Economics

The Problem of the Catch-Up Effect and Post-Crises Economic Growth in the World Leading Countries

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ABSTRACT. According to the World Bank statistical data, the World leading country in economic growth, not only in the post-crisis period but during the last decades, is China. Appearing next after China in economic growth in the post-crisis period are Indonesia and India. The direct comparisons of economic growth by countries are not constructive due to the catch-up effect according to which countries with relatively low levels of economic development find it easier to achieve higher growth rates than countries with more advanced economies due to diminishing capital returns. For measuring the economic development of different countries, the indicators of appropriate gross domestic products per capita are used. The paper proposes the hypothesis of proportional overlap for the catch-up effect. The paper also contains proof of an invariance theorem. After the adjustment for the catch-up effect of the economic growth ratios, the World leading countries in economic growth are Australia, the U.S., Canada and Saudi Arabia. © *2016 Bull. Georg. Natl. Acad. Sci.*

Key words: *economic growth, catch-up effect, G20 countries, economic development*

The problem to reach the stable economic growth has been analyzed in a number of significant publications [1-4].

In order to measure economic growth, it is particularly important to use a more or less adequate method allowing an inter-country comparison. But such a comparison is complicated by the existence of the so-called "catch-up effect." The goal of the paper is to resolve the problem of the catch-up effect. Such an approach gives very different results about the leading world countries in economic growth, with and without the elimination of the catch-up effect. In the paper, such an approach to the resolving of the problem is shown in the example of the leading G20 countries in economic growth in the post-crisis period. The list of G20 countries includes not only countries but the EU as well. Because the paper is focused on the problem of the leading G20 countries in economic growth, further we examine only 19 countries from the G20.

As it is known, economic growth is measured using the indicator: gross domestic product (GDP) growth rate (r). To calculate the indicator, the amount of increase in the real GDP ($\Delta Y = Y^1 - Y^0$, where Y^1 is the real GDP in the reporting period and Y^0 is the real GDP in the base period) should be divided by the amount of the base-period real GDP (Y^0):

Table 1. Indicators of Economic Growth in the G20 Countries in 2010-2013 (See [6])

No.	Countries	Year			
		2010	2011	2012	2013
1	Argentina	9.1	8.6	0.9	2.9
2	Australia	2.0	2.3	3.7	2.5
3	Brazil	7.5	2.7	1.0	2.5
4	Canada	3.4	2.5	1.7	2.0
5	China	10.4	9.3	7.7	7.7
6	France	2.0	2.1	0.3	0.3
7	Germany	4.1	3.6	0.4	0.1
8	India	10.3	6.6	4.7	5.0
9	Indonesia	6.2	6.5	6.3	5.8
10	Italy	1.7	0.6	-2.3	-1.9
11	Japan	4.7	-0.5	1.8	1.6
12	Mexico	5.1	4.0	4.0	1.1
13	Russia	4.5	4.3	3.4	1.3
14	Saudi Arabia	7.4	8.6	5.8	4.0
15	South Africa	3.1	3.6	2.5	1.9
16	South Korea	6.5	3.7	2.3	3.0
17	Turkey	9.2	8.8	2.1	4.1
18	United Kingdom	1.9	1.6	0.7	1.7
19	United States	2.5	1.6	2.3	2.2

$$r = \frac{\Delta Y}{Y^0} \qquad (1)$$

It is common knowledge that one of the problems in measuring economic growth is a comparison of the indicators for countries and regions. The essence of the problem is that due to diminishing returns on capital, with all other things being equal, it is easier to achieve higher rates of economic growth in countries with relatively low levels of economic development than in those with a more advanced economy. In economics, this phenomenon is known as the *catch-up effect* (for example, [5: 546-547]).

To illustrate this effect, let us consider the indicators of economic growth in the G20 countries in the post-crisis period from 2010 up to 2013 (Table 1).

According to the economic growth data for all of the countries listed in Table 1, the leading countries in economic growth during the post-crisis period are China, Indonesia and India. At the same time, negative economic growth occurred in Italy and Japan with the lowest growth rates observed in France, the U.K. and the U.S.

Naturally, a direct comparison of economic growth

indicators does not give a true estimate of the real situation because the level of economic development differ significantly from country to country.

A comparison of countries with different economic development levels is only possible by removing the catch-up effect from the economic growth rates. For this, it is necessary to find a coefficient that would enable us to make an appropriate adjustment of the economic growth rates for these particular countries.

As it is known, the aggregate indicator of a country's economic development is the GDP per capita (y) whose amount is determined by dividing the GDP (Y) by the population (N):

$$y = \frac{Y}{N}. \qquad (2)$$

It should be noted that in comparing countries and regions, the GDP is usually measured in US dollars.

The figures for the GDP per capita are given in Table 2.

For example, according to Table 2, the U.S. economy in 2013 was 7.8 times the economy of China (in terms of the GDP per capita), 15.6 times the

Table 2. Indicators of Economic Development Level (GDP per capita) in the G20 Countries in 2010-2013 (See [7])

No.	Countries	Year			
		2010	2011	2012	2013
1	Argentina	11,460.4	13,693.7	14,679.9	14,715.2
2	Australia	51,800.9	62,133.7	67,524.8	67,458.4
3	Brazil	10,978.3	12,576.2	11,320.0	11,208.1
4	Canada	47,465.3	51,790.6	52,409.2	51,958.4
5	China	4,433.3	5,447.3	6,092.8	6,807.4
6	France	40,706.1	43,809.7	40,908.3	42,503.3
7	Germany	41,723.4	45,870.6	43,931.7	46,268.6
8	India	1,417.1	1,539.6	1,503.0	1,498.9
9	Indonesia	2,946.7	3,469.8	3,551.4	3,475.3
10	Italy	35,875.7	38,367.3	35,132.2	35,925.9
11	Japan	43,117.8	46,203.7	46,679.3	38,633.7
12	Mexico	8,920.7	9,802.9	9,817.8	10,307.3
13	Russia	10,709.8	13,324.3	14,090.6	14,611.7
14	Saudi Arabia	19,326.6	24,116.2	25,946.0	25,961.8
15	South Africa	7,175.6	7,830.5	7,314.0	6,617.9
16	South Korea	22,151.2	24,155.8	24,454.0	25,977.0
17	Turkey	10,135.7	10,604.6	10,660.7	10,971.7
18	United Kingdom	38,363.4	40,972.0	41,053.7	41,787.5
19	United States	48,377.4	49,803.5	51,495.9	53,042.0

economy of Indonesia and 35.4 times the economy of India. Due to the catch-up effect, with all other things being equal, it is much more difficult for the U.S. to achieve an economic growth of 1% than it is for each of these other countries.

It is logical to assume that since the U.S. economy in 2013, for example, was 7.8 times larger in GDP per capita terms than the economy of China, it would be 7.8 times more difficult for the U.S., with all else being equal, to achieve the same economic growth as in China. This can be explained by the following *hypothesis*:

If the level of economic development of one country is α times higher than the level of economic development of another country, achieving the same economic growth in the former will be α times more difficult than in the latter [8: 6].

Let us call this assumption the *hypothesis of proportional overlap of the catch-up effect* or, in short, the *proportional overlap hypothesis*. For its mathematical description, let us divide the GDP per capita of the *i*-th country (y_i) by that of the *j*-th country (y_j):

$$\alpha_{ij} = \frac{y_i}{y_j}. \qquad (3)$$

Based on the essence of the above hypothesis, α_{ij} is the coefficient of proportional overlap by the *i*-th country of the catch-up effect of the *j*-th country. In short, let us call α_{ij} the *coefficient of the proportional overlap*.

For the calculation of the coefficients of the proportional overlap, the "etalon" country for these calculations first needs to be chosen. Given that Australia has the highest level of economic development (in terms of the GDP per capita) among the G20 countries, it is logical, therefore, to use its indicator for making the basic calculations (see Table 3).

If the actual economic growth in the *j*-th country is r_j, then the economic growth in this *j*-th country corresponding to that in the *i*-th country, given the hypothesis of proportional overlap of the catch-up effect, will be:

$$r_{ij}^* = \frac{r_j}{\alpha_{ij}}. \qquad (4)$$

Consequently, r_{ij}^* is the adjusted economic growth of the *j*-th country that can be regarded as corresponding to the economic growth in the *i*-th country. Briefly, let us call r_{ij}^* the *adjusted economic*

Table 3. Coefficients of Proportional Overlap of the Catch-Up Effect (Ratio of GDP per capita in Australia to Similar Indicators of Other G20 Countries)

No.	Countries	Year			
		2010	2011	2012	2013
1	Argentina	4.519991	4.537393	4.599813	4.584267
2	Australia	1	1	1	1
3	Brazil	4.718481	4.940578	5.965088	6.018719
4	Canada	1.091343	1.19971	1.288415	1.298316
5	China	11.6845	11.40633	11.08272	9.909569
6	France	1.272559	1.418264	1.650638	1.587133
7	Germany	1.241531	1.354543	1.53704	1.457974
8	India	36.55416	40.35704	44.92668	45.00527
9	Indonesia	17.57929	17.907	19.01357	19.41081
10	Italy	1.443899	1.619444	1.92202	1.877709
11	Japan	1.201381	1.344778	1.446568	1.746102
12	Mexico	5.80682	6.338298	6.877793	6.544721
13	Russia	4.836776	4.663187	4.792188	4.616739
14	Saudi Arabia	2.68029	2.57643	2.602513	2.598371
15	South Africa	7.219034	7.934832	9.232267	10.19332
16	South Korea	2.338514	2.572206	2.761299	2.596851
17	Turkey	5.110737	5.859127	6.333993	6.1484
18	United Kingdom	1.350269	1.516492	1.644792	1.61432
19	United States	1.070767	1.247577	1.311266	1.271792

Table 4. Adjusted Economic Growth Rates

No.	Countries	Year			
		2010	2011	2012	2013
1	Argentina	2.013279	1.895361	0.19566	0.632598
2	Australia	2	2.3	3.7	2.5
3	Brazil	1.589495	0.546495	0.167642	0.415371
4	Canada	3.115429	2.083837	1.319451	1.540458
5	China	0.890068	0.815337	0.694775	0.777027
6	France	1.571637	1.480684	0.181748	0.18902
7	Germany	3.302374	2.657723	0.26024	0.068588
8	India	0.281774	0.16354	0.104615	0.111098
9	Indonesia	0.352688	0.362987	0.331342	0.298803
10	Italy	1.177367	0.370497	-1.19666	-1.01187
11	Japan	3.912165	-0.37181	1.244324	0.916327
12	Mexico	0.878278	0.631084	0.581582	0.168074
13	Russia	0.930372	0.922116	0.709488	0.281584
14	Saudi Arabia	2.760895	3.337952	2.228615	1.539426
15	South Africa	0.42942	0.453696	0.270789	0.186397
16	South Korea	2.779542	1.438454	0.832941	1.155245
17	Turkey	1.800132	1.50193	0.331544	0.66684
18	United Kingdom	1.407127	1.055067	0.425586	1.053075
19	United States	2.334776	1.282486	1.754031	1.729842

growth of the j-th country. Table 4 reflects the indicator of adjusted economic growth.

Table 5 reflects both indicators – the actual and the adjusted data of economic growth rates.

As is evident from Table 5, the actual economic growth in China, for example, in 2013 was 7.7% and only 2.5% in Australia even though the Australian economy was 9.9 times larger than the Chinese economy in GDP per capita terms. Consequently, the 7.7% growth of the Chinese economy corresponds to the Australian economic growth of 0.8% (7.7:9.9). Similarly adjusted indicators of economic growth in other G20 countries are also given in Tables 4 and 5.

According to Table 6, the leading G20 countries in economic growth are Australia, the U.S., Canada and Saudi Arabia and not China, Indonesia and India.

Table 5. Actual and Adjusted Economic Growths Rates

No.	Countries		Year			
			2010	2011	2012	2013
1	Argentina	actual data	9.1	8.6	0.9	2.9
		adjusted data	2.0	1.9	0.2	0.6
2	Australia	actual data	2.0	2.3	3.7	2.5
		adjusted data	2.0	2.3	3.7	2.5
3	Brazil	actual data	7.5	2.7	1.0	2.5
		adjusted data	1.6	0.5	0.2	0.4
4	Canada	actual data	3.4	2.5	1.0	2.5
		adjusted data	3.1	2.1	1.3	1.5
5	China	actual data	10.4	9.3	7.7	7.7
		adjusted data	0.9	0.8	0.7	0.8
6	France	actual data	2.0	2.1	0.3	0.3
		adjusted data	1.6	1.5	0.2	0.2
7	Germany	actual data	4.1	3.6	0.4	0.1
		adjusted data	3.3	2.7	0.3	0.1
8	India	actual data	10.3	6.6	4.7	5.0
		adjusted data	0.3	0.2	0.1	0.1
9	Indonesia	actual data	6.2	6.5	6.3	5.8
		adjusted data	0.4	0.4	0.3	0.3
10	Italy	actual data	1.7	0.6	-2.3	-1.9
		adjusted data	1.2	0.4	-1.2	-1.0
11	Japan	actual data	4.7	-0.5	1.8	1.6
		adjusted data	3.9	-0.4	1.2	0.9
12	Mexico	actual data	5.1	4.0	4.0	1.1
		adjusted data	0.9	0.6	0.6	0.2
13	Russia	actual data	4.5	4.3	3.4	1.3
		adjusted data	0.9	0.9	0.7	0.3
14	Saudi Arabia	actual data	7.4	8.6	5.8	4.0
		adjusted data	2.8	3.3	2.2	1.5
15	South Africa	actual data	3.1	3.6	2.5	1.9
		adjusted data	0.4	0.5	0.3	0.2
16	South Korea	actual data	6.5	3.7	2.3	3.0
		adjusted data	2.8	1.4	0.8	1.2
17	Turkey	actual data	9.2	8.8	2.1	4.1
		adjusted data	1.8	1.5	0.3	0.7
18	United Kingdom	actual data	1.9	1.6	0.7	1.7
		adjusted data	1.4	1.1	0.4	1.1
19	United States	actual data	2.5	1.6	2.3	2.2
		adjusted data	2.3	1.3	1.8	1.7

The indicators presented in Table 3 are constructed on the principle of choosing the economy of a so-called "etalon" country which, in our case, is Australia, the country with the G20's highest GDP per capita. In this case, its economic growth indicator serves to rank similar indicators of other countries.

It will be interesting if the final results of the economic growth rate comparisons change in the case of using an average indicator for the group of countries instead of those of the "etalon" country.

It is not difficult to show that *the ratio of economic growth rates adjusted to remove the catch-up effect does not change regardless of how they were calculated – based on the indicators of any one country or on the average indicators of the group of countries*.

If the given group consists of m $(i = 1, 2, \ldots, m)$ countries, the average GDP per capita ($\bar{y}$) is calculated as follows:

Table 6. Rankings of G20 Countries by Actual and Adjusted Economic Growths Rates

No.	Countries		Year			
			2010	2011	2012	2013
1	Argentina	actual data	4	3-4	15	7
		adjusted data	7-8	5	15-17	10
2	Australia	actual data	16-17	14	6	8-9
		adjusted data	7-8	3	1	1
3	Brazil	actual data	5	12	14	8-9
		adjusted data	10-11	14-15	15-17	11
4	Canada	actual data	13	13	13	11
		adjusted data	3	4	4	3-4
5	China	actual data	1	1	1	1
		adjusted data	14-16	12	7-8	8
6	France	actual data	16-17	15	18	17
		adjusted data	10-11	6-7	15-17	14-16
7	Germany	actual data	11	10-11	17	18
		adjusted data	2	2	11-14	17-18
8	India	actual data	2	5	4	3
		adjusted data	19	17	18	17-18
9	Indonesia	actual data	8	6	2	2
		adjusted data	17-18	15-16	11-14	12-13
10	Italy	actual data	19	18	19	19
		adjusted data	13	15-16	19	19
11	Japan	actual data	10	19	12	14
		adjusted data	1	19	5	7
12	Mexico	actual data	9	8	5	16
		adjusted data	14-16	13	9	14-16
13	Russia	actual data	12	7	7	15
		adjusted data	14-16	11	7-8	12-13
14	Saudi Arabia	actual data	6	3-4	3	5
		adjusted data	4-5	1	2	3-4
15	South Africa	actual data	14	10-11	8	12
		adjusted data	17-18	14-15	11-14	14-16
16	South Korea	actual data	7	9	9-10	6
		adjusted data	4-5	8	6	5
17	Turkey	actual data	3	2	11	4
		adjusted data	9	6-7	11-14	9
18	United Kingdom	actual data	18	10-11	16	13
		adjusted data	12	10	10	6
19	United States	actual data	15	16-17	9-10	10
		adjusted data	6	9	3	2

$$\bar{y} = \frac{\sum_i^m y_i N_i}{\sum_i^m N_i} = \frac{\sum_i^m Y_i}{\sum_i^m N_i} \qquad (5)$$

where Y_i is the amount of GDP in the i-th country and N_i is the population of the i-th country.

Taking into account (3), the coefficient of proportional overlap of the catch-up effect of the j-th country ($\bar{\alpha}_j$) in the case of the average level of economic development of the countries can be calculated according to the formula:

$$\bar{\alpha}_j = \frac{\bar{y}}{y_j}. \qquad (6)$$

As in (4), the adjusted economic growth of the j-th country ($\bar{r}_j^*$); i.e., the economic growth in the j-th country corresponding to the growth of the group of the countries, given the hypothesis of proportional overlap of the catch-up effect, is determined as follows:

$$\bar{r}_j^* = \frac{r_j}{\bar{a}_j}. \tag{7}$$

If the growth of the world economy is denoted by $\bar{r}$, then, taking into account (1), we obtain:

$$\bar{r} = \frac{\sum_i^m \Delta Y_i}{\sum_i^m Y_i^0}.$$

Let us consider the ratio of adjusted economic growth rates separately. They are calculated based on a particular "etalon" country or on group averages.

Inserting (3) in (4),

$$r_{ij}^* = \frac{r_j y_j}{y_i}. \tag{8}$$

Based on (8), the ratio between the adjusted economic growth of the j-th country corresponding to the economic growth of the i-th country and the actual economic growth of the latter is as follows:

$$\frac{r_{ij}^*}{r_i} = \frac{r_j}{r_i} \cdot \frac{y_j}{y_i}. \tag{9}$$

Similarly, inserting (6) in (7), for the j-th and i-th countries, respectively, we obtain:

$$\bar{r}_j^* = \frac{r_j y_j}{\bar{y}}, \tag{10}$$

$$\bar{r}_i^* = \frac{r_i y_i}{\bar{y}}. \tag{11}$$

A comparison of (10) and (11), i.e., the ratio of the adjusted economic growth rates of the j-th and i-th countries corresponding to the economic growth of the group of the countries, is equal to:

$$\frac{\bar{r}_j^*}{\bar{r}_i^*} = \frac{r_j}{r_i} \cdot \frac{y_j}{y_i}. \tag{12}$$

Comparing (9) and (12), we get:

$$\frac{r_{ij}^*}{r_i} = \frac{\bar{r}_j^*}{\bar{r}_i^*}. \tag{13}$$

Based on (13), we can formulate the so-called invariance theorem [8: 11]: *The ratios of economic growth rates adjusted to remove the influence of the catch-up effect are the same in the case when the indicators of economic growth and the development level, that are used to calculate the coefficients of proportional overlap of the catch-up effect, belong to one selected country from the group of countries or are the average of this group; because the average of the group is a constant, the ratio of economic growth rates adjusted to remove the influence of the catch-up effect does not depend on the choice of the base indicators of economic growth and the development level that are used to calculate the coefficients of the proportional overlap of the catch-up effect.*

ეკონომიკა

მკვეთრი ზრდის ეფექტის პრობლემა და პოსტკრიზისული ეკონომიკური ზრდა მსოფლიოს წამყვან ქვეყნებში

ვ. პაპავა

აკადემიის წევრი, ივანე ჯავახიშვილის სახელობის თბილისის სახელმწიფო უნივერსიტეტის ეკონომიკისა და ბიზნესის ფაკულტეტი და პააატა გუგუშვილის სახელობის ეკონომიკის ინსტიტუტი

მსოფლიო ბანკის სტატისტიკური მონაცემების თანახმად, მსოფლიოს წამყვანი ქვეყანა არა მარტო პოსტკრიზისულ პერიოდში, არამედ ბოლო ათწლეულების განმავლობაში იყო ჩინეთი. პოსტკრიზისულ პერიოდში ეკონომიკური ზრდის მიხედვით ჩინეთის მომდევნო ქვეყნებია ინდონეზია და ინდოეთი. ქვეყნების უშუალო შედარება ეკონომიკური ზრდის მიხედვით არაკონსტრუქციულია მკვეთრი ზრდის ეფექტის გამო, რომლის თანახმადაც კაპიტალის კლებადი უკუგებიდან გამომდინარე, ეკონომიკურად ნაკლებად განვითარებულ ქვეყნებში მაღალი ზრდის ტემპების მიღწევა უფრო ადვილია, ვიდრე ეკონომიკურად უფრო განვითარებულ ქვეყნებში. სხვადასხვა ქვეყნის ეკონომიკური განვითარების გასაზომად გამოიყენება მოსახლეობის ერთ სულზე მთლიანი შიგა პროდუქტის მაჩვენებელი. სტატიაში წამოყენებულია მკვეთრი ზრდის ეფექტის პროპორციული გადაფარვის ჰიპოთეზა. სტატია შეიცავს ინვარიანტულობის თეორემის დამტკიცებას. მკვეთრი ზრდის ეფექტის კორექტირებით ეკონომიკური ზრდის კოეფიციენტების თანახმად ეკონომიკურ ზრდაში მსოფლიოს წამყვან ქვეყნებია ავსტრალია, აშშ, კანადა და საუდის არაბეთი.

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