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The Catch-Up Effect and Regional Comparisons of Growth Indicators

(With the Eastern Partnership Countries as an Example)

We find that direct comparisons of economic growth by region are not constructive due to the catch-up effect, so certain preconditions must be taken into account. We propose adjusting levels of economic growth based on a hypothesis of proportional overlap for the catch-up effect, after which they can be used to compare economic growth across regions.

Key words: economic growth, catch-up effect, regional comparison, countries of the Eastern Partnership.

Economic growth is a central problem, and several important publications are devoted to its study.[1] To assess this phenomenon, we must use the appropriate methods for measuring it. As we know, the two indicators for measuring economic growth are growth rate (R) and rate of increase (r) of gross domestic product (GDP). The first is calculated by dividing real GDP during the reporting period (Y^1) by baseline GDP (Y^0):

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$$R = \frac{Y^1}{Y^0}. \tag{1}$$

To calculate the rate of increase, it is necessary to divide the rate of change in real GDP ($\Delta Y = Y^1 - Y^0$) by the baseline real GDP (Y^0):

$$r = \frac{\Delta Y}{Y^0}. \tag{2}$$

As we know, the relationship between these two parameters is:

$R = 1 + r.$

In practice, to determine economic growth we usually use the second of these two indicators, the rate of increase of real GDP. One of the problems associated with measuring economic growth is the comparison of growth rates across different countries and regions. In essence, due to diminishing capital returns, countries with relatively low levels of economic development find it easier to achieve higher growth rates than countries with more advanced economies, all other things being equal. In economics, this phenomenon is called "the catch-up effect"[2] (from the English[3]).

To illustrate the catch-up effect, consider the numbers provided by the World Bank indexes for economic growth among Eastern Partnership countries[4] (six former Soviet countries are included in the scope of the European Neighborhood Policy: Armenia, Azerbaijan, Belarus, Georgia, Moldova, and Ukraine), as well as in Russia and the United States, during the same period comparing 2009 with 2010 (Table 1). In 2010, all of the countries in Table 1 except Armenia saw economic growth surpassing that of the United States (including almost 2.6 times higher in Belarus, almost 2.4 times in Moldova, and 2.1 times in Georgia). Obviously a direct comparison of economic growth rates in different countries does not give a reliable estimate of the real situation, as the "starting" conditions (i.e., the levels of economic development) in these countries are very different from one another.

Only by adjusting for the catch-up effect in terms of economic growth can we compare them (this also applies to highly developed and underdeveloped countries). To adjust for the catch-up effect, we have to determine which factors will modify economic growth such that one can successfully compare these figures by country and region, which is the purpose of this article.

As we know, the usual indicator of economic development is per

Table 1

Economic Growth and Level of Economic Development in Eastern Partnership Countries, Russia, and the United States

Country	Economic growth in 2010 as compared to 2009 (%)	Per capita GDP in 2009 (US$)	Ratio of actual economic growth in a given country to that of the United States	Proportion of catch-up effect (ratio of U.S. per capita GDP to that of a given country)	Hypothetical economic growth	Ratio of a given country's hypothetical economic growth to U.S. actual economic growth	Ratio of actual U.S. economic growth to a given country's hypothetical economic growth
Azerbaijan	5.0	4,950	1.7	9.1	0.55	0.18	5.45
Armenia	2.1	2,803	0.7	16.1	0.13	0.04	23.08
Belarus	7.7	5,183	2.6	8.7	0.89	0.30	3.37
Georgia	6.3	2,441	2.1	18.5	0.34	0.11	8.82
Moldova	7.1	1,526	2.4	29.6	0.24	0.08	12.50
Ukraine	4.1	2,545	1.4	17.8	0.23	0.08	13.04
Russia	4.3	8,616	1.4	5.2	0.83	0.28	3.61
United States	3.0	45,192	1.0	1.0	3.00	1.00	1.00

capita GDP (y), which is determined by dividing GDP (Y) by the population (N):

$$y = \frac{Y}{N}.$$ (3)

It should be noted that, when comparing regions using this indicator, the result is usually measured in U.S. dollars (see Table 1).[5]

The U.S. economy (in terms of GDP per capita) is 8.7 times larger than the economy of Belarus, 29.6 times that of Moldova, and 18.5 times that of Georgia. Naturally, 1 percent growth in the United States, all else being equal, amounts to considerably more than in each of these listed countries because of the catch-up effect.

Logically, we can assume that, inasmuch as U.S. economic development, for example, was 17.8 times higher in 2009 than the corresponding figure in Ukraine, it was 17.8 times more difficult for the United States to achieve the same economic growth rate as Ukraine, all elese being equal. This argument is based on the following hypothesis: *if the level of economic development in one country is α times the level of economic development in the second, then it will be α times more difficult for the first country to achieve the same economic growth as the second.*

We call this assumption the *hypothesis of proportional overlap for the catch-up effect,* or in short, the *proportional overlap hypothesis.* For its mathematical description we use α_{ij} to denote the ratio of GDP per capita in country i (y_i) to that of country j (y_j) during the same span of time:

$$\alpha_{ij} = \frac{y_i}{y_j}.$$ (4)

Due to the nature of this proportional overlap hypothesis, the proportional overlap of country i to the catch-up effect in country j creates a coefficient that we will call, in short, the *proportional overlap coefficient.*

If the actual economic growth of country j is equal to r_j, then the economic growth of country j, corresponding to the economic growth in country i, under the catch-up effect hypothesis will be calculated as follows:

$$r_{ij}^* = \frac{r_j}{\alpha_{ij}}.$$ (5)

Consequently, r_{ij}^* is the hypothetical economic growth of country j,

which can be used to measure relative economic growth against country *i*. In short, we will call r_{ij}^* the *hypothetical economic growth quotient for country j*.

If we divide the actual economic growth of country *i* (r_i) by the hypothetical economic growth quotient for country *j* (r_{ij}^*), we obtain a value that indicates how many times the economic growth of country *i* really exceeds that of country *j*. Based on Equation (3) we obtain the equation:

$$\beta_{ij} = \frac{r_i}{r_{ij}^*} = \frac{r_i}{r_j}\alpha_{ij}. \tag{6}$$

Given Equations (2)–(5), we can write Equation (6) as:

$$\beta_{ij} = \frac{\dfrac{\Delta Y_i}{N_i}}{\dfrac{\Delta Y_j}{N_j}} = \frac{y_i}{y_j},$$

where y_i and y_j represent per capita GDP increase in countries *i* and *j*, respectively.

Therefore, Ukraine's real economic growth in 2010 was 4.1 percent compared to 2009, and in the United States it was 3 percent, even though the level of economic development in the United States was 17.8 times higher than that of Ukraine. Consequently, Ukraine's 4.1 percent growth corresponds to 0.23 percent growth in the United States (4.1 : 17.8 = 0.23). Table 1 gives the hypothetical economic growth of other countries similarly.

As noted above, the actual economic growth in Belarus, Moldova, and Georgia exceeded that of the United States. In reality we see a completely different picture. Thus, under the proportional overlap hypothesis, the appropriate ratio for measuring the actual economic growth in Belarus against the actual economic growth in the United States is 0.30 (0.89 : 3.0), in Moldova, 0.08 (0.24 : 3.0), and in Georgia, 0.11 (0.34 : 3.0). In other words, according to the actual figures, economic growth in Belarus is almost 2.6 times higher than growth in the United States, but after adjusting economic growth in the United States for the catch-up effect (3.0 : 0.89), U.S. growth, by contrast, exceeds growth in Belarus by nearly 3.4 times. For Moldova the ratio is 12.5 times (3.0 : 0.24), for Georgia, more than 8.8 times (3.0 : 0.34), and so forth.

The numbers given in Table 1 are based on the economic principle of

choice of a so-called country-standard, which in this example is the United States. For a "country-standard" one could select the state that has the highest GDP per capita in the world, and in accordance with this standard, the rates of economic growth in other countries would be adjusted similarly. This approach has one, purely technical drawback. For example, in 2009 in Luxembourg, GDP per capita was very high and amounted to $104,354 (while in the same year, in some other countries, the figure was even higher), and in Burundi, it was only $222 (nor was this the smallest value in the world).[6] So for Luxembourg the proportional overlap of the catch-up effect to the economy of Burundi would be 470.1 (104,354 : 222). This number is so large that, given the actual economic growth in Burundi (3.8 percent in 2010)[7], the corresponding hypothetical growth would be 0.008 percent (3.8 : 470.1). For Burundi, this figure is so small that it would round to zero. This problem also applies to many other countries that have relatively low GDP per capita and insignificant economic growth.

To avoid such difficulties it is better to take the average per capita GDP of a group of countries, which involves calculating the total amount of per capita GDP for the total population. The adjustments in economic growth of each country will be based on this figure as well. Naturally, such an approach for determining the amount of catch-up effect will involve the use of the averaged indicator of economic growth for this group of countries.

If the group in question consists of m countries ($i = 1, 2, ..., m$), then the average GDP per capita ($\bar{y}$) will be calculated as follows:

$$\bar{y} = \frac{\sum_i^m y_i N_i}{\sum_i^m N_i} = \frac{\sum_i^m Y_i}{\sum_i^m N_i}, \tag{7}$$

where Y_i is GDP in country i, and N_i is the population of country i.

If we take into account the possibility of variance in the composition of the group of countries in which we are studying the problem of adequate assessment of the level of economic growth, it would be better for the purposes of our research if we took the average GDP per capita for the global economy and the global economic growth rate. In that case, the basis for comparing indicators will not depend on any changes in the group of countries being studied. Consequently, if m is the total number of countries in the world, then we can determine global per capita GDP by using Equation (7). In 2009 this figure was $8,588.3 per capita for the total world population.[8]

Using Equation (4) for the average level of world economic develop-

ment, the proportional overlap of the catch-up effect in country j ($\bar{\alpha}_j$) will be calculated as follows:

$$\bar{\alpha}_j = \frac{\bar{y}}{y_j}. \tag{8}$$

By analogy with the ratio in Equation (5), the hypothetical economic growth of country j ($\bar{r}_j^*$) (i.e., economic growth in country j corresponding to global economic growth under the proportional overlap hypothesis) will be defined as:

$$\bar{r}_j^* = \frac{r_j}{\bar{\alpha}_j}. \tag{9}$$

If we denote global economic growth as $\bar{r}$, with regard to Equation (2) we obtain:

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

In 2010, global economic growth was 4.2 percent.[9]

Using Equation (6), $\bar{\beta}_j$ shows how many times the world's economic growth really differs from economic growth in country j:

$$\bar{\beta}_j = \frac{\bar{r}}{\bar{r}^*} = \frac{\bar{r}}{r_j}\bar{\alpha}_j.$$

Table 2 summarizes the economic growth and the level of economic development in the Eastern Partnership countries, Russia, and the United States, all of which are adjusted to exclude the influence of the catch-up effect on their respective indexes, as calculated globally.

When we compare the results shown in Tables 1 and 2, the question arises as to whether these results are identical. In other words, it is important to determine whether changes exist in the ratio of hypothetical economic growth (which excludes the influence of the catch-up effect) depending on changes in baseline levels of economic development, on which the coefficients of proportional overlap for the catch-up effect were also based.

As we can see, *regardless of which method we accept as a basis for verifying economic growth (i.e., a hypothetical calculation of the economic growth indicators) in order to eliminate the catch-up effect, either the economic performance and growth of one country or the average performance of the global economy, the ratio of these revised rates of economic growth does not change.*

To confirm this, we consider hypothetical growth calculated on the

Table 2

Economic Growth and Level of Economic Development in Eastern Partnership Countries, Russia, the United States, and Globally

Country	Economic Growth in 2010 as compared to 2009 (%)	Per capita GDP in 2009 (US$)	Ratio of actual economic growth in a given country to global economic growth	Proportion of catch-up effect (ratio of the global per capita GDP to that of a given country)	Hypothetical economic growth	Ratio of a given country's hypothetical economic growth to actual global economic growth	Ratio of the actual global economic growth to a given country's hypothetical economic growth
Azerbaijan	5.0	4,950.0	1.19	1.735	2.88	0.69	1.46
Armenia	2.1	2,803.0	0.50	3.064	0.69	0.16	6.09
Belarus	7.7	5,183.0	1.83	1.657	4.65	1.11	0.90
Georgia	6.3	2,441.0	1.50	3.518	1.79	0.43	2.35
Moldova	7.1	1,526.0	1.69	5.628	1.26	0.30	3.33
Ukraine	4.1	2,545.0	0.98	3.375	1.21	0.29	3.47
Russia	4.3	8,616.0	1.02	0.997	4.31	1.03	0.97
United States	3.0	45,192.0	0.70	0.190	15.79	3.76	0.27
Globally	4.2	8,588.3	1.00	1.000	4.20	1.00	1.00

basis of any individual country, and growth based on the aggregate performance of the global economy.

Substituting Equation (4) into Equation (5), we obtain:

$$r_{ij}^* = \frac{r_i y_j}{y_i}. \tag{10}$$

From Equation (10), the hypothetical economic growth of country j as it corresponds to growth in country i, and the actual economic growth of country i are equal to one other:

$$\frac{r_{ij}^*}{r_i} = \frac{r_j}{r_i} \cdot \frac{y_j}{y_i}. \tag{11}$$

Similarly, substituting Equation (8) into Equation (9) for countries j and i, respectively, we obtain:

$$\overline{r}_j^* = \frac{r_j y_j}{\overline{y}}, \tag{12}$$

$$\overline{r}_i^* = \frac{r_i y_i}{\overline{y}}. \tag{13}$$

We combine Equations (12) and (13), that is, we calculate the ratio of hypothetical economic growth of country j to the hypothetical economic growth of country i as they correspond to global economic growth:

$$\frac{\overline{r}_j^*}{\overline{r}_i^*} = \frac{r_j}{r_i} = \frac{y_j}{y_i}. \tag{14}$$

Comparing Equations (11) and (14):

$$\frac{r_{ij}^*}{r_i} = \frac{\overline{r}_j^*}{\overline{r}_i^*}. \tag{15}$$

Based on Equation (15), we can formulate an *invariance theorem: the ratio of hypothetical economic growth, excluding the influence of the catch-up effect, does not depend on the choice of basic economic growth indicators or the countries' levels of development, which were used to calculate the proportional overlap for the catch-up effect.*

As an illustration of Equation (15), we can compare the ratio of economic growth, excluding the influence of the catch-up effect, in Ukraine and the United States, for example (see Tables 1 and 2). Table 1 shows that the ratio is 0.08, and Table 2 also shows 0.08 (1.21 : 15.79).

The invariance theorem suggests that this approach eliminating the

catch-up effect in terms of economic growth for the purpose of comparing different regions is not a controversial one, and can be applied in practice without too much difficulty.

The approach for assessing the catch-up effect that we have proposed in this article can be further developed by improving the proportional overlap hypothesis.

Notes

1. See, for example, J.E. Stiglitz, A. Sen, and J.P. Fitoussi, *Mismeasuring Our Lives: Why GDP Doesn't Add Up. The Report by the Commission of the Measurement of Economic Performance and Social Progress*. New York: New Press, 2010; R. Dzh. [R.J.] Barro and Kh. Sala-i-Martin [X. Sala-i-Martín], *Ekonomicheskii rost* (Moscow: Binom. Laboratoriia znanii, 2010); M. Flerbe, "Za predelami VVP: v poiskakh mery obshchestvennogo blagosostoianiia," Parts 1 and 2, *Voprosy ekonomiki,* 2012, nos. 2 and 3.

2. See N.G. Menk´iu [Mankiw], *Printsipy ekonomiki* (St. Petersburg: Piter Kom, 1999), pp. 523–24.

3. See N.G. Mankiw, *Principles of Economics* (Mason, OH: Thomson South-Western, 2004), pp. 546–47.

4. See World Bank, "GDP Growth (Annual Percentage)," 2012; available at http://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG/.

5. See World Bank, "GDP per Capita (Current US$)," 2012; available at http://data.worldbank.org/indicator/ NY.GDP.PCAP.CD/.

6. Ibid.

7. See World Bank, "GDP Growth."

8. See World Bank, "GDP per Capita."

9. See World Bank, "GDP Growth."