A model to estimate macroeconomic parameters for growth in EU

Lucian Liviu Albu

Abstract

A main problem for macroeconomic studies continues to be the estimation of capital stock and some derived indicators like coefficient of capital, depreciation rate, etc. In this way we are proposing a simple and intuitively model in order to estimate such basic macroeconomic indicators but avoiding to knowing the amount of capital stock. By applying a simulation model in case of European Union data for a set of periods, we obtained some relevant result. One of them is referring to the negative impact of last global crisis on the coherence of a classic type model. Such model is adequate mostly for a period of continuous increasing in GDP as it was for EU during the period 2000-2007.

1. Introduction

There is a long period of debating on how are included variables or factors in a production function and more important how they are evaluated based on available statistical data. Most of studies are coming from the classical theory initially developed by Solow (1957). Using basic variables and parameters in so-called classic model of economic growth a number of significant derived indicators where considered. Last years, under the impulse of the Conference Board (CB) meetings (and especially since 2008, when an annual global economic outlook starting to be published), some significant progress was registered. Last one is including projections for the medium term, 2013-2018, and for the long term, 2019-2025 (Chen et al, 2012). The supporting of limited but comparable data is already offered from long time ago by the Penn World Table (PWT). PWT is a standard source of data on real GDP across countries. At present, the last version (version 8) of PWT is already prepared by experts from the University of California, Davis and the University of Groningen, continuing the input from research made at the University of Pennsylvania. Using prices collected by the International Comparisons Program (ICP) and constructing PPP (Purchasing Power Parity) exchange rates, this version (like in version 7), is based on the 2005 benchmark. However, version 8 is developing previous versions of PWT in some significant aspects. Thus, there are changes to the measurement of real GDP that will be incorporated in this "next generation" of PWT (Feenstra et al, 2013). Despite of progresses in database, different opinions regarding the relevance of macroeconomic indicators related to stock of capital and its efficiency still exist. In order to avoid some ambiguity in estimating the amount of capital stock, we propose a simple model that, at least in case of a period of continuous growth in GDP, permits to simulate a classic type growth mechanism.

2. Empirical evidences in EU

According to the theory, investment in new fixed capital and in incorporated new technology is main factor of GDP growth. In a long term perspective, as income per capita is growing there are certain corresponding trends in case of some macroeconomic derived variables, as follows: coefficient of capital is increasing (or equivalent, efficiency of capital is decreasing), growth rate of GDP is decreasing, the amortisation (consumption of capital) is covering a higher proportion of total investment, etc.

As empirical evidence, using available data, we are presenting the spatial distribution in EU of some macroeconomic indicators usually regarded as being significant to describe the growth mechanism: GDP per capita (y) GDP growth rate (r), the investment share in GDP (α), computed as Gross Fixed Capital formation (including Acquisitions less disposals of valuables), and efficiency of investment (β). As graphical representation we are using stylised maps of EU, where LO is longitude (on its left side relating to the origin, 0

meridian, the Western longitude was changed in negative values) and LA latitude. In such stylised maps the two small island countries (Malta and Cyprus) were excluded from EU28 and the proportion between longitude and latitude was conserved like in geographical maps.

For a set of selected indicators we computed the annual average levels by countries in the last two decades (detailed computed data are presented in Appendix). In Fig. 1(a), first map of EU26, yM means GDP per capita, per year (in current USD), and in Fig. 1(b), second map of EU26, rM is annual GDP growth rate (as %). In Fig. 2, first map shows spatial distribution in EU26 of the investment share in GDP, αM (as %), and second map spatial distribution of investment efficiency, βM (as %), computed as the ratio between GDP growth and investment. On stylised maps of EU, like in geodesic maps, there are a number of contour lines, but transitions among regions are smoothed. Regions with darker colour mean lower level of indicators and those with lighter colour mean higher level of them.
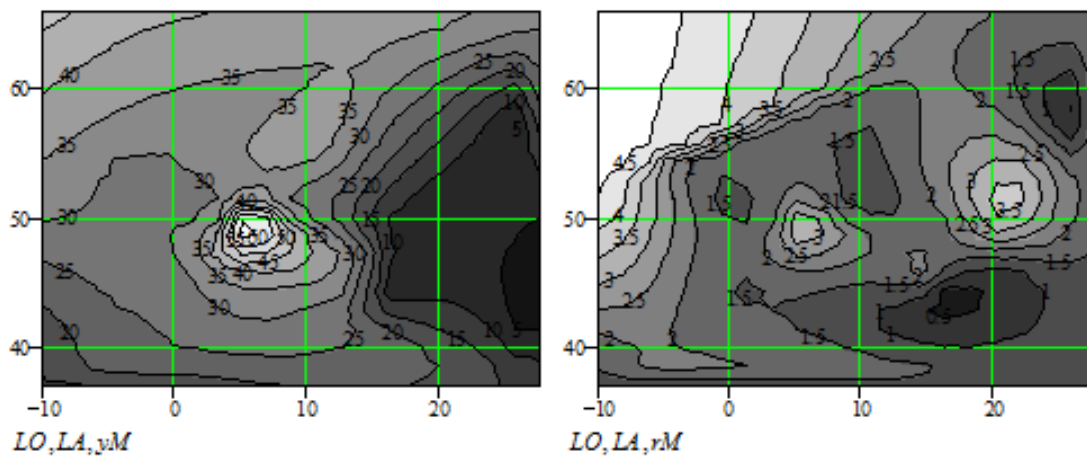
Source: Own calculations based on EUROSTAT data.

Fig. 1. (a) Distribution of GDP per capita in EU, 1990-2011; (b) Distribution of GDP growth rate in EU, 1991-2012
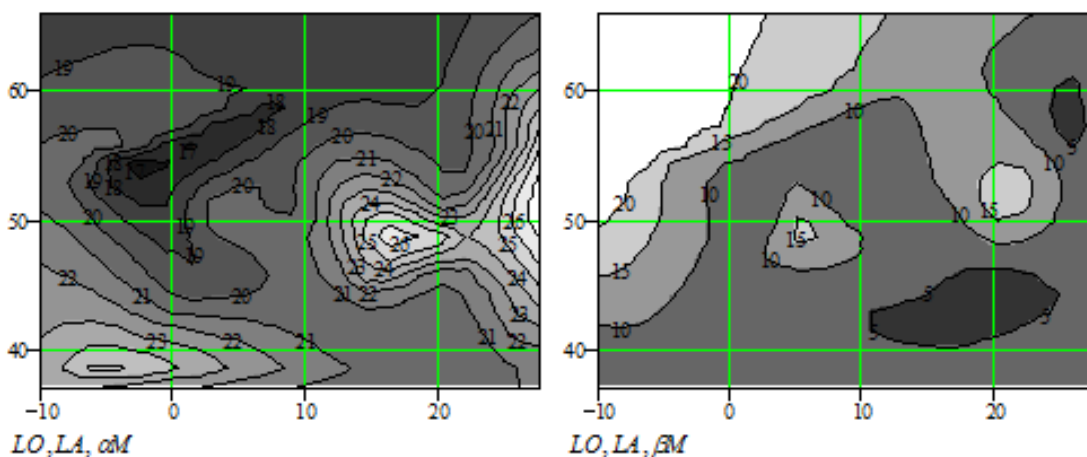
Source: Own calculations based on EUROSTAT data.

Fig. 2. (a) Distribution of investment share in GDP in EU, 1990-2011; (b) Distribution of investment efficiency in EU, 1991-2012

For instance, in case of GDP per capita distribution during last two decades in EU, Fig. 1(a), we can see as a general rule an increasing tendency from the right side (eastern regions) to the left side (western regions) and to

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from the bottom side (southern regions) to the top side (northern regions). Highest levels of GDP per capita in EU are located in a region around Luxemburg (60 contour line). A similar rule seems to be in case of GDP growth rate distribution and indeed in case of investment efficiency, Fig. 1(b) and Fig. 2(b), but in a different fashion. The rule for spatial distribution in EU of investment share in GDP, Fig. 2(a), seems to be opposite to that for distribution of GDP per capita.

As we can see below, the spatial distribution in EU is very sensitive to the change of analysed period, excepting the spatial distribution of GDP per capita which continues to remain stable. This is perhaps the reason for EU policy to improve permanently the convergence programmes in order to diminish the disparities among countries and among regions in EU at the NUTS 2 level. Is important to highlight that during last decade the convergence process within EU continuously advanced despite of last year's crisis. For instance, in case of EU (Croatia became a member only in July 2013), it was demonstrate a strong convergence between Eastern group of countries (EU10) and Western group of countries (EU15). So, if in 2000 the GDP per capita (expressed in Purchasing Power Standard, PPS) in EU-10 represented only 44.5% of the EU average, compared with 115.5% for the EU-15, in 2012 this represented 62.6% of EU average, compared to 109.5% for the EU-15.

3. A model to simulate the growth mechanism in EU

Classic theory of economic growth focuses only on labour, capital and technical progress, as growing factors. Today, other variables are included by authors in the model of production function, such as human capital, total factor productivity (TFP), energy, productivity, etc., and other indicators where derived. For instance, in PWT8.0 version the variable capital was considered not only as an alone factor but it was divided by types of fixed capital, such as structures (residential and non-residential), Transport equipment, Computers, Communication equipment, Software, and Other machinery and assets. In case of labour input there are considered Employment (Number of persons engaged) and Human capital (Average years of schooling and assumed rate of return) (Inklaar and Timmer, 2013). In matter of measuring labour input, PWT follows the standard approach in the literature. In case of capital, some authors concluded that among countries there is no significant relationship between GDP per capita and the coefficient of capital (capital/output ratio), contrary to the standard classical theory. However, while for structures and for transport equipment there is an insignificant relationship, for computers, software and other machinery, this coefficient increases with the level of GDP per capita. Other authors consider that neo-classical theory offers us an integrated framework and further we can estimate capital stocks, capital services and depreciation (Oulton and Srinivasan, 2003). Although for developed countries already there are methods to estimate stock of capital by considering certain hypothesis about its depreciation, some problems still persist (OECD, 2001 and OECD, 2009). Among them we can enumerate: significant difference between GDP deflator and investment deflator, when new fixed capital is added to the existing stock of capital; different cohorts of fixed capital have various age and depreciation rate; problems related to the estimation of using capacity degree of fixed capital stock and length of their life, etc.

Despite of these debates in economic literature, taking into account the lack of some analytic comparable macroeconomic data, we are calling a simple model derived from the standard theory of economic growth (Albu, 2006). Idea is that at the aggregate level such model is fundamental equivalent to more detailed models. Its advantage is coming from using only few available macroeconomic data. Based on it we shall try to estimate some limits for parameters involved in the relationship between investment and growth and to derive some significant relations among them. Moreover, on it we can test if the classic growth theory is confirming in case of EU. We start with the following presumed relation between GDP growth rate (r) and the share of investment in GDP (α):

$$r = a*\alpha + b \tag{1}$$

where a and b are parameters. Indeed, from yearly published macroeconomic data, it is known that r and α are computed as follows:

$$r \equiv \Delta Y/Y \qquad \text{and} \qquad \alpha \equiv I/Y \tag{2}$$

where ΔY is the yearly GDP growth, I is investment (computed as Gross Fixed Capital formation, including Acquisitions less disposals of valuables), and Y is GDP.

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Also, taking into account that the growing rate of GDP is a function of investment share, $r=f(\alpha)$, we can consider it to be derived from a higher order function $F(\alpha)$, as follows:

$$F(\alpha) = (a/2)*\alpha^2 + b*\alpha + c \qquad (3)$$

where c is a parameter. This function could offer some quantitative information about the equilibrium condition of the system, and for stability and limits of parameters in equation *(1)*. A critical value of parameter *c*, *ccr*, is done by solving

$$\Delta(c) = b^2 - 4*a*c = 0 \qquad (4)$$

$$ccr = (b^2)/(2*a) \qquad (5)$$

From the model described by equation *(1)* can be simple derived some basic indicators for the growth mechanism already reported in many macroeconomics studies. One of them is critical value of α:

$$\alpha cr = -b/a \qquad (6)$$

as the minimum level of investment share to ensure at least zero GDP growth rate ($r=0$).

Between critical values of *c* and α there is the following relation

$$ccr = \alpha cr*(-b/2) \qquad (7)$$

Moreover, taking into account that yearly the total amount of investment (*I*) is coming from the sum of amortisation (*A*) of fixed capital (*K*), which is compensating the depreciation of capital stock (or consumption of capital), and investment in new fixed capital (*In*) or growth of fixed capital stock (ΔK):

$$I \equiv A + In \qquad (8)$$

the investment share α can be divided in two components:

$$\alpha cr = A/Y \qquad (9)$$

and

$$\alpha n = 1 - \alpha cr = In/Y \qquad \text{or} \qquad \alpha n = \Delta K/Y \qquad (10)$$

In terms of Harrod-Domar model, *In* is net fixed investment or saving, *S*, and in long-run the capital coefficient (or stock of fixed capital/output ratio) is defined as follows:

$$k \equiv K/Y \qquad (11)$$

The growth rate of stock of fixed capital is:

$$\Delta K/K = (\Delta K/Y)/(K/Y) = s/k \qquad (12)$$

where *s* is the ratio of net fixed investment or saving to *Y*. In macroeconomics, the savings ratio and capital coefficient are considered fundamental factors for accumulation and growth, assuming that all saving is used to finance fixed investment.

Taking into account that in case of no investment the capital, *K*, is yearly decreasing with depreciation of capital (covered by amortisation, *A*), we can define the depreciation rate of capital (presumed for simplification as being proportional to the capital stock):

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$$\rho \equiv A/K \qquad\qquad (13)$$

Considering that the estimates of capital stock are based on the perpetual inventory model, in the context of proposed model, we can see that the depreciation rate of capital is corresponding to the parameter *b* in equation *(1)*, as follows:

$$\rho = -b = 1/d \qquad\qquad (14)$$

where *d* can be interpreted as the average age (in years) of the capital stock. Moreover, a relation between the coefficient of capital, *k*, and parameter *a* in equation *(1)* could be deduced:

$$k = 1/a \qquad\qquad (15)$$

In Table 1 we are presenting our estimation results for six different periods by using average data for all countries in EU28. We can see that only for four selected periods the estimated values for basic parameters of the model are in line with theory. Thus, only for time intervals 1996-2012, 1996-2007, 2000-2012, and 2000-2007 the cumulative conditions are fulfil (*a>0* and *b<0*). Moreover, in case of the period 1996-2012 the EU average level for the implicit parameter *k* (6.48) is too high, as aggregate level for all EU countries, comparing with values used in other studies, as well as for the implicit parameter *d* (124 years as average age of fixed capital functioning). Also, for the period 1996-2007 the estimated depreciation rate of fixed capital ρ (1.7%) is far from usually used rates in literature (mostly used rates in other studies are close to 5%). In case of the period 2000-2007 the EU economy seems to functioning more close to a model conforming to the theory. It was a period of continuous growth for all 28 actual members of EU (excepting Malta in 2001, -1.5%, and in 2004, -0.5%).

Table 1. Average level in EU for macroeconomic parameters, in case of selected periods

Period\Parameters	(a)	(b)	(αcr)	(k)	(d)	(ρ)
			%		years	%
1990-2012	-0.065	3.328	51.412	-15.447	-30.046	-3.328
1990-2007	0.028	1.979	-71.495	36.122	-50.523	-1.979
1996-2012	0.154	-0.807	5.230	6.480	123.896	0.807
1996-2007	0.252	-1.700	6.754	3.973	58.823	1.700
2000-2012	0.225	-2.785	12.395	4.450	35.903	2.785
2000-2007	0.366	-4.308	11.762	2.731	23.215	4.308

Source: Own calculations based on EUROSTAT data.

Useful conclusions could be also extracted from the changes among selected periods in correlation coefficients, which are presented in Table 2 (where values of coefficients are computed by using individual data for all countries in EU28 and for all years within a period) and in Table 3 (where values of coefficients are computed by using average data for countries in EU28).

According to the theory, the expected sign for correlations between *y* and *α* and respectively between *y* and *r* must be negative, and between *α* and *r* to be positive. In case of last correlation the positive coefficient could represent a measure of the direct impact of investment on growth. We can see from data in Table 2 that, within the whole period 2000-2012, the crisis (started in many EU countries in 2008) has dramatically affected this correlation: for the interval 2000-2007 the value of coefficient is +0.429, but for the whole interval 2000-2012 it going down to only +0.089. Similar is happening within the period 1996-2012: for the interval 1996-2007 the value of coefficient is +0.227, but for the whole interval 1996-2012 it going down to only +0.054. From data in Table 3 we can see that in case of considering average data a blur of the impact of crisis on correlations is resulting.

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Table 2. Correlation between macroeconomic variables in EU by using individual data, in case of selected periods

| Period\Correlation coefficient	(y, α)	(y, r)	(α, r)
1990-2012	-0.195	-0.049	+0.111
1990-2007	-0.138	+0.114	+0.213
1996-2012	-0.307	-0.264	+0.054
1996-2007	-0.270	-0.139	+0.227
2000-2012	-0.346	-0.289	+0.089
2000-2007	-0.313	-0.303	+0.429

Source: Own calculations based on EUROSTAT data.

Table 3. Correlation between macroeconomic variables in EU by using average data for countries, in case of selected periods

Period\Correlation coefficient	$(yM, \alpha M)$	(yM, rM)	$(\alpha M, rM)$
1990-2012	-0.535	+0.363	-0.168
1990-2007	-0.394	+0.369	+0.070
1996-2012	-0.549	-0.224	+0.397
1996-2007	-0.441	-0.266	+0.512
2000-2012	-0.540	-0.446	+ 0.528
2000-2007	-0.436	-0.500	+0.609

Source: Own calculations based on EUROSTAT data.

Finally, based on average data we are presenting in Fig. 3 three simulation versions of the growth model (corresponding to the last three selected periods in Table 3). The estimated functions of GDP growth are $r1e(\alpha)$, $r2e(\alpha)$, and $r3e(\alpha)$, corresponding to periods 1996-2007, 2000-2012, and 2000-2007. Moreover, on graphical representation for the first and third periods there are marked the critical values for the investment share in GDP, $\alpha cr1$ and $\alpha cr3$ and those for parameters signifying the depreciation rate of fixed capital, as $b1$ and $b3$.
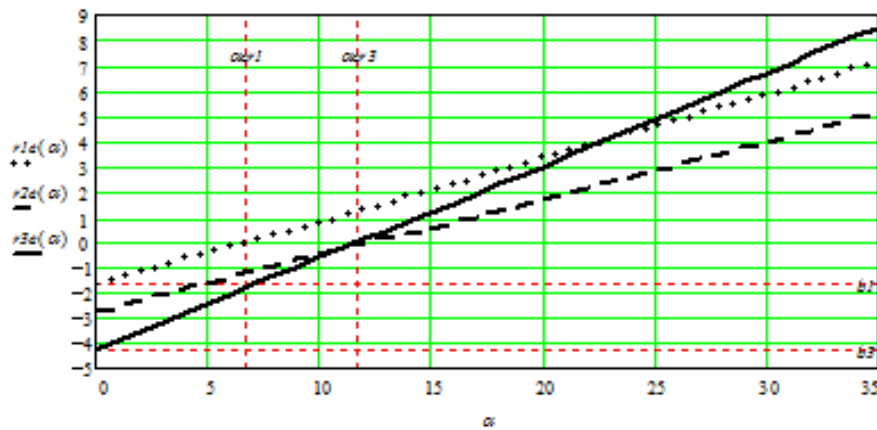
Source: Own calculations based on EUROSTAT data.

Fig. 3. Estimated function of GDP growth rate in EU for 1996-2007, 2000-2012, and 2000-2007

4. Conclusion

In order to avoid problems with comparable data, mainly in case of estimating the stock and structure of fixed capital, an alternative solution is to build a simulation model based on the growth rate as function of investment share in GDP. Such model is adequate mostly for a period of continuous increasing in GDP. This was the case in EU for the period 2000-2007. For this interval the EU economy seems to functioning close to the standard theory. As output of applying our simulation model we are reporting as average levels for EU: a capital coefficient of 2.7, a depreciation rate of fixed capital of 4.3% (corresponding to 23 years as average age of fixed capital functioning), and 11.8% as lower limit for investment/GDP ratio (necessary to obtain a zero GDP growth rate), etc. Further research is due in order to obtain estimations for parameters in case of different group of countries in EU (old members and new members for instance) and to characterise their particular mechanism of growth.

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Appendix

Average level for selected indicators in EU countries, 1990-2012

	Countries\indicators	(αM)	(rM)	(βM)	(yM)
		%	*%*	*%*	*Thou USD*
1	Austria	22.920	2.078	9.065	32.467
2	Belgium	20.658	1.711	8.281	31.063
3	Bulgaria	22.797	1.160	5.088	2.902
4	Croatia	21.683	0.346	1.596	7.483
5	Cyprus	19.804	3.222	16.267	18.810
6	Czech Rep.	26.436	1.792	6.779	9.715
7	Denmark	19.416	1.449	7.464	39.934
8	Estonia	27.635	1.789	6.472	7.370
9	Finland	20.006	1.832	9.156	31.567
10	France	19.219	1.471	7.654	29.471
11	Germany	19.742	1.502	7.607	30.481
12	Greece	20.529	1.396	6.799	17.024
13	Hungary	21.410	0.999	4.668	7.503
14	Ireland	20.483	4.646	22.680	34.042
15	Italy	20.389	0.804	3.944	25.783
16	Latvia	24.435	0.459	1.880	5.438
17	Lithuania	21.795	0.888	4.074	5.555
18	Luxembourg	20.454	3.592	17.560	67.798
19	Malta	20.258	3.143	15.514	12.470
20	Netherlands	20.131	2.037	10.117	32.658
21	Poland	20.342	3.766	18.513	6.274
22	Portugal	23.211	1.416	6.101	14.775
23	Romania	24.357	1.357	5.573	3.507
24	Slovakia	25.501	2.751	10.790	7.243
25	Slovenia	23.847	1.972	8.269	14.410
26	Spain	25.393	2.158	8.498	21.019
27	Sweden	18.035	2.141	11.873	35.640
28	UK	16.593	1.989	11.985	28.820

Source: Own calculations based on EUROSTAT data.