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SHORT TERM AGGREGATED SUPPLY CURVES FOR OECD COUNTRIES IN 1991 – 2013

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Abstract: Politicians used to determine such macroeconomic targets as GDP growth rate, inflation rate, unemployment rate. They are interested in relationships between: unemployment rate and GDP growth rate (the Okun's law), unemployment rate and inflation rate (the Philips curve) as well as between inflation rate and GDP growth rate (aggregate supply curve - SAS), put forth directly, eg. a straight line or a parabola, or indirectly, i.e. as a function Okun's with inserted Philips function. SAS derived from the Okun's and Philips curves estimated for OECD countries in the period 1991 to 2013 are analysed *vis a vis* curves reflecting direct relationships.

Keywords: Okun's law, short-term Philips curve, neutral inflation, short-term aggregate demand curve, B curve, OECD countries

INTRODUCTION

Economic policymakers determine usually a few strategic macroeconomic targets, for instance, the GDP growth rate, the inflation rate band, the range of the unemployment rate, the range of exchange rate, stability of public finances, improvement of infrastructure, increasing of living standards of citizens.

Majority (if not all) of these targets are expressed, directly or indirectly, in quantitative terms. Both macroeconomic policymakers and macroeconomic theoreticians are interested not only in the levels and dynamics of every of these targets but also in interdependencies between them, especially between GDP growth rate, inflation rate and unemployment rate. Relationships between two of the three are known as Okun's curve, Philips curve and the aggregate supply curve, respectively.

The aim of the paper is the show that any of the four short term aggregate supply curves, derived separately for every OECD country on the basis of two Okun's curves and two Philips curves, estimated on quarterly data 1991Q1 - 2013Q4, are inferior *vis* *a vis* the two respective curves, reflecting the direct relationships, estimated on the same data sample.

RELATIONSHIPS BETWEEN MACROECONOMIC POLICY TARGETS

Let us assume that there are three macroeconomic policy targets: GDP growth rate, [r(GDP)], inflation rate, [r(p)], and unemployment rate, [UNR]. Between these targets there are, in particular, relationships between any two of them.

The relationship between UNR and r(GDP) is known as the Okun's law:

$$r(GDP) = f(UNR, \xi_{UG}) \qquad (1)$$

where ξ_{UG} is the random variable (the letters U and G correspond to unemployment and r(GDP) thus indicating the independent variable and the dependent one.

The Okun's law is also expressed by a number of formulas[1]. The original formula adopted by A. Okun has the following form [Okun 1962]:

$$r(GDP) - r(pGDP) = f[UNR - t(UNR), \xi_{UG}] \qquad (2)$$

where r(pGDP) is the potential r(GDP), t(UNR) is the long term UNR trend.

In turn, the relationship between UNR and r(p) is most often expressed by the short term Philips curve [Philips 1958][2]:

$$r(p) = f\,(UNR, \xi_{Up}) \qquad (3)$$

where ξ_{Up} is the random variable (the letter p corresponds to r(p) thus indicating the independent variable. The concept of this curve has been widely criticized. Its critics have been awarded six times by the Nobel Prize Committee [Domitrovic 2011]. The subject of criticism, in particular, were proven by M. Friedman [1963] and E. S. Phelps [1968, pp. 678-711] the lack of applicability to long-term analyses and the assumption that the level of inflation is equal to nominal wage dynamics as well as the coexistence of the two phenomena instead of their time sequence [Machaj 2013] causing wage-inflation spiral that may be properly solved only by taking into account the proposals of T. Sargent and C. Sims concerning methods of analysis of causes and effects in the economy (the VAR model) [http://www.nobelprize.org/nobel_prizes/economic-sciences/laureates/2011/press.html]. Nevertheless Philips curve is still recognized in theory and applied in practice [Domitrovic 2011].

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[1] Some of them are given in main text and in references of: Shevchuk [2010, pp. 75-90]. A comprehensive list of empirical studies is given, i. a., in Durech et al. [2014, pp. 57-65] and in Elsby et al. [2010].

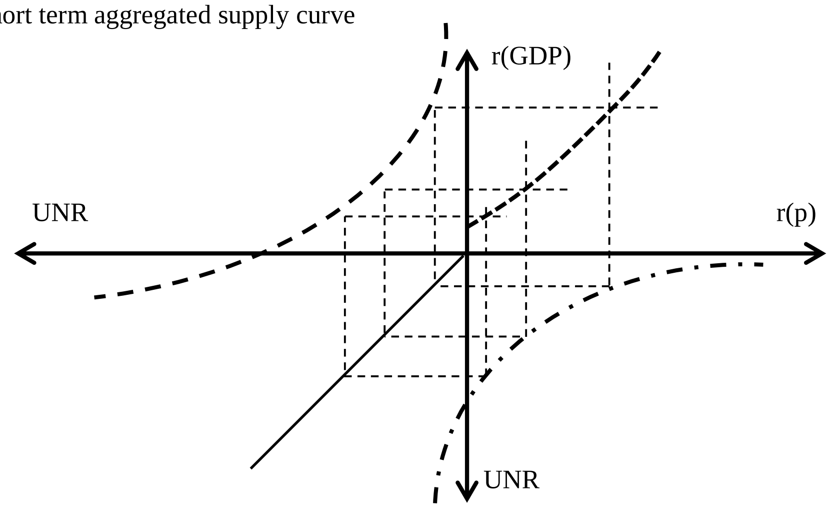
[2] There is a very vast literature on this subject including many papers comparing results of different investigations. See for instance, Carre [2010], Daniskova and Fidrmuc as well as Mavroeidis et al. [2014]. There are thousands of empirical analyses based on models with different specifications for the USA only.

Also, the relationship between r(p) and r(GDP) known as short term aggregated supply curve (SAS) is subject to both theoretical analyses and practical considerations [Błaszczuk 2014b][3]. It can be obtained analytically substituting the inverted Philips curve (3) into the Okun's curve (1):

$$r(GDP) = f\{G[r(p)]\} \quad (4)$$

or derived graphically (Figure 1).

Figure 1. Short term aggregated supply curve



Source: own elaboration based on [Burda and Wyplosz 1993, Chapter 11.5.3]

The shape of SAS depends, of course, on its analytical form, which, in turn, depends on the analytical forms of the respective Okun and Philips functions. In specific cases, it may be a linear function.

From the practical point of view, relationships between r(p) and r(GDP) should account for the J. Bednarczyk's [2011] concept of neutral inflation, which means the level of inflation in the economy ensuring its maximum r(GDP)[4]. In addition, J. Bednarczyk [2012] claims that the level of neutral inflation is different for different countries in different time points and that it does not need neither to be close to any level, decided in an arbitrary manner, as is the case in practice, for example 0% or 2%, nor be less than, for example, enlarged by 1.5 p.p. average level of inflation in the three EU countries with the lowest levels of inflation (excluding unusual situations).

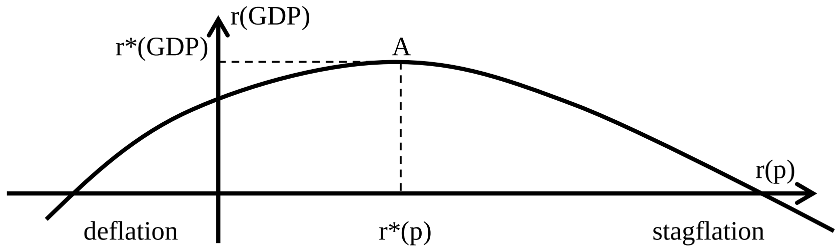
[3] Comprehensive presentations on the theoretical and empirical studies on this curve are given, for instance, in: Ball et al. [1988] and in: Mankiw and Reis [2010].

[4] In my opinion, the neutral inflation is the inflation that occurs when the GDP growth rate is maximum, so it is co-occurring with, not ensuring, the maximum GDP growth rate.

Moreover, in practice, the low pace of GDP growth rates, in particular close to 0, and even negative, coexist with levels of inflation, both much higher than the neutral inflation, referred to as stagflation, as well as the lower one - referred to as deflation that causes fear of monetary authorities[5].

In view of the above, a hypothesis was bet that the SAS takes the form, more or less, similar to the shape of the curve B shown in Figure 2 that reflects both the neutral inflation, r*(p), and the corresponding maximum GDP growth rate, r*(GDP), as well as the low rates of GDP going hand in hand, as is the case in practice, both with a negative inflation rates and its high levels.

Figure 2. The relationship between inflation rates and the GDP growth rates (B curve)



Source: own elaboration

Further on the SAS curve and the B curve are subject to empirical verification.

ASSUMPTIONS OF THE INVESTIGATION. SOURCES OF STATISTICAL DATA. METHOD OF ANALYSIS

Firstly, it has been assumed that the analysis cover all the OECD countries in the period of, more or less, the last two Juglar cycles, i.e. 1990Q1-2013Q4.

Secondly, it has been assumed that the OECD statistics would be used to ensure the comparability of the results. Therefore there were considered:

a) Harmonised Consumer Prices (HCPI) - all items, percentage changes from previous period, seasonally adjusted, http://stats.oecd.org/index.aspx?DatasetCode=MEI_PRICES [28 Apr 2014];
b) Harmonised Unemployment Rate (HUNR): all persons, seasonally adjusted, http://stats.oecd.org/index.aspx?DatasetCode=KEI [28 Apr 2014];
c) Growth Rate of Gross Domestic Product (r(GDP)) - expenditure approach, growth rate compared to previous quarter, seasonally adjusted, http://stats.oecd.org/WBOS/index.aspx [28 Apr 2014].

[5] This is because central bank cannot effectively counteract an increase of real interest rates as its interest rates may not be cut down below 0. Therefore, in order to fight deflation, it cuts interest rates in advance and, usually, increases the liquidity of commercial banks on a large scale, thus encouraging them to increase the supply of cheap loans to boost demand, which in turn will result in an increase in prices [Wojtyna 2004, pp. 252-277].

Unfortunately, these data do not correspond in full to the assumptions adopted. Namely, data on:

a) r(GDP) lack for Greece and for other countries start from different time points;
b) HCPI are lacking for 8 countries[6] and are available usually for periods shorter than for r(GDP) and HUNR, sometimes for relatively short time periods[7].

Moreover, in some cases estimated data (estimates) are given and in some other there are breaks (in collection and/or aggregation methods). In the absence of other information, estimates have been adopted, and the information about the breaks have been totally ignored.

Next it has been assumed for each country separately that r(GDP) dependence upon HUNR may be explained by the hyperbolic (h) and logarithmic (l) functions with intercept [Błaszczuk 2014a, p. 49]:

$$r^{hUG}_{kt}(GDP) = b^{hUG}_{0k} + b^{hUG}_{1k}\,(1/HUNR_{kt}) + \xi^{hUG}_{kt} \qquad (5.1)$$

$$r^{lUG}_{kt}(GDP) = b^{lUG}_{0k} + b^{lUG}_{1k}\,\ln(HUNR_{kt}) + \xi^{lUG}_{kt} \qquad (5.2)$$

where: k = 1, 2, … – country number and t = 1, 2, … – quarter number.

It has been adopted, therefore, that the increase in UNR causes slower and slower declines in r(GDP) and, moreover, it has been taken into account, appearing in practice, the possibility of a negative r(GDP).

The same functions have been applied for relationships between HUNR and HCPI [Błaszczuk, 2015, p. 17]:

$$HCPI_{kt} = b^{hUp}_{0k} + b^{hUp}_{1k}\,(1/HUNR_{kt}) + \xi^{hUp}_{kt} \qquad (6.1)$$

$$HCPI_{kt} = b^{lUp}_{0k} + b^{lUp}_{1k}\,\ln(HUNR_{kt}) + \xi^{lUp}_{kt} \qquad (6.2)$$

It has been adopted, therefore, that the increase in UNR causes slower and slower declines in r(p), and it has been taken into account, occurring in practice, possibility of deflation when HUNR are high.

Combining each of the Okun's functions with each of the Philips ones four SAS functions have been computed: SAS hh, SAS hl, SAS lh and SAS ll.

Then it has been assumed that r(GDP) may be explained by the polynomial function of the second degree of HCPI [Błaszczuk, 2014b, pp. 36-37]:

$$r_{kt}(GDP) = b^{pG}_{0k} + b^{pG}_{1k}(HCPI_{kt}) + b^{pG}_{2k}(HCPI_{kt})^2 + \xi^{pG}_{jt} \qquad (7)$$

Every of the five functions were estimated separately for each of the 25 countries, whereby the numbers of observations were not always the same. In all estimations it has been assumed that OLS may be used taking into account, inter alia, that the functions (7.1) trough (9) are linear after appropriate transformations.

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[6] Australia, Canada, Chile, Israel, Japan, Korea, Mexico and New Zealand.

[7] Switzerland: 15 observations, Turkey: 35 observations; Iceland: 44 observations, in other cases: more than 60 observations.

RESULTS OF ANALYSIS

The results of the research are partially in accordance with expectations (for detailed results of estimation of the Okun's curve, the Philips curve and the B curve see Błaszczuk D. J. (2014a), Błaszczuk D. J. (2015) and Błaszczuk D. J. (2014b), respectively). Above all, do not dismay relatively low, and sometimes even very low, values of R^2 because dispersions of points on the vast majority of the 3 times 25 charts reflecting respective relationships do not allow to assume in advance any trends.

Okun's functions

It is worth noticing that, in general, the type of function does not affect the statistical significance of estimates of the structural parameters, and estimates of structural parameters for only nine countries are clearly statistically significant (t stat > 2,00)[8]. It is not exactly true in case of estimates of intercepts.

The estimates of the structural parameter in the logarithmic models of 8 countries[9] are clearly irrelevant statistically (t stat ($b^L{}_{1j}$) < 1.00)[10]. On the other hand estimates of intercept are clearly irrelevant statistically in 10 cases, however somewhat for different countries[11].

Slightly better results in this respect there were obtained in case of hyperbolic models. Namely, the United Kingdom has disappeared from the list of countries with clearly statistically irrelevant estimates of structural parameters, and as many as 6 countries[12] have disappeared from the list of countries with clearly statistically irrelevant estimates of intercept, but 4 new[13] popped up on it.

It is worth noting that, in general, type of function does not affect the statistical significance of the estimates of the structural parameters

Surprising is a significant convergence of both theoretical lines (due to a high negative correlation between estimates of the structural parameters of both functions) practically for all countries despite the fact that the values of the explaining variable are clearly (and sometimes by far) different from unity[14].

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8 Belgium, Czech Republic, Finland, France, Hungary, Irland, Portugal, Spain and Switzerland.

9 Denmark, Estonia, Germany, Poland, the Slovak R., Slovenia, Turkey and the UK.

10 Expected and unexpected results have been also received by other authors, for instance, Klimczyk and Wronowska [2010, pp. 263-272].

11 From the list disappeared: Poland and the United Kingdom and appeared on it: Austria, the Netherlands, Norway and Sweden.

12 All except for Estonia and Turkey.

13 Namely: Iceland, Luxembourg, the United Kingdom and the United States.

14 In linear models with explanatory variables ln x and 1/x, respectively, a theoretical values for x > 0 but close to 1 are very similar because there is a dual weak inequality:
1 - 1/x =ln x = x – 1. Therefore in such a case the values of the coefficients do not play a significant role in determining theoretical values of the explained variable. In particular, for $1 \leq x \leq 2$, 1 - 1/x is a pretty good estimate of the bottom value of ln x. [Kuratowski [1971].

Finally, it should be noted that logarithmic lines are compatible with the expected ones in case of 11 countries[15] while in case of hyperbolic models such a compatibility takes place only in case of 9 countries[16]. The estimates of structural coefficients are statistically significant in each case for the same 4 countries[17] only.

Philips functions

The type of the function basically does not affect the statistical significance of the structural coefficients. The values of them are clearly irrelevant statistically in case of logarithmic models for 10 countries[18], and, in the case of hyperbolic ones Poland complements this list. Evaluations of structural coefficients are more important statistically in the case of the hyperbolic models, with the exception of four countries[19] for which they are only slightly lower from their counterparts.

Slightly different results have been obtained for the intercept. Only for three countries[20] the type of function does not affect the assessment of its statistical significance. Estimates of intercept are by far more important statistically in case of logarithmic models, with the exception of all six countries, for which values of the structural coefficients have opposite signs to the typical Philips curve[21], and Spain, Germany and Switzerland. In case of logarithmic models they were clearly insignificant statistically only for three countries[22], and, in case of hyperbolic models list of clearly irrelevant statistically intercepts covered 9 countries[23].

In this context, it should be noted that no matter what type of function in case of only six countries[24] theoretical lines are incompatible with the expected ones but only for two countries[25] the evaluations of the structural coefficients are statistically significant. For the remaining 19 countries evaluations of structural coefficients are statistically significant only in the case of seven countries[26].

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[14] Expected and unexpected results have been also received by other authors, for instance, Klimczyk and Wronowska [2010, pp. 263-272].

[15] Hungary, Iceland, Ireland, Luxembourg, Poland, Portugal, Slovenia, Spain, Turkey, the United Kingdom and the United States.

[16] Poland and Slovenia have disappeared from the both lists above.

[17] Hungary, Ireland, Portugal and Spain. It should be noted that three of four remaining belong to the GIPSI group subject to huge problems during the last economic crisis.

[18] Germany, Hungary, Iceland, Italy, Luxembourg, Norway, the Slovak Republic, Spain, Turkey and the United States.

[19] Poland, the Slovak Republic, Slovenia and Turkey.

[20] Slovenia, Spain and Switzerland.

[21] Hungary, Iceland, Italy, Luxembourg, the Slovak Republic and the United Kingdom.

[22] Hungary, Italy and the United Kingdom.

[23] Austria, Belgium, the Czech R., Estonia, Finland, the Netherlands, Norway, Turkey and USA.

[24] Hungary, Iceland, Italy, Luxembourg, the Slovak Republic and the United Kingdom.

[25] The Slovak Republic and the United Kingdom.*

[26] Estonia, Finland, France, Ireland, the Netherlands, Portugal and Sweden.

SAS and B curves

Of the 25 countries under analysis, shapes of both the Philips curve and the Okun one were simultaneously in line with expectations (typical) for only 5 countries in case of both hyperbolic curves and only for two more in case of both logarithmic curves (see Table 1). Thus, typicality/non-typicality of the shape of the curve does not depend on the type of the function in 23 cases.

Table 1. Typicality of hyperbolic (h) and logarithmic (l) Okun (O) and Philips (Ph) curves

Country	O		Ph		Country	O		Ph		Country	O		Ph	
	h	l	h	l		h	l	h	l		h	l	h	l
Austria			+	+	Iceland	+	+			Slovenia		+	+	+
Belgium			+	+	Ireland	+	+	+	+	Spain	+	+	+	+
Czech R.			+	+	Italy					Sweden			+	+
Denmark			+	+	Luxembourg	+	+			Switzerland			+	+
Estonia			+	+	Netherlands			+	+	Turkey	+	+	+	+
Finland			+	+	Norway			+	+	United Kingdom	+	+		
France			+	+	Poland		+	+	+	United States	+	+	+	+
Germany			+	+	Portugal	+	+	+	+	X				
Hungary	+	+			Slovak R.					X				

Source: own elaboration

As a result, there are 5 different situations (see Table 2 and Annexes 1 through 5[27]). As expected, the SAS hh [long broken line] and SAS ll [starred line] are linear while the other two - SAS hl [exponential solid line] and SAS lh [logarithmic broken line] - have respective nonlinear shapes. Both linear functions practically overlap in all 23 cases when the typicality of the shape of the SAS curve does not depend on the type of O and Ph functions. Moreover, all four SAS curves match themselves in the proximity of the average values of (p) and r(GDP).

[27] HCPI values occur on the x-coordinate while r(GDP) on the y-coordinate. The degree of convexity/concavity of the respective curves is not fully comparable between the countries because of the different calibration of the axes.

Table 2. Combinations of typicality/non-typicality of the Okun and Philips curves

Curve		Okun (O)		Total
		typical	non-typical	
Philips (Ph)	typical	5[a)]	12[b)]	19
	non-typical	4	2	6
Total		9[a)]	14[b)]	25

Note: a) +2 in case of both logarithmic curves. (b) + 2 in case of both hyperbolic curves as well as in case of Okun hyperbolic curve and any Philips curve.

Source: own elaboration

In no case the shape of SAS curve reflects dependencies between r(p) and r(GDP) observed in practice described by the linear trend (solid straight line) or polynomial of the second order one (solid parabolic line). Moreover, the goodness of fit measured by R^2 in case of the polynomial functions is better from a few dozen percent to ten times than in case of the linear functions.

In all five cases with typical shapes of O and Ph curves and two with both non-typical ones, all the SAS curves have positive slopes. In first case SAS hl are increasing faster and faster while SAS lh are increasing slower and slower and opposite is true in the other case. The linear trends have negative slopes for Turkey in the first group and the Slovak Republic in the second while B curves have typical shapes for all countries.

There is a mirror reflection of the above in all twelve cases with non-typical shapes of O curves and typical Ph ones and all four cases with typical shapes of O curves and non-typical Ph ones. Namely, all the SAS curves have negative slopes. Moreover, in the first case SAS hl are decreasing faster and faster while SAS lh are decreasing slower and slower and opposite is true in the other case. In the first group of countries the linear trends have negative slopes for the Czech Republic, Finland and the Netherlands while B curves have untypical shapes for Denmark and Sweden. In the second group the linear trend has positive slope for Hungary only while B curve has untypical shapes for Iceland only.

Somewhat different pictures are in case of the two countries with non-typical hyperbolic Okun's functions. Negative slopes have SAS hh and SAS hl while positive have SAS lh, SAS ll and the linear trend that is not far from SAS ll. B curve has typical shape for Slovenia only.

Summing up, in cases when the (linear) SAS hh and SAS ll have positive slopes and (nonlinear) SAS hl and SAS lh with positive slopes grow faster and faster their shapes are similar to those discussed in macroeconomic literature.

CONCLUSIONS

Further research is required for countries with non-typical Okun's and/or Phlips and/or B curves. One of the directions is their estimation for different time periods, starting, for instance, from the beginning of previous business cycle (approximately

2001Q1[28]) and finishing on the recent available data. The other possibility is to substitute simultaneous relationships by the lagged ones thus allowing for time sequence of the respective variables (endogenous or exogenous)[29].

On top of that the attempt must be made to explain the reasons of differences across the analysed OECD countries.

Despite of the above, the SAS curves, widely discussed in the macroeconomic literature and very helpful in understanding of many macroeconomic issues, especially connected with macroeconomic policy measures, have no empirical justification whatever the shapes of Okun's and Philips curves. They are inferior, as regards the goodness of fit not only with respect to the B curve (polynomial of the second order) but even to the linear trend.

Nevertheless, when they are linear or nonlinear and growing faster and faster, they may reflect quite well behaviour of the respective economy in given period.

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[28] In some cases it will not affect the number of observations and in other its reduction will not be great.

[29] It means the UNR–r(GDP) spiral as well as UNR–r(p) and r(p)–r(GDP) ones.

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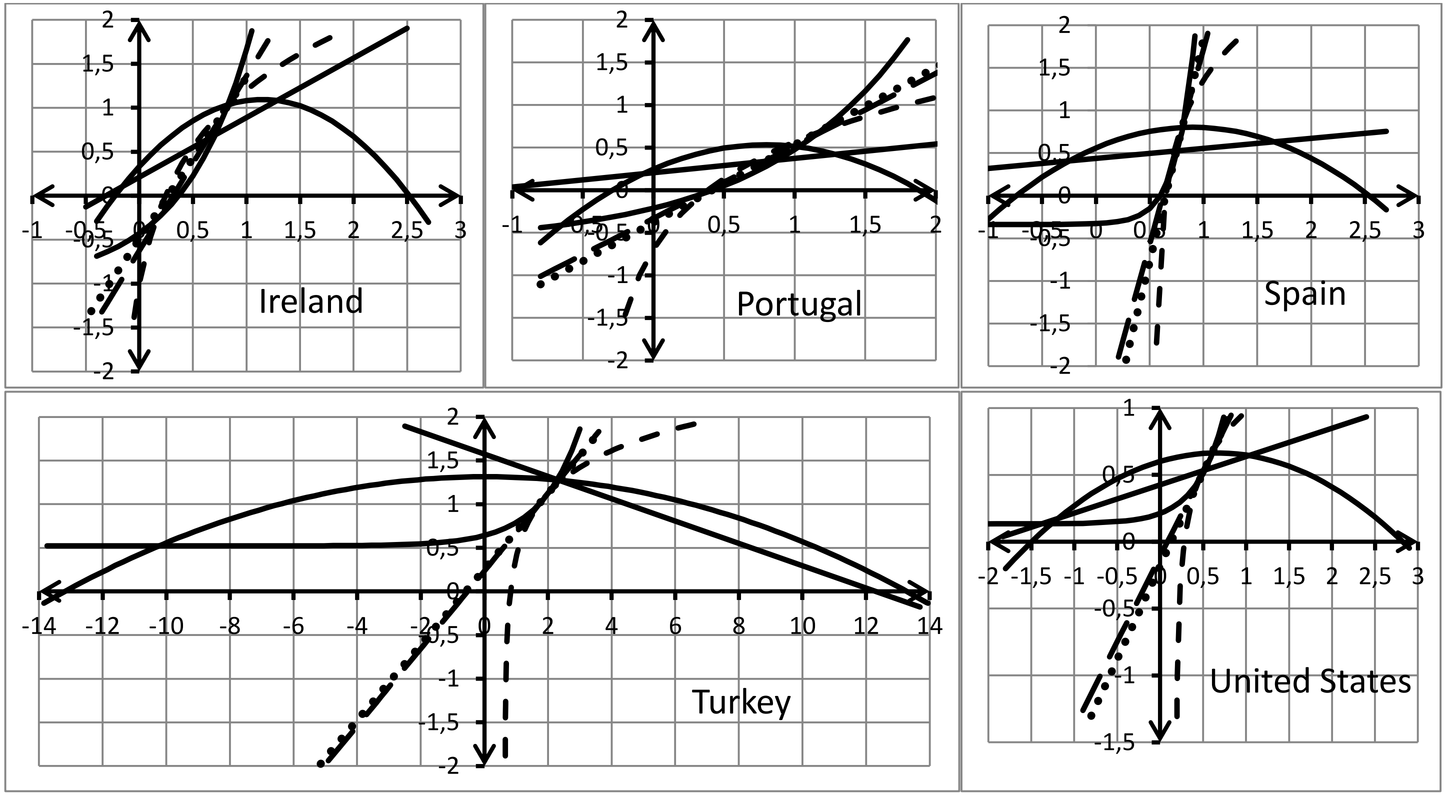
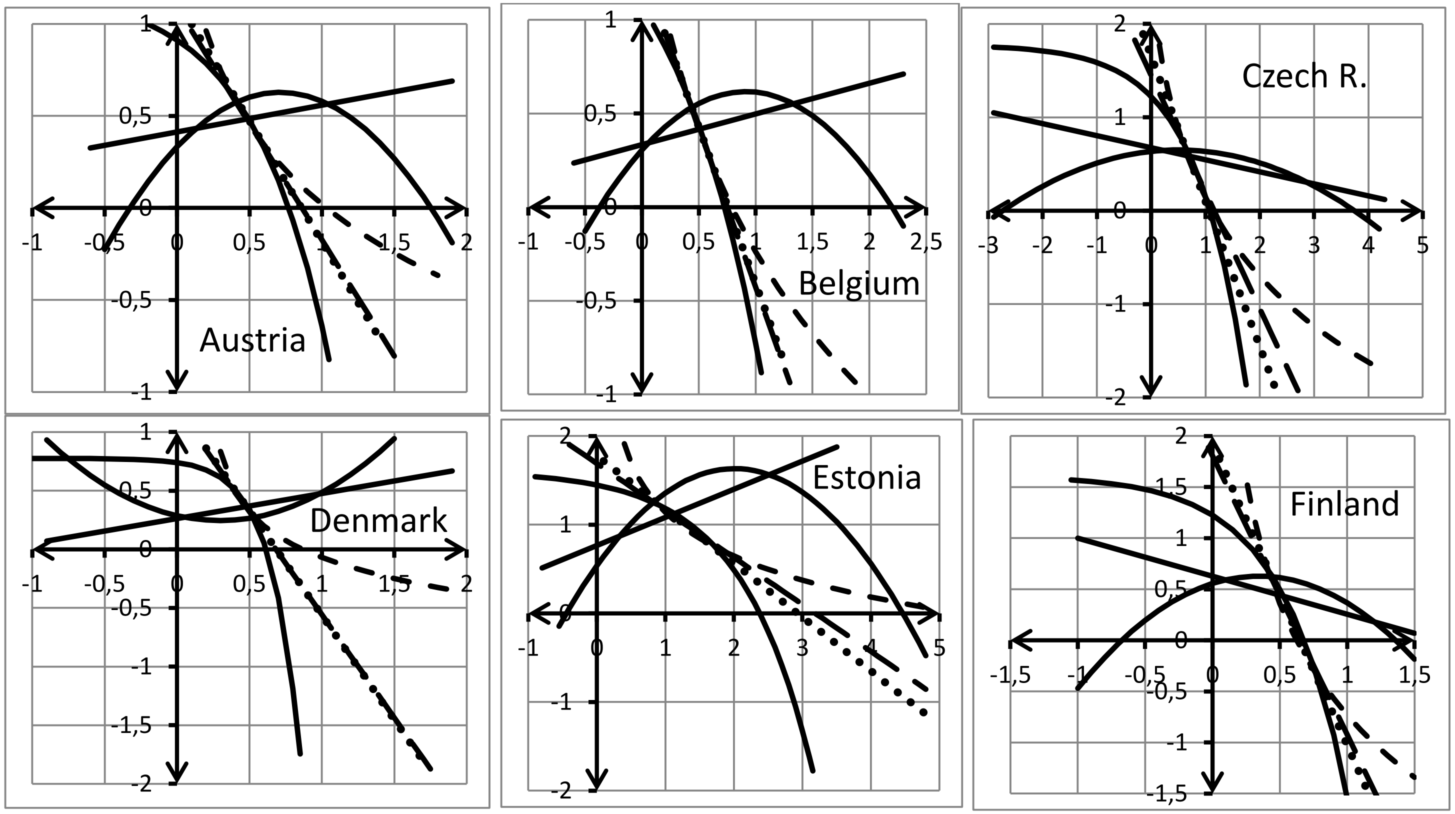
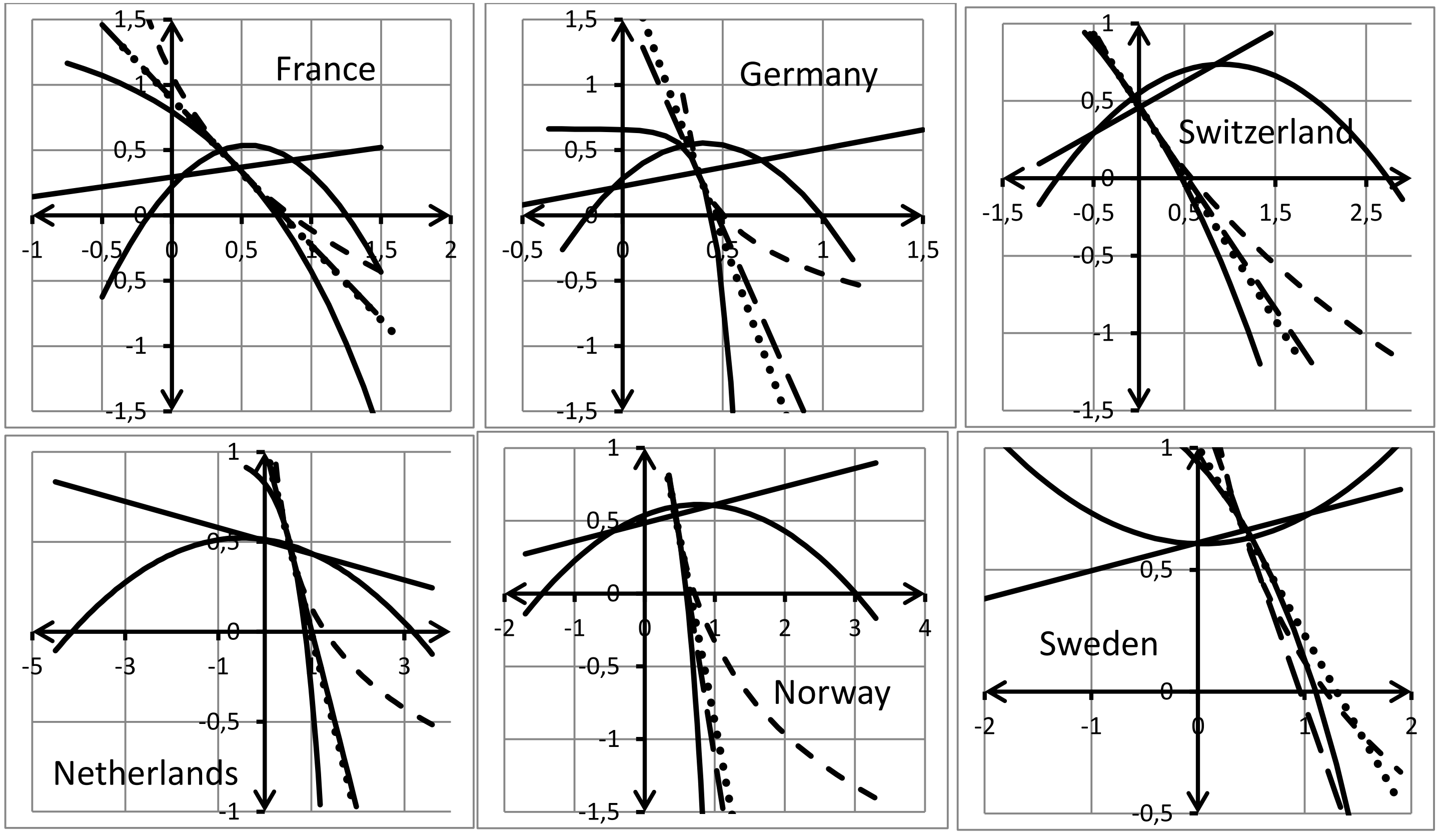
Annex 1. Six SAS curves for countries with typical Okun and Philips curves



Source: own computations

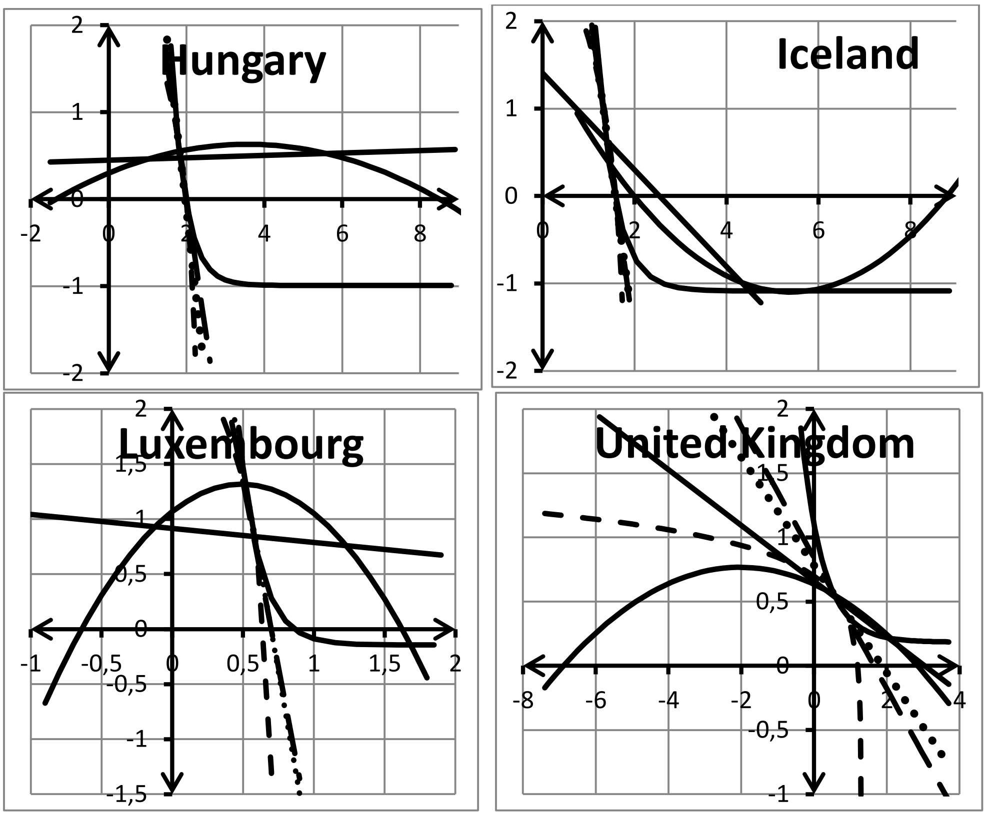
Annex 2. Six SAS curves for countries with non-typical Okun curves and typical Philips curves





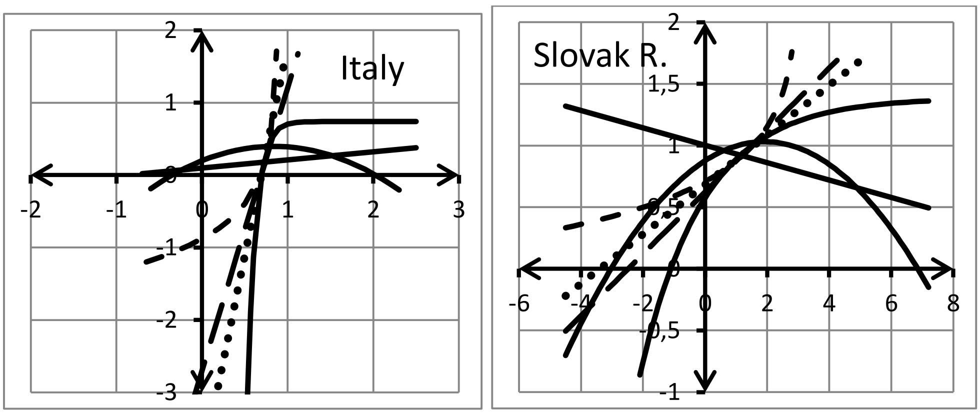
Source: own computations

Annex 3. Six SAS curves for countries with typical Okun curves and non-typical Philips curves



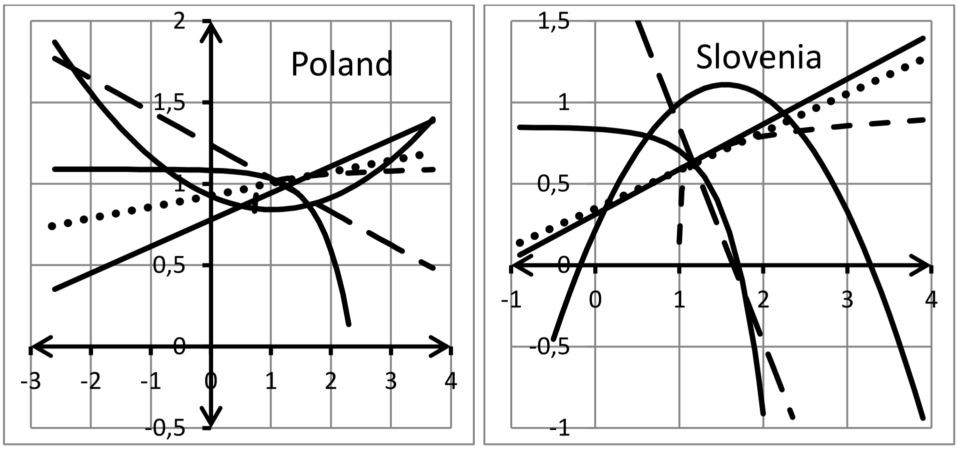
Source: own computations

Annex 4. Six SAS curves for countries with non-typical Okun and Philips curves



Source: own computations

Annex 5. Special cases



Source: own computations