1999-2014.

Correlation matrix

1999-2014	BG	CZ	DE	ES	FR	IT	HU	PL	RO	UK
BG	**1.00**	**0.66**	**0.42**	**0.72**	**0.76**	**0.79**	**0.92**	**0.21**	**0.71**	**0.84**
CZ	**0.66**	**1.00**	**0.41**	**0.27**	**0.37**	0.49	0.60	0.59	**0.88**	0.50
DE	**0.42**	**0.41**	**1.00**	0.45	0.50	0.61	**0.39**	0.45	**0.07**	**0.42**
ES	**0.72**	**0.27**	0.45	**1.00**	**0.97**	**0.94**	**0.83**	**0.37**	**0.17**	**0.93**
FR	**0.76**	**0.37**	0.50	**0.97**	**1.00**	**0.98**	**0.86**	0.45	**0.25**	**0.95**
IT	**0.79**	0.49	0.61	**0.94**	**0.98**	**1.00**	**0.88**	0.48	**0.32**	**0.95**
HU	**0.92**	0.60	**0.39**	**0.83**	**0.86**	**0.88**	**1.00**	**0.31**	0.59	**0.94**
PL	**0.21**	0.59	0.45	**0.37**	0.45	0.48	**0.31**	**1.00**	**0.31**	**0.40**
RO	**0.71**	**0.88**	**0.07**	**0.17**	**0.25**	**0.32**	0.59	**0.31**	**1.00**	0.43
UK	**0.84**	0.50	**0.42**	**0.93**	**0.95**	**0.95**	**0.94**	**0.40**	0.43	**1.00**

It is possible to extract valuable information by looking at the correlation matrix of the output gap for the selected countries. The high and low correlations are highlighted. In order to establish what is a high correlation, what is a medium one and what is a low correlation, we consider the table below, for the case of 16 observations:

n	df	p value	t	r
16	14	0.1	1.762	**0.426**
16	14	0.01	2.98	**0.623**

The interpretation of the values in the table is as follows:

- for values between [0,0.426), the correlation is low, the probability is lower than 90%;

- for values between [0.426,0.623), the correlation is medium, with a probability of at least 90% but lower than 99%;

- for values between [0.623,1], the correlation is high, with a probability of at least 99%, with a significance level equal to or better than 1%.

All correlations are positive and many of them are strong. Some correlations are almost perfect, like the bilateral correlations among the group Spain, France, Italy and the UK. It is interesting that Germany, which is also part of the old member states group, does not display very high correlations either with the other old members or with the new members. As can be observed also in the plot, it seems that Germany has followed a somewhat different path for the output gap compared to the other countries, with negative values in a period when most countries were booming, before the recent crisis started.

The new member states do not generally display such high correlation coefficients as the old members, with the exception of Hungary and Bulgaria. Otherwise, a strong correlation can be seen between the Czech Republic and Romania. Poland has no strong correlation, while the smallest correlation coefficient is the one between Germany and Romania, only 0.07.

It is interesting and worth looking at these correlations into more detail, since a lot of information can be derived from them. A few striking features can be underlined. For example, Germany's business cycles seem to be out of synchronization with the ones from the rest of the analysed countries. This is unusual considering how large the weight of Germany is in the European economy and the fact that many countries are influenced by the evolutions in Germany via trade and other channels. It is strange that the UK and Germany display relatively low co-movement, while the UK and Bulgaria seem to be much closer from this point of view. Similarly, it is unusual for a country that has a lot of trade with Germany, namely Romania, to be practically uncorrelated from the point of view of the business cycle. This is however observed over a limited time frame and it is also true that the German economy is a very specific case and it is not necessarily too similar to the ones of other old member states. A detailed analysis as to why does Germany behave differently is highly relevant, but it is not in the scope of this article.

We also consider the period 1999-2011, and the correlation matrix is presented in the next table. The correlation coefficients are quite close to the coefficients for the period 1999-2014.

Correlation matrix

1999-2011	BG	CZ	DE	ES	FR	IT	HU	PL	RO	UK
BG	**1.00**	0.61	0.42	0.68	0.75	0.78	0.91	0.03	0.68	0.84
CZ	0.61	**1.00**	0.40	0.09	0.21	0.37	0.53	0.52	0.87	0.38
DE	0.42	0.40	**1.00**	0.49	0.59	0.72	0.41	0.50	0.05	0.46
ES	0.68	0.09	0.49	**1.00**	0.98	0.92	0.78	0.08	0.03	0.90
FR	0.75	0.21	0.59	0.98	**1.00**	0.97	0.83	0.12	0.11	0.93
IT	0.78	0.37	0.72	0.92	0.97	**1.00**	0.84	0.20	0.21	0.92
HU	0.91	0.53	0.41	0.78	0.83	0.84	**1.00**	0.06	0.55	0.92
PL	0.03	0.52	0.50	0.08	0.12	0.20	0.06	**1.00**	0.20	0.10
RO	0.68	0.87	0.05	0.03	0.11	0.21	0.55	0.20	**1.00**	0.35
UK	0.84	0.38	0.46	0.90	0.93	0.92	0.92	0.10	0.35	**1.00**

The data samples have 13 observations and in order to establish the strong, medium and low correlations, we consider the table below.

n	df	p value	t	r
13	11	0.1	1.795	**0.476**
13	11	0.01	3.11	**0.684**

The interpretation is quite similar to the case before, the values are only slightly different. The correlation matrix has highlighted strong and low correlations, according to the values of the table. In this case Germany is strongly correlated with Italy.

We try to make a ranking of the most stable economies from the point of view of the output gap. The next table considers different indicators calculated for the period 1999-2014, with the first place depicting the most stable economy, and the last place the most unstable economy. For two indicators the ranking of the countries is similar, while for the third one it is slightly different.

In an ideal state, the output gap should be zero, therefore we sum up the absolute values of the deviations from this ideal state and define it as a Stability Indicator (SI).

$$SI = \sum_{i=1}^{n} abs(output\_gap_i)$$

According to this way of ranking, Germany has the most stable economy, followed by Poland. The ranking of Poland is an interesting result, and we may make a reference to the fact that Poland has avoided recession during the current crisis, which may have had an important impact on the actual output not drifting away much from the potential output. Seven countries under scrutiny are relatively close to each other and therefore distributed over a relatively narrow range. Romania is clearly an outlier, with a value of the indicator which suggests a lot of instability and possibly special circumstances in comparison to the other countries taken into consideration.

When considering the standard deviation, the situation looks very similar.

An additional indicator of stability is the Mean Absolute Deviation (MAD). According to the MathWorks Documentation Center, MAD is defined as:

$$MAD = \frac{1}{n}\sum_{i=1}^{n} abs(output\_gap_i - \overline{output\_gap})$$

The next table also depicts the ranking according to the Mean Absolute Deviation, which is largely in line with the previous ranking, with two exceptions: France and the United Kingdom change places and also the Czech Republic and Spain, respectively.

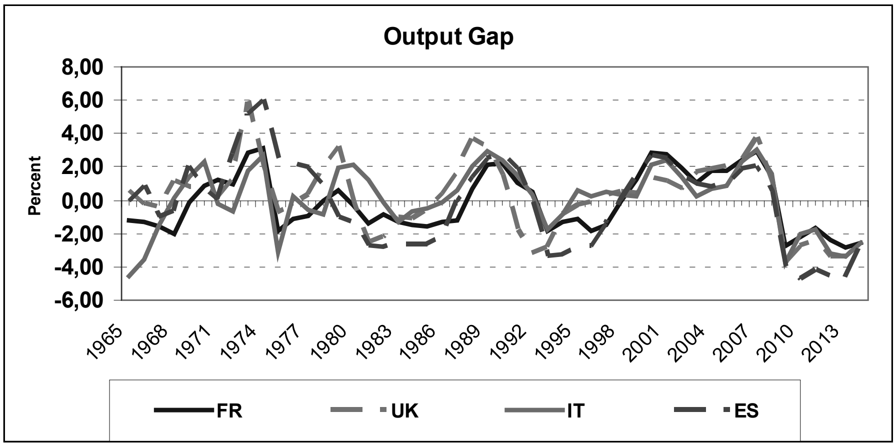
Mean Absolute Deviation

	SI	Standard deviation			MAD
Germany	19.78	1.61		Germany	1.23
Poland	26.65	2.04		Poland	1.67
Italy	31.50	2.30		Italy	2.00
United Kingdom	34.26	2.45		France	2.07
France	34.46	2.45		United Kingdom	2.17
Hungary	36.90	2.77		Hungary	2.32
Bulgaria	38.79	2.78		Bulgaria	2.42
Spain	40.48	2.96		Czech Republic	2.53
Czech Republic	41.12	3.27		Spain	2.68
Romania	72.08	5.50		Romania	4.43

Taking a look at the period 1965-2014

For four countries (France, United Kingdom, Italy and Spain) we have available data going back to 1965 (50 observations). This allows us to take a closer look and try to investigate more about the series in the remainder of the analysis.

The next figure plots the output gap series for France, UK, Italy and Spain.



The correlation matrix for the four countries, for the period 1965-2014.

1965-2014	FR	UK	IT	ES
FR	**1.00**	0.71	0.77	0.80
UK	0.71	**1.00**	0.64	0.74
IT	0.77	0.64	**1.00**	0.57
ES	0.80	0.74	0.57	**1.00**

The values used for determining high, medium and low correlations for series of 50 observations:

n	df	p value	t	r
50	48	0.1	1.679	**0.236**
50	48	0.01	2.69	**0.362**

All correlations are positive and strong according to our criteria, inline with the correlations in the period 1999-2014. However, the levels are lower for the whole period 1965-2014, which is an interesting result.

In the following we take a closer look at this by proposing an additional split of the data: the period 1965-1989 and 1990-2014 respectively, each one containing 25 observations. There are more reasons to consider such a split, such as the fact that the year 1990 can be regarded as a point where a lot of structural changes start to take place due to the fall of communism in Eastern Europe, and at the same time the process of European integration begins to accelerate, due to political and economic reasons. Moreover, the two sub-samples are equal and comparison is facilitated.

The values used for determining high, medium and low correlations for series with 25 observations are depicted in the table below.

n	df	p value	t	r
25	23	0.1	1.717	**0.337**
25	23	0.01	2.806	**0.505**

The two correlation matrices are presented in the next two tables.

Correlation matrix
period 1965-1989

1965-1989	FR	UK	IT	ES
FR	**1.00**	0.70	0.62	0.69
UK	0.70	**1.00**	0.44	0.64
IT	0.62	0.44	**1.00**	0.23
ES	0.69	0.64	0.23	**1.00**

Correlation matrix
period 1990-2014

1990-2014	FR	UK	IT	ES
FR	**1.00**	0.82	0.91	0.96
UK	0.82	**1.00**	0.85	0.79
IT	0.91	0.85	**1.00**	0.90
ES	0.96	0.79	0.90	**1.00**

For the period 1965-1989, several correlations remain strong, and there is also a low correlation between Italy and Spain.

For the period 1990-2014, all correlations are strong and higher than the ones for the period 1965-2014.

These results are interesting and confirmed also by the shape of the output gap plot. They can be considered valuable evidence that these European economies are moving together in a much more synchronised way and closer over time. It is an indication of the fact that there is indeed European integration and it becomes stronger with time.

Another aspect worth investigating is the frequency of the economic cycles. It is interesting to approximate how long does such a cycle last for, on average. We consider an economic cycle to be composed of a boom period, in which the output gap should be positive, followed by a bust phase in which the output gap becomes negative, with the end of the cycle being a bounce-back of the output gap up to the zero level.

According to this definition, we obtain the results from the next table:

	FR	UK	IT	ES
Changes in the sign of the output gap	8	9	12	8
Number of cycles	4	5	6	4

These results imply that, on average, for our dataset of four countries, an economic cycle lasts for 10.5 years, which is inline with intuition.

The way the values are distributed may provide additional information. We make a convention to depict the number of values that exceed certain thresholds, as follows (all in percent): values that are greater than 1, values that are greater than 2, values that are greater than 3 and respectively values that are lower then -1, -2, and -3 accordingly.

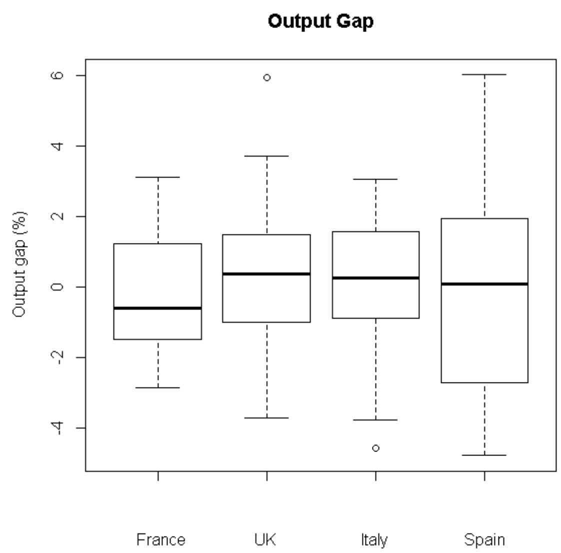
For example, the values that exceed 1 also contain the values that exceed 2 and 3, while the values lower than -1 also contain the values lower than -2 and -3. The results:

Values exceeding selected thresholds

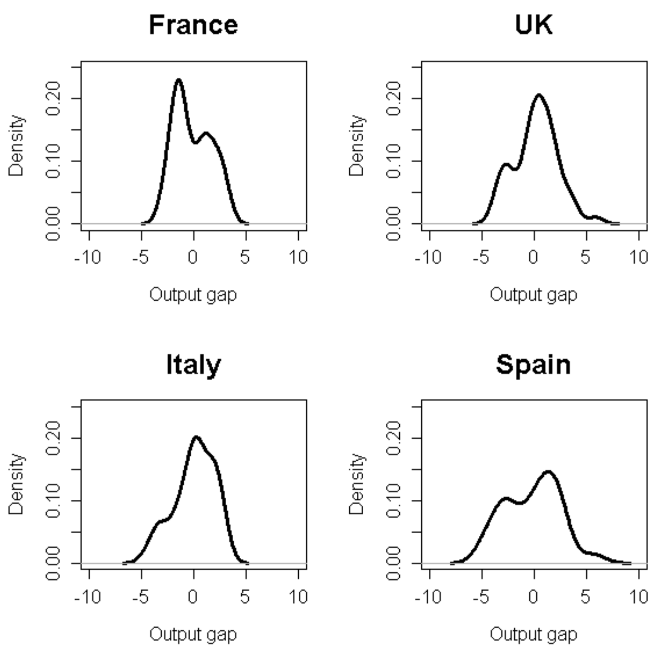
>3 %	1	5	1	2
>2 %	8	8	10	11
>1 %	16	18	17	18
	FR	**UK**	**IT**	**ES**
<-1 %	23	12	12	20
<-2 %	6	10	7	16
<-3 %	0	4	6	7

The UK has the most positive outliers above the 3% threshold, namely 5, while the most negative outliers below the -3% threshold belong to Spain. It is interesting to see the case of Spain with regard to the negative values, but actually 5 of the 7 negative outliers are recorded in the period 2009-2013, which means that the particular situation is mostly due to the recent crisis.

In order to have a closer look, it is useful to generate the boxplots of the output gap series for the four countries (the next figure). As it can be observed, France has the most compact distribution, while the one of Spain is the most spread out. However, the median of Spain is closest to zero. There are two outliers, a positive one for the UK and a negative one for Italy.

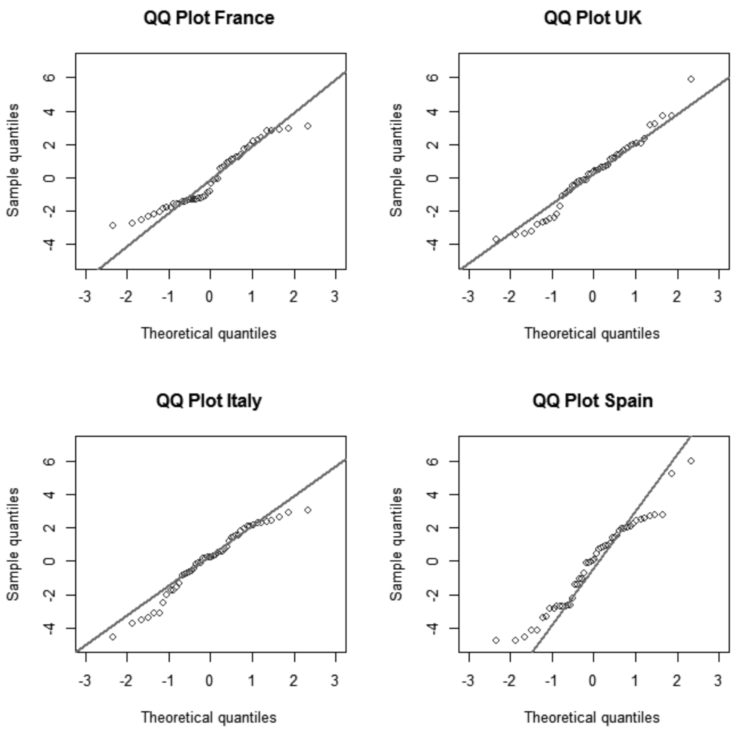


The figure above is done in R with the help of examples from the Quantnet project (http://sfb649.wiwi.hu-berlin.de/quantnet/index.php?p=start) and the guide “Introduction to R” by Marlene Müller, Fraunhofer Institut Techno- und Wirtschaftsmathematik.



The density estimates are presented in the figure above. Another graphical indication of the way the values are distributed can be displayed by means of a QQ plot, in the figure below. The two figures are done in R with the help of examples from the Quantnet project: http://sfb649.wiwi.hu-berlin.de/quantnet/index.php?p=start

The QQ plot compares the sample quantiles of the data for the four countries with the theoretical quantiles of the normal distribution. Ideally, if the sample values are normally distributed, they should be scattered along the line. We have at least three countries that fit the normal distribution quite well, namely France, the UK and Italy. Of these, the UK sample is the closest. Spain seems to be less close to the theoretical normal distribution and this is in line with the information we have gathered so far.



In order to establish the normality of the sample data in a quantitative way, we are going to perform a normality test, namely the Jarque-Bera test.

The results are available in the next table.

	FR	UK	IT	ES
X-squared	3.8074	0.1246	2.9357	0.9114
df	2	2	2	2
p-value	0.1490	0.9396	0.2304	0.6340

The Chi-squared distribution is used, with two degrees of freedom, because two parameters are being estimated, namely skewness and kurtosis. The critical value at 5% significance level is 5.99. The null hypothesis is that the data is normally distributed, while the alternative hypothesis is the data is not normally distributed.

From the values above we can see that for all four countries there is not enough evidence to reject the null hypothesis. Therefore, we consider the data for all countries to be normally distributed.

Before concluding, it is worth investigating another statistical issue, namely the reliability of the Jarque-Bera test in the case of small samples. We can take for instance 400 simulations of samples of 50 observations each, containing random normal numbers. In about 5% of the cases we expect to reject the normality assumption, which means about 20 cases. We can study the behaviour and reliability of the Jarque-Bera test in small samples by looking at the simulation results.

We generated a matrix of dimensions (50,400), containing 400 vectors each containing 50 random normal numbers. We performed the Jarque-Bera test for the 400 simulations and we accepted the null hypothesis in 387 cases and rejected the null hypothesis in 13 cases. The 13 rejections are well below our expected 20 rejections. Therefore, according to this simulation exercise, the Jarque-Bera test is suitable for determining normality in small samples of 50 observations.

Conclusion

The amplitude of the movement of the economies around the equilibrium point is generally higher for the group of new member states in comparison with the group of old member states, period 1999-2014. However, Poland displays robust stability and is second after Germany in rankings of the stability of the ten states, while Spain is less stable than several of the new member states (Poland, Hungary, Bulgaria in one ranking and Poland, Hungary, Bulgaria and the Czech Republic in another ranking).

An interesting result is that there exist many strong positive correlations of the output gap for various countries; this suggests that business cycles are synchronized to a large extent. Moreover, of particular relevance is the analysis done for France, UK, Italy and Spain, which considers the evolution of the correlations over time. In our framework, the mentioned countries become more correlated with time, which implies that business cycles become more synchronized in the more recent period. This is strong evidence of deeper European economic integration and has many possible implications. An important implication would be related to the concept of optimal currency area, which requires countries in a currency area, such as the euro area, to have economies that move together and minimize asymmetric shocks.

Another useful result is that, according to our ad-hoc defined methodology, for the case of France, UK, Italy and Spain, period 1965-2014, an economic cycle lasts for 10.5 years.

Finally, considering the period 1965-2014, the output gap data for France, UK, Italy and Spain is normally distributed. This result is obtained by using the Jarque-Bera test. Additionally, the reliability of this test for small samples is confirmed by a simulation exercise.

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