

ANALYSIS OF THE EFFECTS OF THE EURO CHANGEOVER ON THE INFLATION AFTER 2007

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Abstract

In this paper we study the so-called changeover effect in six states that adopted Euro after 2007. We developed the new model for computation of the changeover effect. It is based on the comparison of the inflation in state that adopted Euro with average inflation in other states that are geographically near the evaluated state and have similar economics. To capture long-term impact of Euro introduction on inflation we monitored the inflation for 18 months: 6 months before Euro introduction and 12 months after it.

We observed that the biggest changeover effect in 18 months was in Estonia. The inflation was 2.53% bigger than the average inflation in benchmark states. Similarly, the changeover effect in Malta was 1.08%, 1.86% in Slovenia and 0.93% in Cyprus. We did not observe any changeover effect in Latvia nor Slovakia.

We also formed three regression models to predict the behavior of inflation in 2015. We used them to estimate the total inflation in Lithuania, the last state that adopted Euro on 1 January 2015. The linear model gives interval estimation of the total inflation in 18 months (1.27%; 4.76%) and logarithmic model gives interval (-0.09%; 3.34%).

Keywords: euro, currency changeover, inflation, regression analysis.

JEL Classification: E31, E47, E50, F36

1. Introduction

The Euro is the currency used currently by the 19 of the 28 member states of the European Union. It was introduced on 1 January 1999. Euro coins and banknotes were put into circulation in 12 states (Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain) on 1 January 2002. Later, six other states adopted the Euro: Slovenia on 1 January 2007, Malta and Cyprus on 1 January 2008, Slovakia on 1 January 2009, Estonia on 1 January 2011 and Latvia on 1 January 2014. The last country which adopted euro is Lithuania on 1 January 2015.

Change in the currency may have an impact on inflation, the so-called “changeover effect”. The conversion to the new currency increases the prices and the reason cannot be simply explained by, for example, rounding of the prices only.

Before the Euro adoption the economists expected that Euro changeover in 2002 would have no or only very small effect on inflation. After 2002 many research papers showed that there was an impact of the changeover on prices and although it was close to negligible, it was significantly larger than what most central banks and economists had expected. These studies commonly found that price increases were limited to certain categories of goods and services and that their impact on total inflation was modest. In most cases the estimate of the effect of changeover was from 0.2% to 0.3% (Hüfner and Koske, 2008), which is in line with results estimated by Eurostat for the whole Euro Area (table no. 1).

Table no. 1: Inflationary impact of the euro changeover

Country	Sample period	Estimated impact on consumer prices [%]
Netherlands	01/2002	0.2 – 0.4
Portugal	01/2002 – 03/2002	0.24
Belgium	06/2001 – 04/2002	0.18
Germany	01/2002	0.3
Euro area members	12/2001 – 01/2002	0.2 – 0.61
Euro area aggregate	12/2001 – 01/2002	0.09 – 0.28
Malta	12/2007 – 01/2008	0.2 – 0.3

Source: (Hüfner and Koske, 2008)

In contrary to these results, many European consumers felt that the Euro introduction had led to much higher increase in prices (Eife and Coombs, 2007). In subsequent studies numbers of conjectures have been formulated to explain the discrepancy between the official statistics and inflation perceptions. It was usually explained by the disproportionate influence of a few industry prices on individual perceptions and by emphasizing the role of psychological factors (Angelini and Lippi, 2007). Difference between perceived and official inflation in Euro Area is in fig. no. 2.

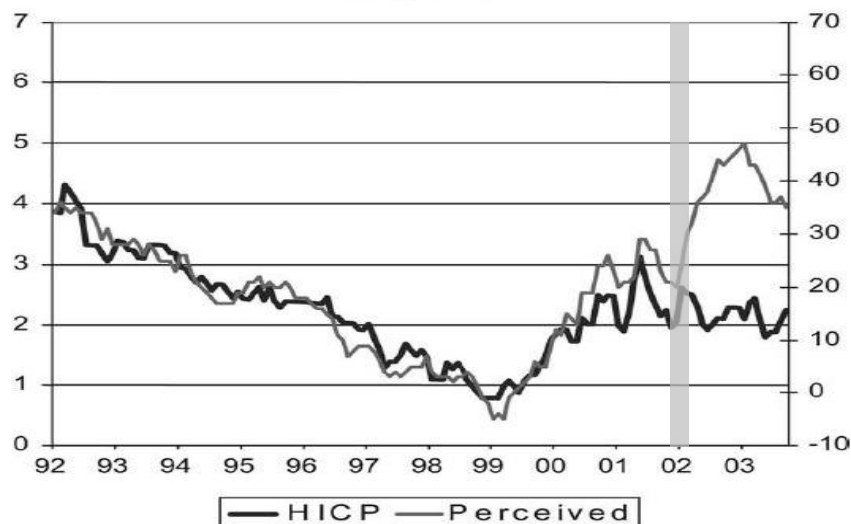


Fig. no 2: Perceived and official inflation in Euro Area

Source (Angelini and Lippi, 2007)

However, these papers did not provide an answer to whether the calculated price increase was measured correctly during the changeover. Rather, they follow the assumption that the statistics are correct. The most difficult task faced by researchers is the absence of reliable alternative price level measures. Some of the studies (Jemec, 2010), (Hüfner and Koske, 2008) compare the inflation in selected country to the average inflation of the EU or entire Eurozone while others take into account the inflation in a particular country only a few months before and a few months after the Euro introduction (table no. 1).

This approach cannot be used in all cases. Slovakia, for example, joined the Eurozone in 2009, when financial crisis has considerably reduced the inflation. It is not adequate to compare the inflation in Slovakia with all other states of Eurozone or EU since the impact of the financial crisis was not of the same extent in all states of EU or Eurozone.

In this paper we compare the inflation in the state that introduced the Euro with only several selected countries. We have chosen states that are geographically close to the evaluated state or states with similar levels of economics (similar GDP per person).

Also, governments were making efforts to prevent unjustified price increases, especially in the moment of Euro introduction. That is why we do not monitor the inflation in several months only, but consider much longer time period: 6 months before and 12 months after the Euro adoption. This should reveal the possible price increases over larger period of time.

2. Euro changeover effect

We study the effect of the Euro introduction on inflation in six countries that adopted Euro after 2007. We divided them into three groups (the year of Euro introduction is in the brackets).

- **Group South:** Cyprus (2008), Malta (2008), Greece, Italy, Portugal, Spain and Slovenia
- **Group Central:** Slovenia (2007), Slovakia (2009), Austria, Croatia, Czech Republic, Hungary, Italy, Poland and Switzerland
- **Group North:** Estonia (2011), Latvia (2014), Denmark, Finland, Lithuania, Poland and Sweden.

We measure the price increases by harmonized indices of consumer prices (HICP). The HICPs are economic indicators constructed to measure the changes over time in the prices of consumer goods and services acquired by households. Data were collected from Eurostat database.

We use two measures to detect the unjustified price increases on money changeovers. First, we plot the chart with monthly rates of inflation of all evaluated states. This way we compare the time changes in inflation over period of 18 months. Second, we calculate the average inflation in the evaluated state during 18 months and compare it with the average inflation in other selected states. The average inflation is calculated by the formula for geometric average \bar{x}_g :

$$\bar{x}_g = \sqrt[n]{x_1 \cdot x_2 \cdot \dots \cdot x_n} = \sqrt[n]{\prod_{i=1}^n x_i} \quad (1)$$

where x_i is the monthly inflation and n is the number of months.

2.1. Group South

In January 2008, Cyprus and Malta joined the Euro zone. We show (fig. no. 2) monthly rate of change of inflation in these states and other selected states: Greece, Italy, Portugal, Spain and Slovenia.

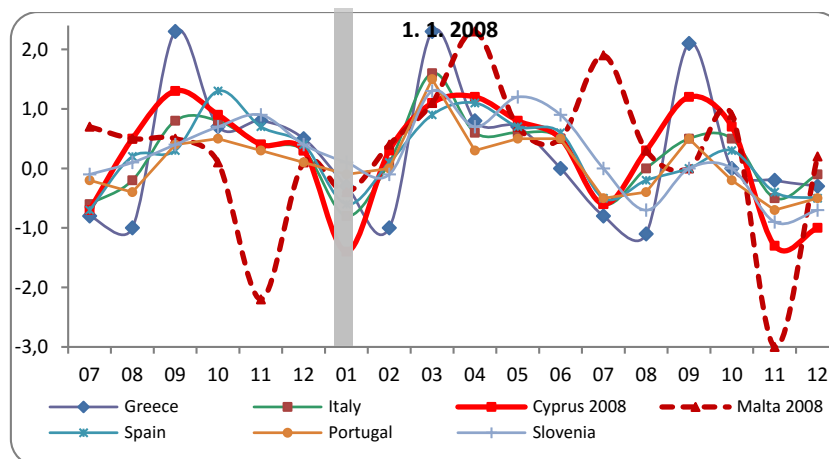


Fig. no. 2: Monthly rate of change of inflation, Group South (Source: own research)

It is not possible to see any big differences between inflation in Cyprus and Malta and other states. In Malta, the inflation was lowest in October and November 2007 and in November 2008. In contrary, in July 2007 and in April, July, October and December 2008 the values of inflation were the highest amongst all evaluated states. In Cyprus was inflation the lowest in January and December 2008. These data do not provide clear evidence of higher inflation in Malta and Cyprus compared to other selected states. That's why we calculated using formula (1) the average inflation in these states.

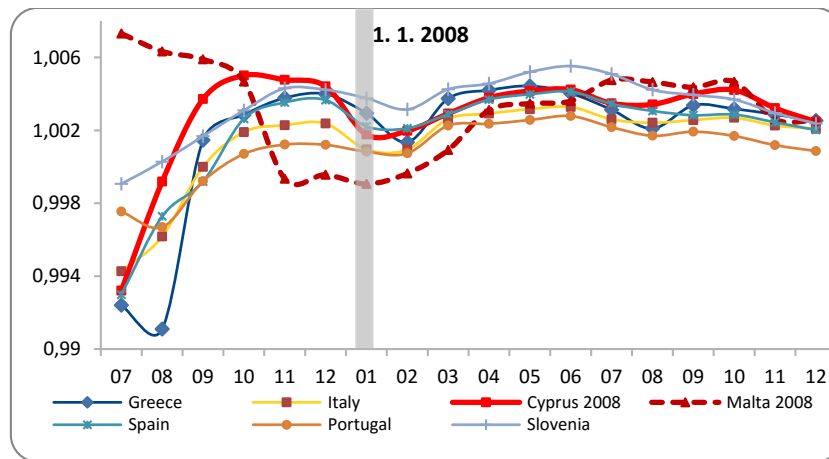


Fig. no. 3: Average inflation, Group South (Source: own research)

We see (fig. no. 3) that the average inflation in Malta and Cyprus is slightly higher than in other states. For example, the average monthly inflation in Malta was smaller than in other states from the November 2007 to March 2008. However, it grew in next months and after 18 months the average monthly inflation was 1.00256. The average inflation in Cyprus was 1.00247, while the average inflation in other 5 states was 1.00198. It means that the total inflation in 18 months was 4.55% in Cyprus and 4.70% in Malta, but the average of total inflation of the remaining states was only 3.62%.

The total inflation after 18 months in Cyprus was higher than average of total inflations in remaining states; the ratio of these total inflations is $\frac{1.0455}{1.0362} = 1.009$. The total inflation after 18 months in Malta was also higher than average of total inflations in remaining states and the ratio of these total inflations is $\frac{1.0470}{1.0362} = 1.0104$.

2.2. Group Central

Slovenia adopted Euro in January 2007. We show (fig. no. 4) monthly rate of change of inflation in Slovenia and in Czech Republic, Croatia, Italy, Hungary, Austria, Poland, Slovakia and Switzerland.

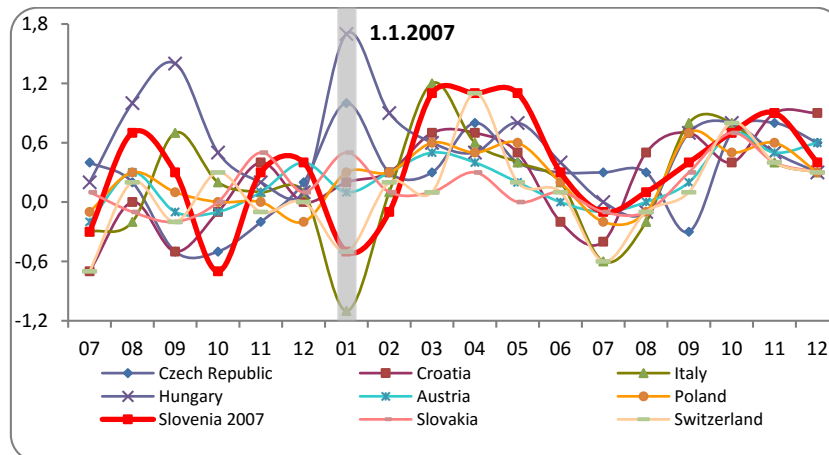


Fig. no. 4: Monthly rate of change of inflation in 2007, Group Central (Source: own research)

The values of inflation in Slovenia are highest in May 2007 and lowest in October 2006 and in February 2007. The evolution of inflation over time in these states is shown in fig. no. 4.

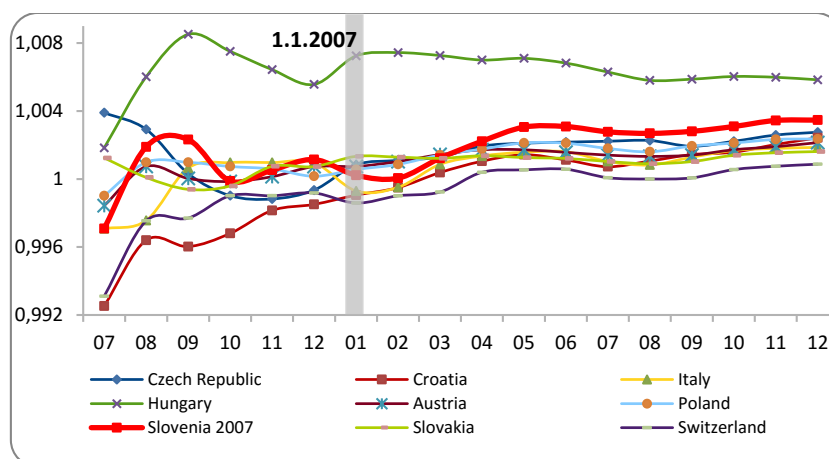


Fig. no. 5: Average inflation in 2007, Group Central (Source: own research)

The greatest average values of inflation are in Hungary (fig. no. 5). The second largest values are in Slovenia. The average inflation in Slovenia during 18 monitored months is 1.0034, while the average inflation of remaining states is 1.0024. The total inflation in Slovenia is 6.43% and the average of the total inflation in eight remaining states of Group Central is 4.57%.

The total inflation after 18 months in Slovenia was higher than average of total inflations in remaining states; the ratio of these total inflations is $\frac{1.0643}{1.0457} = 1.0178$.

Slovakia adopted Euro in January 2009. In fig. no. 6 there is the monthly rate of change of inflation in 2009 in the Group Central. The inflation in Slovakia is reaching moderate values.

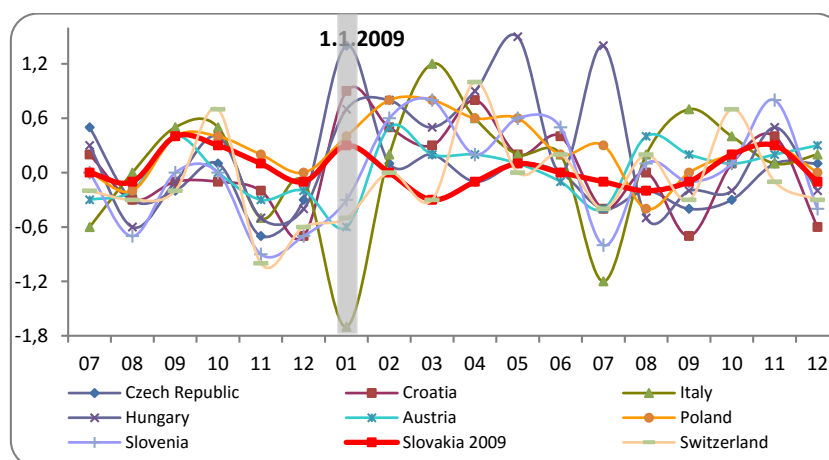


Fig. no. 6: Monthly rate of change of inflation in 2009, Group Central (Source: own research)

In fig. no. 7 there is the average inflation in Slovakia and in other states. The average inflation in Slovakia during 18 monitored months is 1.00042, while the average value in other eight selected countries is 1.00063. The total inflation in Slovakia is 0.75% and the average of total inflation in other states of Group Central is 1.14%.

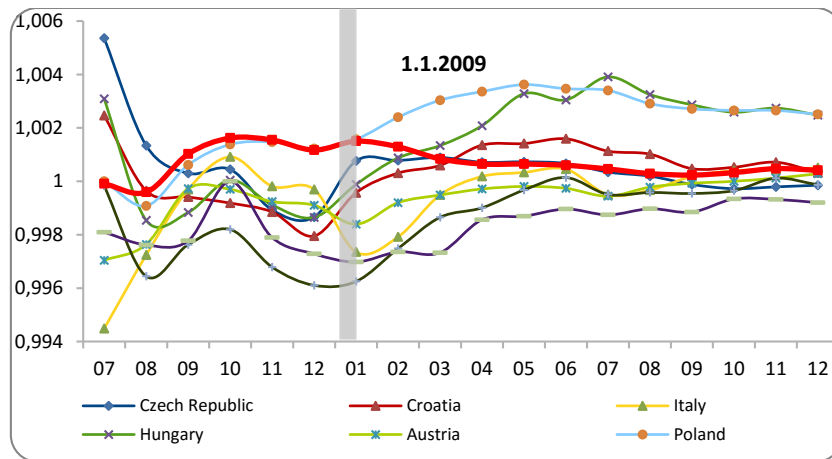


Fig. no. 7: Average inflation in 2009, Group Central (Source: own research)

Slovakia adopted Euro in 2009, when the impacts of the crisis have shown. The crisis reduced the inflation, but this effect had different levels in various countries. The total inflation in Hungary and Poland was higher than in other states of this group. It is difficult to analyze the effect of Euro introduction on inflation in Slovakia, but there is no clear evidence of higher inflation in Slovakia. The total inflation in Slovakia is actually smaller than average inflation.

The total inflation after 18 months in Slovakia was smaller than average of total inflations in remaining states; the ratio of these total inflations is $\frac{1.0075}{1.0114} = 0.9961$.

2.3. Group North

In this group there are also two states that adopted Euro. First was Estonia in January 2011. In fig. no. 8 there is monthly rate of change of inflation in Estonia, Denmark, Latvia, Lithuania, Poland, Finland and Sweden.

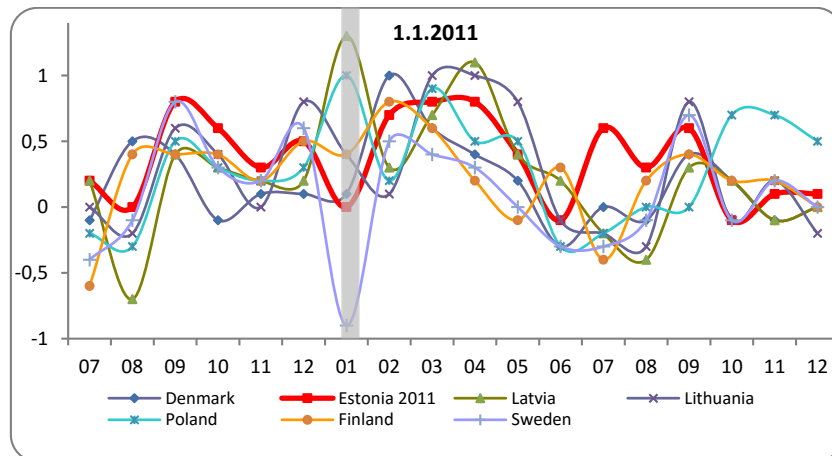


Fig. no. 8: Monthly rate of change of inflation in 2011, Group North (Source: own research)

The values of inflation in Estonia are higher than inflation in other states in October and November 2010 and in July and August 2011.

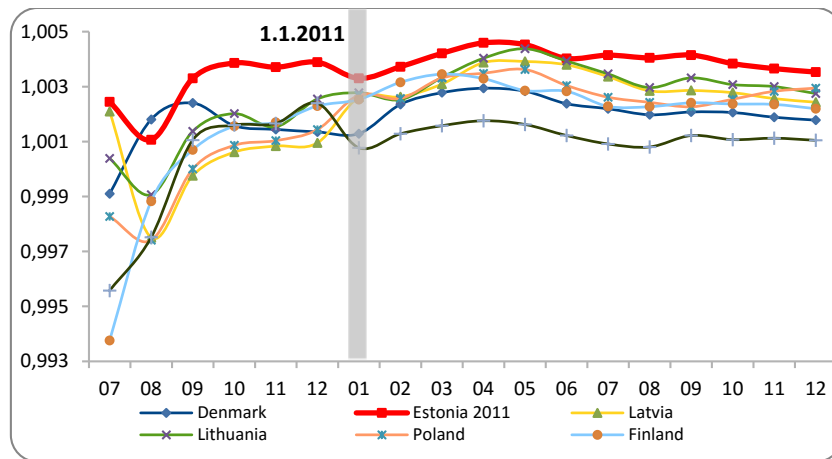


Fig. no. 9: Average inflation in 2011, Group North (Source: own research)

The average inflation in Estonia is the highest of all selected states (fig. no. 9). The average inflation in Estonia during 18 observed months is 1.0035 and in other 6 states is 1.0022. The total inflation in Estonia is 6.55% and the average of the total inflation in other states in this group is 4.02%.

The total inflation after 18 months in Estonia was higher than average of total inflations in remaining states; the ratio of these total inflations is $\frac{1.0655}{1.0402} = 1.0243$.

Latvia adopted the Euro in January 2014. In fig. no. 10 there is monthly rate of change of inflation in states of Group North.

The values of the inflation in Latvia were lowest in August 2013, August 2015 and in December 2014. The highest values were in October 2013, January 2014, April 2014 and in June.

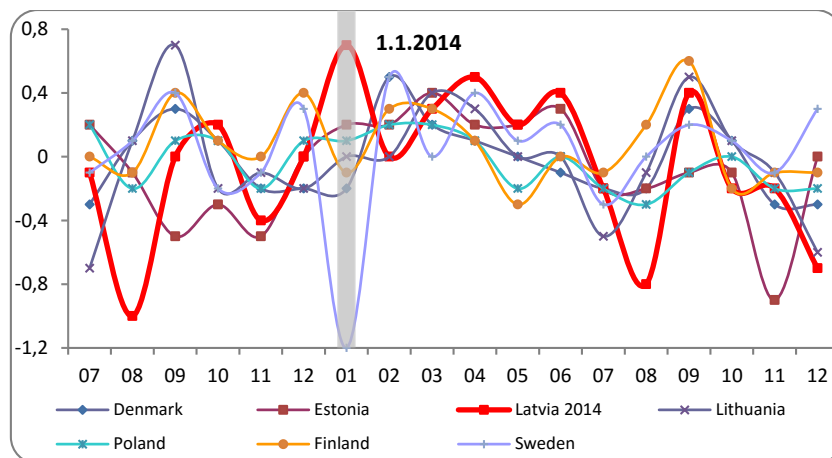


Fig. no. 10: Monthly rate of change of inflation in 2014, Group North (Source: own research)

The average inflation (fig. no. 11) in Latvia during 18 observed months is 0.999431 and in other six states it is 0.999975. The total inflation in Latvia is -1.02% and the average of total inflation in other states in this group is -0.04%.

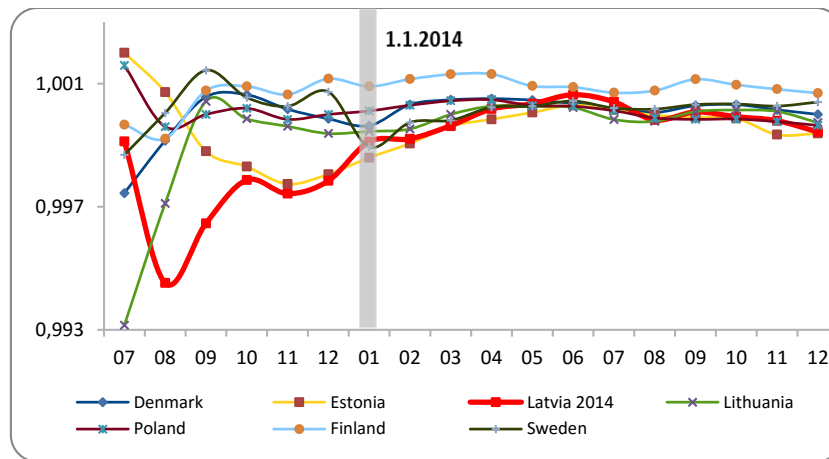


Fig. no. 11: Average inflation in 2014, Group North (Source: own research)

The total inflation after 18 months in Latvia was smaller than average of total inflations in remaining states; the ratio of these total inflations is $\frac{0.9898}{0.9996} = 0.9902$.

2.4. Changeover effect in states that adopted Euro after 2007

In the previous sections we compared the total inflation in states that adopted Euro to the average inflation in remaining states of the group. In four countries the inflation was higher than average inflation of remaining states and in two countries the inflation was smaller than average inflation. The highest inflation ratio was in Estonia and smallest ratio was in Latvia (table no. 2).

Table no. 2: Total inflation and inflation ratio

State	Total inflation of evaluated state [%]	Average of total inflations [%]	Difference of inflations [%]	Inflation ratio
Cyprus	4.55	3.62	0.93	1.009
Malta	4.70	3.62	1.08	1.0104
Slovenia	6.43	4.57	1.86	1.0178
Slovakia	0.75	1.14	-0.39	0.9961
Estonia	6.55	4.02	2.53	1.0243
Latvia	-1.02	-0.04	-0.98	0.9902

Source: own research

We use two values of inflation ratio of Estonia and Latvia for estimation of inflation in Lithuania for period of 12 months after euro adoption in 2015.

3. Mathematical Models

To predict the progress of inflation in Lithuania, we study average inflation in the Group North. We create several regression models that describe average inflation from July 2013 to December 2014. We use these regression models for prediction of the average inflation in Group North in 2015.

We formed 5 regression models: linear, polynomial, exponential, logarithmic and power. Since exponential and power models give almost identical results to linear model, we use only linear model. In table no. 3 there are regression equations and the coefficients of determination for selected models.

Table no. 3: Regression models

Model	Regression equation	Coefficient of determination
linear	$y = 0,00006943x + 0,99919758$	$R^2 = 0,51479907$
polynomial	$y = -0,000011x^2 + 0,00027847x + 0,9985$	$R^2 = 0,79052757$
logarithmic	$y = 0,00053828\ln(x) + 0,9987688$	$R^2 = 0,69800372$

Source: own research

Since all three coefficients of determination are sufficiently high, we can use all these models for an estimation of inflation in Group North (fig. no 12). The greatest growth of inflation is predicted by the linear model. Based on this model the total increase of prices from July 2013 to December 2015 would be 2.27 %. The logarithmical model predicts that the total increase of prices from July 2013 to December 2015 will be 0.89 %. The polynomial model forecasts decrease of the total prices by 5.78 %.

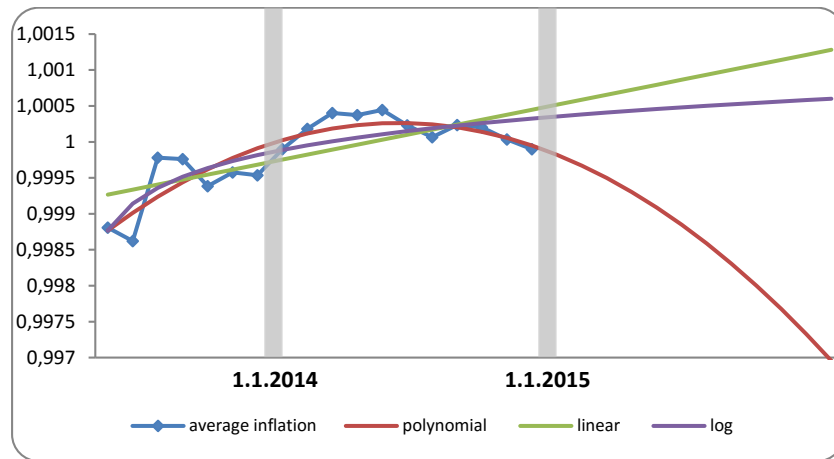


Fig. no. 12: Inflation estimation of Group North [07/2013 – 12/2015] (Source: own research)

In the Group North the inflation ratio of Estonia is 1.0243. It means that total inflation in Estonia during 18 months was 2.43% higher than average of total inflations in remaining states of Group North. In contrary, inflation ratio of Latvia is 0.9902. It also means that total inflation in Latvia during 18 months was 0.98% smaller than average of total inflations of remaining states of Group North.

For each of our three regression models we use these two ratios to calculate the boundaries in which the estimated inflation of Lithuania should lie.

First, we calculated average inflation for 18 months for linear model by $\frac{\text{average inflation in December 2015}}{\text{average inflation in July 2014}} = \frac{1.00128}{1.000031} = 1.00125$. Total inflation in 18 months is $(1.00125)^{18} = 1.02273$, which means that total inflation for 18 months is 2.27%.

By multiplying the total inflation with the highest and the smallest inflation ratio we get interval estimation $(1.02273 \cdot 0.9902; 1.02273 \cdot 1.0243) = (1.0127; 1.0476)$. The interval estimation of total inflation for polynomial and logarithmic models are calculated the same way. The results in [%] are shown in table no. 4.

Table no. 4: point and interval estimation of total inflation

Model	Point estimation [%]	Interval estimation [%]
linear	2.27	(1.27; 4.76)
polynomial	-5.78	(-6.70; -3.49)
logarithmic	0.89	(-0.09; 3.34)

Source: own research

From values in table no. 4 we can see that these three models give different interval estimations. Based on the linear model, the total inflation in Lithuania for 18 months (from July 2014 to December 2015) will be between 1.27% and 4.76%. Similarly, the logarithmic model predicts the total inflation in Lithuania to be between -0.09 % and 3.34 %.

The coefficient of determination is the highest for polynomial regression model (table no. 4), that is why this model should most accurately predict the inflation in Group North in 2015. The interval estimation of total inflation in Lithuania is between -6.70 % and -3.49 %. However, the values calculated by this polynomial model do not seem to be economically realistic. From this point of view other two interval estimations calculated from linear and logarithmic regression models give more sensible results.

Our conclusions were confirmed by data currently available. At time of writing this article values of inflation for the first four months of 2015 were available in the Eurostat database. We calculated the average inflation in Group North for January 2015 to April 2015 and added these four values to the graph, as shown in fig. no.13. It is apparent that polynomial model doesn't correctly describe the behavior of average inflation in 2015.

In spite of the fact that the coefficient of determination is the highest for polynomial regression model, linear and logarithmic models probably better describe average inflation in 2015.

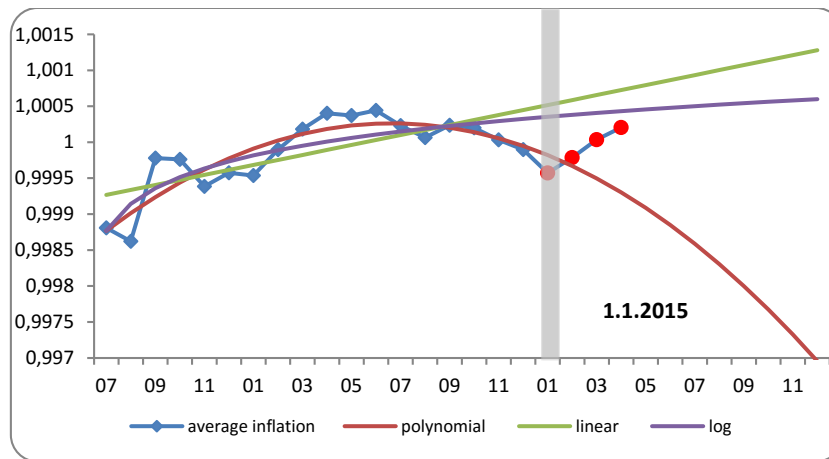


Fig. no. 13: Inflation in Group North [07/2013 – 04/2015] (Source: own research)

4. Results

In the first part of this paper we studied the so-called changeover effect. We compared the inflation in six states (Cyprus, Malta, Slovenia, Slovakia, Estonia and Latvia) that adopted Euro from 1 January 2007 to 1 January 2014 with other states that are geographically near the evaluated states or have similar economics. We divided them into three groups. To capture long-term impact of Euro introduction on inflation, we monitored values of inflation for 18 months: 6 months before Euro introduction and 12 months after it.

In four evaluated states (Cyprus, Malta, Slovenia and Estonia) the total inflation was higher than the average inflation of the other states in the group. The biggest difference between total and average inflation was in Estonia. Total inflation in Estonia for 18 months was 6.55 %, while the average inflation of remaining states of Group North was 4.02 %.

In two evaluated states (Slovakia and Latvia) the total inflation was smaller than the average inflation in the group. Slovakia adopted the Euro in 2009, when the impacts of the crisis had different effects in different countries. That's why it is difficult to analyze the effect of euro introduction on inflation in Slovakia. From statistical point of view, there is no clear evidence of changeover effect in Slovakia.

The last evaluated state was Latvia. The value of total inflation was -1.02 % and average inflation of other states in group was -0.04 %. It means that during 18 months the prices in Latvia decreased by 1.02 % while the average decrease of prices was only 0.04%. We did not observe any changeover effect in Latvia neither.

In second part of this paper we studied the average inflation in Group North. We formed three regression models which predict the behavior of inflation in 2015. The highest coefficient of determination 0.79 has polynomial model. Coefficients of determination for linear and logarithmic models are 0.51 and 0.70, respectively.

The function of polynomial model is concave and decreasing, that's why we cannot consider this model to be economically relevant. This conclusion is supported by the first four values of average inflation in 2015 (fig. no. 13). In this case the regression model with the highest coefficient of determination is not appropriate for estimation of average inflation. Although the statistical methods are powerful and useful tools, they have to be used in accordance with economic requirements and conditions.

As we previously mentioned, the last state that adopted the euro so far is Lithuania in 1 January 2015. We cannot measure the changeover effect in this state because our proposed method requires 12 values of inflation after euro adoption.

We used three calculated regression models for estimation of average of total inflation in the Group North in December 2015. Then we used the highest and the smallest values of inflation ratio of all states that adopted Euro after 2007 to calculate the boundaries of total inflation in Lithuania. The linear and logarithmic models give similar interval estimation of total inflation for 18 months: (1.27; 4.76) for linear model and (-0.09; 3.34) for logarithmic model. As we already mentioned, interval estimation (-6.70; -3.49) given by polynomial model is not economically correct.

5. Conclusion.

Despite the expectations of economists that the Euro changeover would have no effect on inflation, several studies showed that there actually was small impact of the changeover on prices. For calculation of this effect they used different approaches. We developed a new model based on long-term comparison of inflation in evaluated state to the inflation in other selected countries. In compliance with previous results we observed the changeover effect in Cyprus, Malta, Slovenia and Estonia. The total inflation in 18 months in Cyprus was 0.93% bigger than the average of inflation in benchmark states. Similarly, it was 1.08% in Malta, 1.86% in Slovenia and 2.53% in Estonia.

We used data available in the Eurostat database to propose several regression models to predict the development of average inflation. We applied the inflation ratio to estimate the intervals in which the total inflation in Lithuania for 18 months will be located.

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