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## Macroconstants of Development: A New Benchmark for the Strategic Development of Advanced Countries and Firms

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**“Macroconstants of Development”: A new benchmark for the strategic development  
of advanced countries and firms**

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**Abstract:** This research proposed a new indicator of countries’ development called “*macroconstants of development*”. The literature review indicates that the concept of “*macroconstants of development*” is not used at the moment in neither the theory nor the practice of industrial policy. Research of longitudinal data of total GDP, GDP per capita and their derivatives for most countries of the world was conducted. An analysis of statistical information has been done by employing econometric analyses.

Based on the analysis of the statistical data, which characterizes the development of large, technologically advanced countries in ordinary conditions, it was identified that the average acceleration of an individual country’s development is practically independent of time. Therefore, the new indicator “*macroconstants of development*”, which characterizes the acceleration rate of a country’s technological development, was proposed. Several advantages were recognized for the proposed indicator of acceleration, rate of growth of GDP and GDP per capita, over other commonly-used development indicators.

The findings of this research indicated that the majority of large, technologically advanced countries can be grouped together using the proposed indicator, the acceleration rate of development or “*macroconstants of development*”. The practical application for employing the “*macroconstants of development*” as a single indicator is to more accurately forecast 15 or more years of long-term development of individual countries as well as large firms.

Overall, the contribution of this research is a proposed new direction to study the development of the world’s economic systems at the micro, meso and macro levels. As a result, the new advanced method will be available to policy makers for economic development decisions under the market conditions.

**Keywords:** firm, forecasting, development, economics, potential, a constant pattern, clustering.

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## 1. Introduction

The growth of the aggregated measures of production, such as gross domestic product (GDP) and GDP per capita, are some of the most common indicators of economic growth. Statistical data indicates, on average, the GDP is increasing in most countries although with different growth rates (Cavusgil et al., 2013). The indicator of the GDP growth is directly linked to its speed and acceleration rate. In the environment where GDP for the majority of the countries is constantly increasing, the opportunity to become a global leader will be dependent on the country's average long-term GDP acceleration growth rate, specifically GDP per capita. The country's long-term leadership position, including its technological progress, is directly linked to its economic development growth. GDP is the sum of the gross values added for all residents and institutions engaged in production, and is created primarily by firms. Therefore, it is a stable measurement of the economic performance of the country and is considered to be one of the most important indicators of the firms' development in the competitive environment. It is commonly accepted that technological capabilities are a fundamental factor to achieve any substantial goals, including an increase in quality of life or a higher income (Archibugi & Coco, 2004). It is difficult to determine where the technological capabilities are a determinant or an effect of economic growth.

Forecasting and planning are critical to identify opportunities and threats, and position yourself for future success. This research proposed a new characteristic of strategic development known as "*macroconstants of development*," which can be employed for long-term forecasting of economic and technological development for advanced countries as well as large firms.

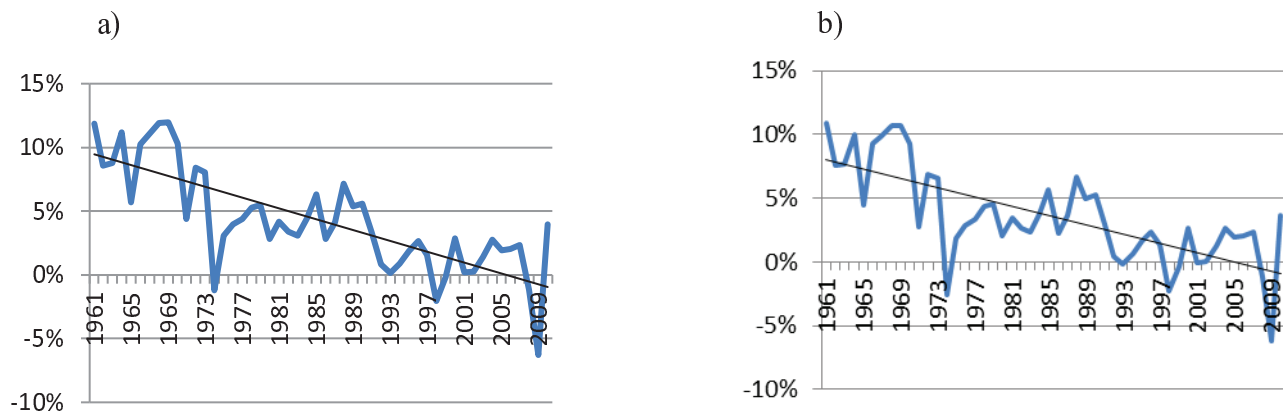
## 2. The research problem

GDP and GDP per capita are considered to be universal measures of economic performance. Stockhammer et al. (1997) stated that GDP is used as the key indicator for a country's economic policy development, despite its inadequacy. However, some researchers criticize those indicators due to their inability to accurately represent the whole picture, including the measurement of the standard of living or the country's progress (Bregar, 2008). One of the explanations is that GDP simply counts everything produced in a country, such as products and services, and ignores other issues. For example, a country may achieve a high level of GDP, but at the same time can over exploit its natural resources or misallocate investments (Bregar, 2008). Additionally, the level of GDP is also not an appropriate measure of welfare (Stockhammer et al., 1997).

A number of researchers have been criticizing general grouping approaches for relying exclusively on aggregate, general country indicators because these macro indicators may not accurately reflect market development for a product (Sakaria et al., 2007). Countries' market estimation methods employ aggregate market potential and overall attractiveness, based on the ranking of economic indicators. Those characteristics may include indicators of size, production, competition, wealth, growth, and other factors which can be derived from economic development, internal stability and cohesion (Sakaria et al., 2007). However, those methods fail to take into account a country's heterogeneity and economies of scale in production, or may use outdated secondary data. Moreover, GDP neglects to take into account future welfare reductions, income inequality, economic stagnation, and other factors. Therefore, it does not provide a comprehensive view of the country's economic welfare. As a result of this shortcoming, economists try to find alternative methods which can be used to project a country's strategic development.

The literature review indicates that the concept of "*macroconstants of development*" is at the moment not used in either the theory (Suharev, 2014) or in the practice of industrial policy (Mayburd, 2000; Maddison, 2004; Meddison, 2012; Mankiw, 2009) On the other hand, the inverse characteristic of countries' development, such as the rate of instability, is a known unit of measurement. The existence of instability is not too difficult to verify. This can be done by investigating trends for the aggregated GDP percentage change or the percentage change for GDP per capita for the advanced countries. Figure 1 demonstrates the negative trend for GDP percent change and GDP per capita percent change using the example of Japan between 1961 and 2010.

**Figure 1** Trends of the aggregate GDP percentage change (a) and the GDP per capita percentage change (b) on example of Japan, 1961-2010.



Source: calculated

In economic theory, the uneven growth of countries' economic development and the existence of cycles of economic activity (economic conditions) are generally accepted. A significant amount of effort is allocated to research those economic activity cycles. Both the chaotic unevenness and the cycles of economic activity are usually interpreted as fluctuations along the long-term trend of economic development. For practitioners, the research on characteristics of this trend is, in some cases, even more important than the study of the exact deviations from it.

From the practical position, it is particularly important to identify the constant characteristics of a long-term development trend of the advanced countries. The identified constant would serve as a benchmark and as a target for long-term development for both the technologically leading countries and for countries that only seek to enter in their group.

The analysis of dynamics of economic development of major advanced countries suggests that over the next 15 - 20 years their development can potentially be characterized by some stable quantitative measurement unit. We are proposing that measurement is *the average acceleration rate of the development*, which is not time-dependent. Based on our research of the dynamics of advanced economies including the world's technological leaders, the following research statement is proposed:

After reaching a certain level of development in the post-industrial period, the acceleration rate of development for large, technologically advanced countries can be characterized by the certain constants of macroeconomic development. We called those constants the actual "*macroconstants of development*" or "*macroconstants*". The assumption is that *macroconstants of development* is a

stable characteristic of the country's level of development over a long period of time between 15 and 40 years.

### **3. Methodology and the Results**

The existence of *macroconstants* will be analyzed using the coefficient of determination between the studied factor and time. If the value of coefficient of determination is insignificant, then it can be argued that the magnitude of the investigated factor (Y) does not depend on time (X). The assessment of the significance of the coefficient of determination will be analyzed using the Student's t-test, a statistical hypothesis test.

The results of t-statistic tests demonstrated that for most cases the absolute value of test statistics is lower than the critical value ( $t < t_{\text{critical}}$ ) with the probability of 99% ( $p\text{-value} < 0.01$ ). Therefore, this confirms the high probability that there is no relationship between the investigated factor (Y) and the time (X). Typically, researchers seek to find relationships between economic characteristics. In this case, the problem is reverse; this study investigated that some countries during certain stages of their development might have the development indicator, which is non-time dependent.

In order to identify this indicator or the *actual macroconstants of development*, major performance characteristics of the world countries were investigated using the World Bank data. For example, research was conducted to examine the changes over time for macroeconomic indicators such as GDP, the GDP growth rate, the percentage of annual GDP growth, as well as these indicators per capita and per employed person. In total, nine major indicators were selected to conduct the investigation.

In order to justify the existence of *macroconstants* for the select group of advanced countries, three stages of analyses were executed. In the first stage, nine indicators, as potential *macroconstants* candidates, were investigated in order to identify which one could claim the status of *macroconstants*. Additionally, the selection criteria were established to select countries who's development could be characterized by the previously identified *macroconstants*. In the second stage, the favorable conditions, as well as limitations, were researched to find which produce *macroconstants*. The third stage demonstrated that *macroconstants* have a high probability to continue its existence either as is or with a small modifications.

#### ***The first phase***

In the first phase of the research, all nine major indicators that can potentially claim the status of *macroconstants of development* were researched. The analyses were conducted on more than 200 countries. As a result, three indicators were selected as possible candidates to become *macroconstants*. These were: the percent of GDP growth, which is the most commonly used measure of macroeconomic development, the absolute value of GDP per capita, and the value of the absolute growth of GDP per capita per year.

### The percent of GDP growth

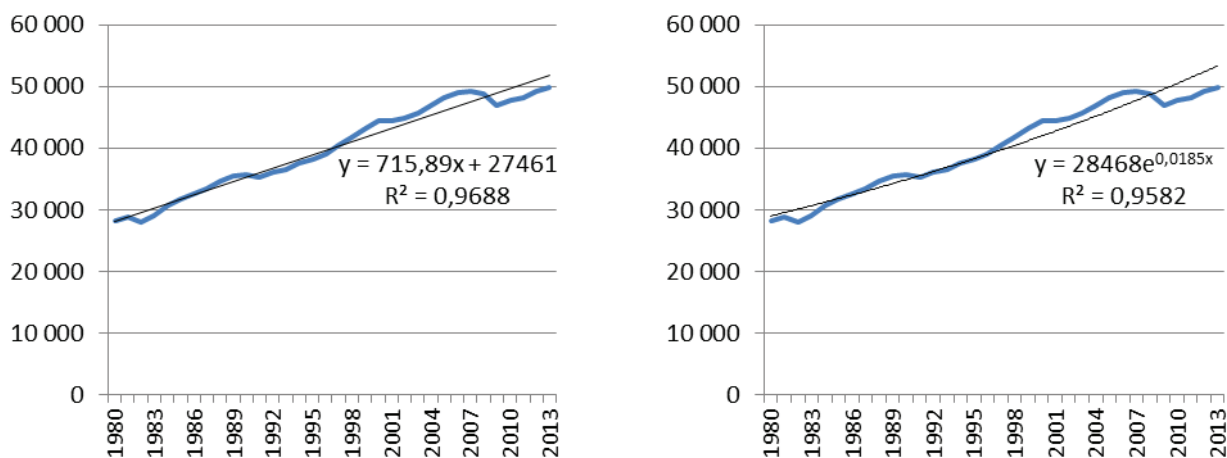
One of the rare arguments in favor of the presence of constants of macroeconomic development or *macroconstants* is the constant percentage increase of Gross National Product (GNP) in the United States during a significantly long period of time. For almost 100 years, between 1890-1986, the United States had the constant annual GNP percentage growth rate of 3.2%.

However, statistical data indicates that the leading economies of the world are not capable of maintaining a constant percentage growth rate for a long period of time. The modern practices of major developed countries often demonstrate that the percentage growth rate is significantly decreased over time, for example after the wave of industrialization. This can be seen in examples of the economic development of Japan, the U.K., France, Germany (see Figure 1).

Moreover, the GDP percentage growth rate can be difficult to accurately compare between different countries. First, the same percentage of growth for macroeconomic indicators for various economies is quite different. With the increase of the GDP base, the same percentage growth begins to be similar to the absolute value. Second, the growth rate of aggregate macroeconomic indicators (not per capita) is a weak reflection of the real economic growth due to the influence of hidden factors such as the population growth. For example, if the population growth in the country in any given year was 3% and the GDP growth was the same 3%, then, in fact, per capita growth in wealth has not occurred at all. Additionally, it can be demonstrated that in the GDP per capita with a constant percentage growth rate or an exponential increase in the absolute value of its growth, there is a hidden decline in the percentage growth over the period of time.

Figure 2 demonstrates the GDP per capita of the United States in US Dollars (in 2009 value) between the period of 1980-2013 with linear and exponential trends. Although, as can be seen through ocular inspection, during this period of time two trends behave almost identically, the coefficient of determination captures the slight difference between these trends in favor of linear. This means that a linear increase in this case ( $R^2=0.9688$ ) describes the trend better than the exponential trend ( $R^2=0.9582$ ). Therefore, the real GDP growth only approximately corresponds to the exponential trend or the constant rate of growth.

**Figure 2.** GDP per capita of USA, 1980 to 2013, the linear trend (left) and the exponential trend (right).



The analysis of a longer period reveals much more significant differences between the average value of percent GDP growth during different time intervals. According to our computations, in the United States between the period of 1929-2013, the average percentage growth rate of GDP per capita was 2.4%. However, if you separate the available data into two equal periods of 42 years each, it becomes obvious that the percentage growth is significantly declines over time. It was 3.06% in the first period and 1.91% in the second, i.e. is reduced by one third.

#### *The absolute value of GDP per capita*

In addition to the percent of GDP growth, which was previously discussed, another potential candidate for the role of *macroconstants of development* is the absolute value of GDP per capita. However, this indicator is closely linked to the value of time and, therefore, cannot be claimed to be a constant over time.

#### *The absolute growth of GDP per capita*

The last contender for the role of *macroconstants of development* is the absolute growth of GDP per capita per year. This research demonstrated that the indicator could claim to be the *macroconstants*, but only under certain conditions.

### ***The second phase***

In the second phase of the research it was determined under what conditions or criteria of selection *macroconstants of development* may arise. In order to select countries where *macroconstants* may be present, 214 countries were under investigation using three previously identified criteria.

The first selection criterion limits the minimum size of the country's population. According to our evaluation the boundary is 3 million people. This lower limit is also close to the minimum population of the leading countries of the world, which are included in the annual statistical and analytical reports for the USA Bureau of Labor Statistics (BLS). For example, the minimum population for countries to be included in the BLS report for 2011 was 3.4 million people (Ireland). Rounding down we identified a boundary of at least 3 million people as a minimum size of countries population.

The second criterion requires that the countries belong to the "post-industrial period" of development. Based on the previous research (Asaliev and Yusim, 2012), the lower boundary of the "post-industrial period" is that countries reach the values of real GDP per capita of \$15,000 in US dollars (in the 2005 value). The third criterion requires that the countries were included in the "post-industrial period" of development for a long period of time, i.e. no less than 15 years.

After applying those three identified criteria to all countries in the world the following 13 countries remained for the further consideration: Australia, Belgium, Canada, France, Germany, Greece, Italy, Japan, South Korea, the Netherlands, Spain, the UK, and the USA.

Additionally, in order to select a period of stability or normal development, economic crisis and the stagnation period data were excluded from the analysis, as well as data for the three years with the highest rates of the economic growth.

Figure 3 demonstrates the linear trend of the absolute growth of GDP per capita with time for the example of the Germany during its period of stable economic development between 1969 -2011.



The analyses demonstrate the lack of dependency between the absolute growth in GDP per capita and time ( $R^2=0.0004$ ,  $t=0.111$ ,  $t$  critical  $=2.7444$ ,  $t < t$  critical). We can conclude that this relationship is non-significant with a probability of 99%.

**Figure 3.** The GDP per capita of Germany, 1969 -2011

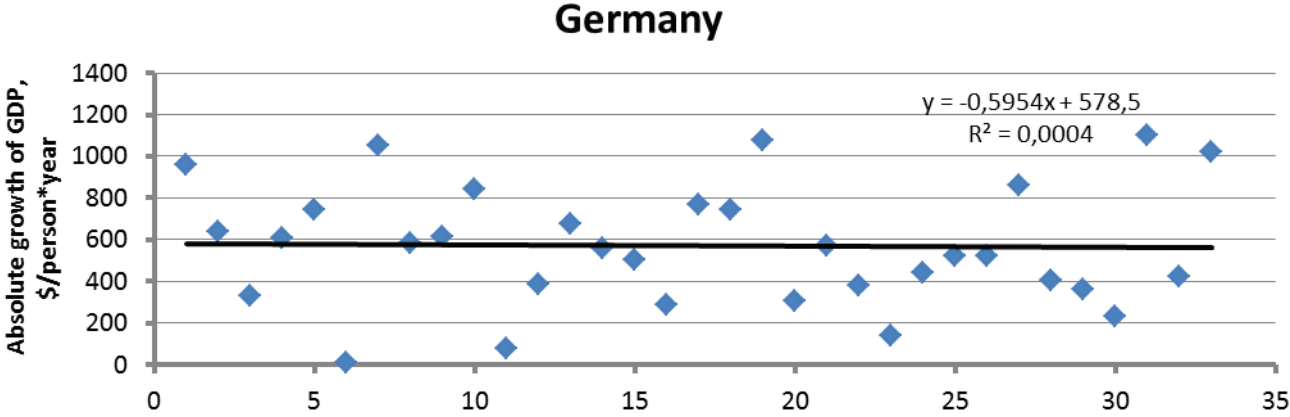
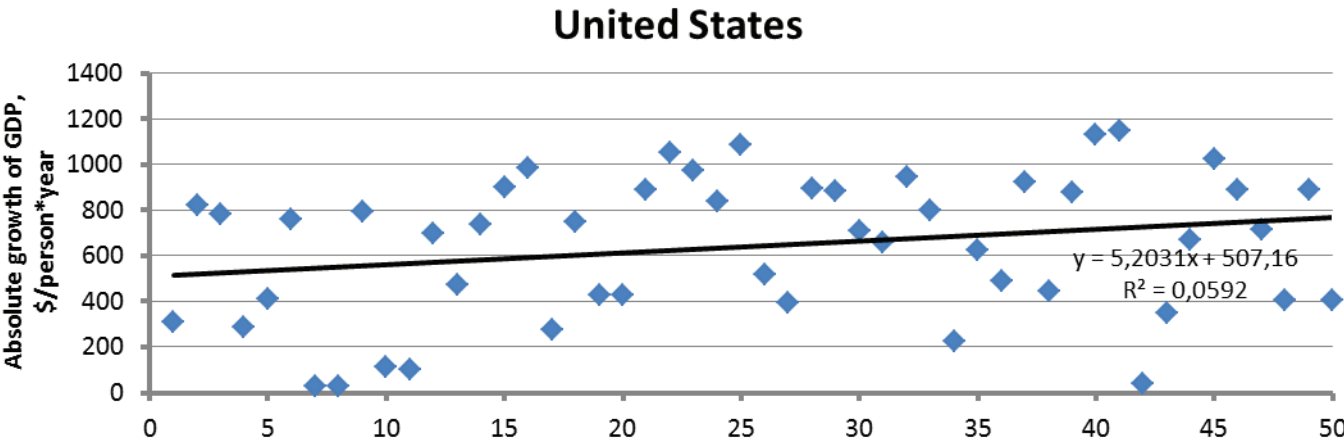


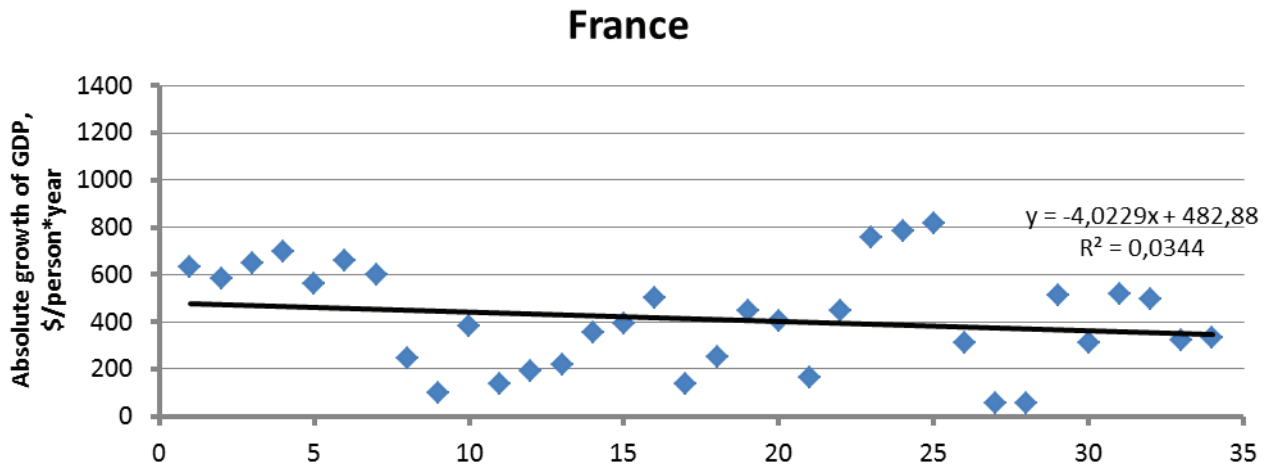
Figure 4 demonstrates the development trend for the example of the United States for the longest post-industrial period among all countries of the world. This was the period of stable economic development between the years of 1948-2011. Visually, the regression line indicates an increase in the growth rate of GDP per capita. However, the statistical analyses did not confirm the increase in the rate of growth of GDP over time. This is also statistically insignificant by Student's test value of  $R^2$  ( $t = 1,739$ ,  $t$  critic.  $= 2.682$ ,  $t < t$  critical). We can conclude that this relationship is non-significant with a probability of 99%.

**Figure 4.** The GDP per capita of USA, 1948 -2011



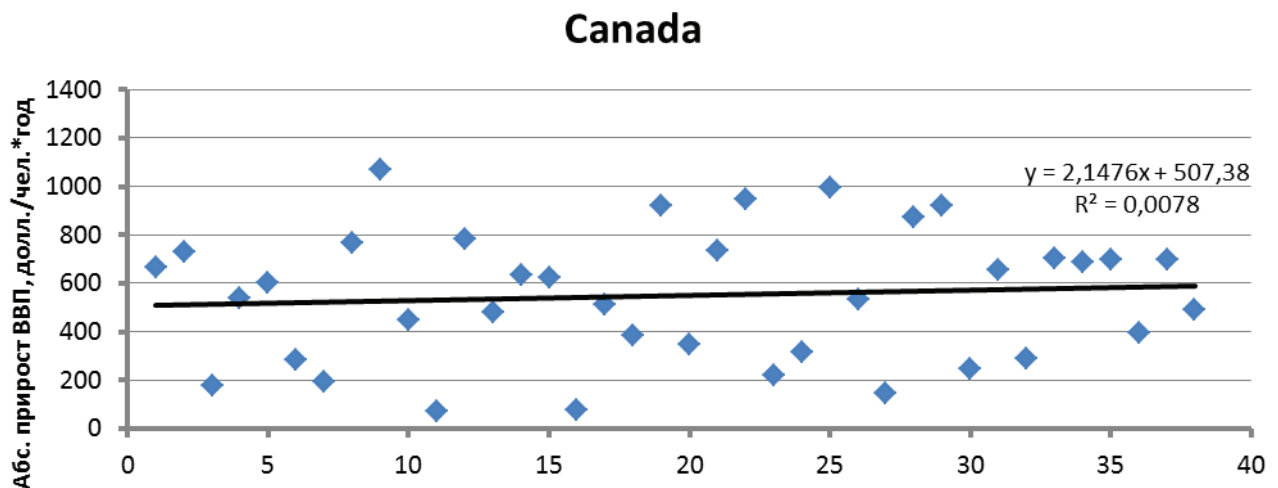
The existence of *macroconstants of development*, as was previously demonstrated in the examples of the United States and Germany, was confirmed for other globally leading countries during their stable periods of economic development (see Figures 5, 6 & 7). The values of the growth rate of GDP per capita are expressed in US dollars (in 2005 value).

Figure 5. The GDP per capita in France, 1971 -2011



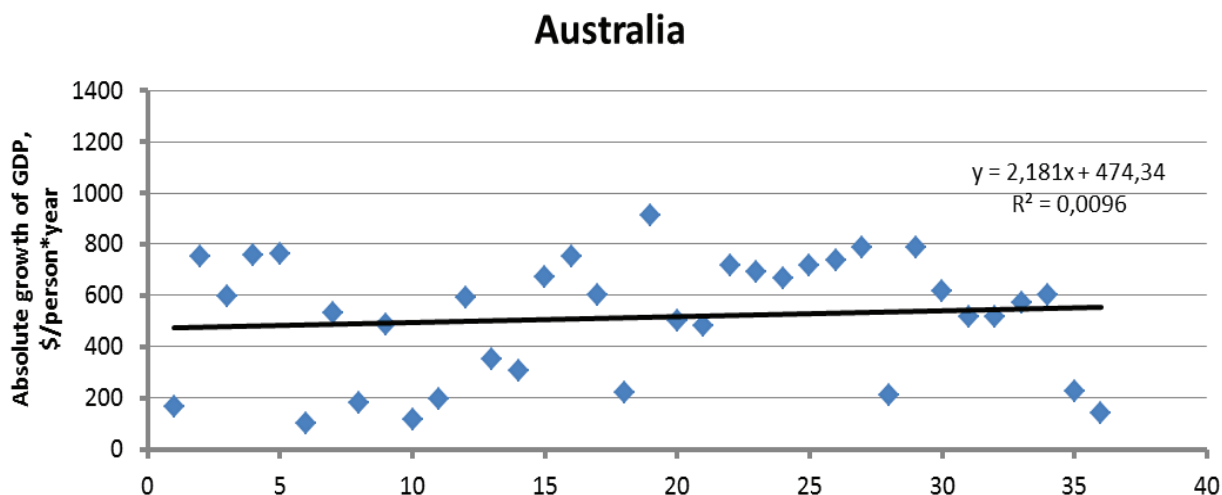
Results:  $t = 1.067$ ,  $t$  critical = 2.738; non-significant with a probability of 99%

Figure 6. The GDP per capita in Canada, 1965 -2011



Results:  $t = 0.533$ ,  $t$  critical = 2.719; non-significant with a probability of 99%

Figure 7. The GDP per capita in the Australia, 1966 -2011



Results:  $t = 0.573$ ,  $t$  critical = 2.728; non-significant with a probability of 99%

The research findings indicated that similar results were obtained for all 13 countries under investigation.

The value of the coefficient of determination  $R^2$  near to zero, allows us to conclude that for countries that met the three defined criteria of selection, the absolute growth GDP per capita in the stable economic environment does not depends on time. Based on the results in the second stage of the analysis, we can argue that only for major countries and only under the normal conditions during the post-industrial period, *macroconstants of development* will occur.

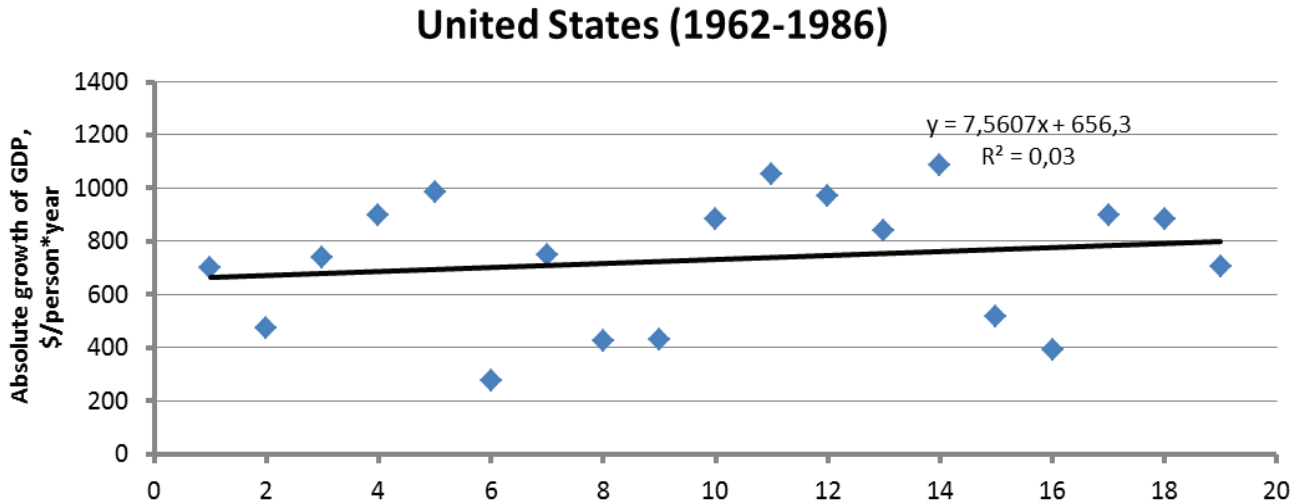
The purpose of this research was to demonstrate the existence of *macroconstant of development*, which occurs in the major advanced countries of the world when data during the period of crises and three years with the highest development rate are excluded. At the same time, it should be mentioned that in most cases, *macroconstants* can also occur during crisis and the most productive years, but they are not as strong.

### ***The third phase***

The task of the third phase of this research was to investigate the dynamics of the developed countries in order to demonstrate that *macroconstants*, which were identified for the previous years will continue to exist in its present state or with small modification. This problem is explained by comparing two USA *macroconstants* identified for two consecutive periods of 25 years, between the years of 1962-1986 and between the years of 1987-2011 (see Figures 8 & 9). The rate of development of the country for the first 25 years is a good indicator to forecast the development rate for the following 25 years.

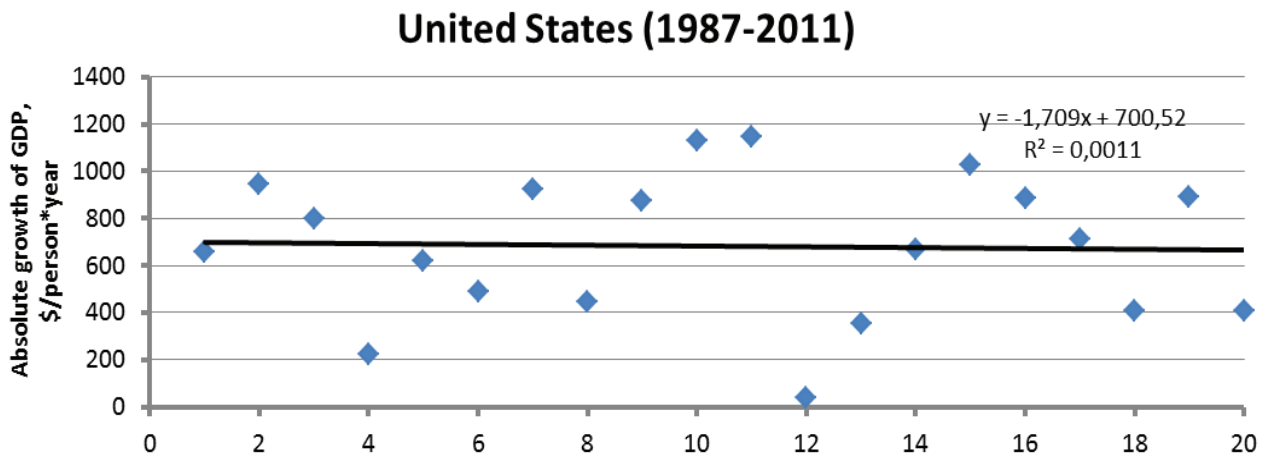
The rate of development of the US in the next 25 years was 683 USD per person per year (see Figure 9), which is 6.7 % different from the growth rate of the initial 25 years period of 732 USD per person per year (see Figure 8). Therefore, the forecasting for such long period of time is quite accurate. This means, that the characteristic of the development which has occurred in the first 25 years, has been preserved in the next 25 years.

Figure 8. The GDP per capita in the US for initial 25 years in a period of economic development



Results:  $t = 0.725$ ,  $t$  critical = 2.898; non-significant with a probability of 99%

Figure 9. The growth of GDP per capita in the US for the next 25 years in a period of economic development



Results:  $t = 0.14$ ,  $t$  critical = 2.878; non-significant with a probability of 99%

Table 1 demonstrates the identified values of the actual *macroconstants* of major developed countries, measured over three periods: for the entire period of post-industrial development, for the first 20 years of post-industrial development, and for the next 20 years of post-industrial development.

**Table 1.** Macroconstants of development of the major advanced countries

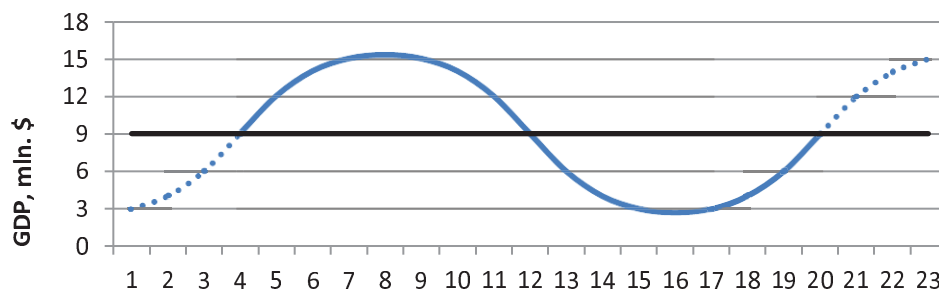
Country	Current Macroconstants, 2005 US \$ per cap.		
	All post-industrial period	The first 20 years of post-industrial period	The next 20 years of post-industrial period
United States	639.8	505.4	683.7
Japan	555.6	611.0	531.3
Germany	568.4	588.7	561.7
France	412.5	406.7	400.8
United Kingdom	601.0	523.4	696.3
Italy	435.6	499.2	422.7
Korea, Rep.	837.4	837.4	837.4
Spain	468.4	477.2	461.0
Canada	549.3	515.6	591.5
Australia	514.7	477.9	560.3
Netherlands	592.8	571.7	615.3
Belgium	500.6	516.7	500.0
Greece	462.5	462.5	462.5
<i>Average</i>	549,1	538,0	563,4

*Source: calculated*

#### 4. Discussion

The limitations for the application of a correlation coefficient are commonly accepted. The cases of the zero value of the correlation coefficient can demonstrate that behind each of them, there is some additional information that correlation analysis does not take into account. Additionally, if the relationship between the variable under investigation is not linear, then the interpretation of results based on the correlation coefficient will be inaccurate. For example, variables might have a complex non-linear relationship, such as demonstrated in Figure 10, and the correlation coefficient of zero will not identify any important information, which explains the relation between variables.

**Figure 10.** The Sinusoidal Pattern of GDP Growth and Decline



In complex nonlinear dependencies, the average value of the dependent variable will remain unchanged for any sufficiently long or infinite interval of the independent variable, as a result of

correlation coefficient limitations. The following example can demonstrate this. Let's assume that the change of annual gross domestic product (GDP) is sinusoidal and its cycle is 16 years (see. Fig. 10). In this case, the average GDP of the country in 16 years will be equal to the horizontal trend line. It could be interpreted that the country's GDP was without any change. The same result can be seen at the end of each full cycle of a sine wave.

We can argue that in the case of cyclic dependencies, such as a sine wave, as well as chaotic deviations, the zero value of the correlation coefficient demonstrates no relation between dependent and independent variables. It should be noted that in our example, we are not talking about the change in the dependent variable, but the absence of its long-term connection with the independent variable (such as time). This argument supports our proposition for the appearance of the statistical constants.

The interpretation of the concept of the actual *macroconstants of development* indicates that the *macroconstant* represents a strategically important characteristic of the country's economy. At a high value of *macroconstants*, the country is able to efficiently develop over a long period without the effect of any market fluctuations. At a low value of *macroconstants*, the country cannot ensure its high growth rates, even under favorable circumstances.

Moreover, due to the fact that the lion's share of the country's GDP is created by companies, the management of companies receive a clear guidance for the development of domestic as well as international markets under intense competition. If the rate of the company's development is below the country's current *macroconstants*, than the company will lose to the competition. If the company's rate is higher, than it will prosper in the market. Therefore, the actual *macroconstants of development* of major advanced countries can be used as the benchmark for the strategic assessment a firm's competitiveness.

The actual *macroconstants of development* of the country is a unique indicator of the average development of all its businesses. Therefore, if a company wants to remain successful and competitive, it is important to follow a pace of development that is not below the average. Additionally, the identified values of *macroconstants of development* can and should be an essential reference point for industrial policy of technologically advanced countries, or a goal for any country trying to achieve this level, regardless of its size.

The purpose of this research was to test the hypotheses that a group of similar countries will have its own *macroconstants*. The hypothesis testing, that the independent current *macroconstants* will originate within the groups of countries, was conducted using the methods of cluster analysis. In test mode, the clustering was performed on the set of selected 13 advanced countries.

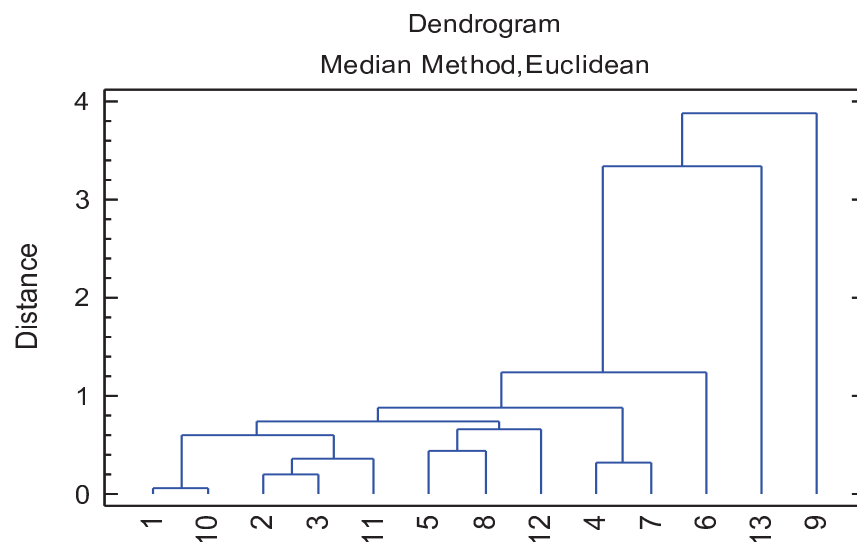
A group of countries under certain conditions, including GDP growth rate and post-industrial periods, can be identified that have similar values of current *macroconstants*. The population size was also considered in the cluster analyses. To test the hypothesis the following standard hierarchical methods<sup>1</sup> were employed:

1. Single linkage. Also known as the "method of a nearest neighbor".
2. Complete linkage. Also known as the "method of a distant neighbor."
3. Pair-group method using arithmetic averages.
4. Pair-group method using the centroid average.
  - Unweighted

- Weighted (median)
5. The Ward's method.

An evaluation of homogeneity of the sample size and division of the sample into clusters were conducted using a Euclidean<sup>2</sup> metric. In all cases, the three-sigma rule  $3\sigma$  was used as a criterion for the clustering divisions. If the distance between objects were less than three standard deviations, than countries were group together. Otherwise, they were grouped differently. However, the method of clustering did not give, at first sight, a satisfactory result. Countries simply joined each other in the hierarchical clustering with the rule of  $3\sigma$  combining countries into one group with the exemption of South Korea. The example of dendrogram is shown in Figure 11.

**Figure 11.** Clustering based on population ( $3\sigma = 3.7$ )



The vertical axis in Figure 10 shows the distance between objects. The connecting lines in the first step demonstrate which objects are close to each another. In following steps the same lines are attached to the next closest objects, which were already connected in the first step. This continues until the last object is connected. The abscissa presents the select countries which participated in the process of clustering: 1) Australia; 2) Belgium; 3) Canada; 4) France; 5) Germany; 6) Greece; 7) Italy; 8) Japan; 9) The Republic of Korea (South Korea); 10) The Netherlands; 11) Spain; 12) The United Kingdom; and 13) The United States of America.

The fact that some countries, with the average value of the acceleration growth rate of their GDP, were not divided into groups, demonstrates opportunities for their close development. This is characterized by the total average intra-group *macroconstants*, which valued \$540 (in the 2005 value) over the forecast period until 2030 and in the absence of a technological revolution. The maximum deviation between the growth of development for different countries and the group *macroconstant* is within 25%. The value of countries intra-group *macroconstant development* should serve as a lower boundary for the firms' rate of development.

## 5. Conclusion

In conclusion, our research findings can be summarized as the following: First, we confirmed that the development of technologically advanced countries, which should be in the stages of post-industrial development, is characterized by the unique *macroconstant development*, which is the acceleration rate of GDP per capita. Second, there is only one group of major advanced countries, the development of which in a stable environment is characterized by the intra-group *macroconstants*. Third, the value of the group *macroconstant development* for the technologically advanced leaders can serve as a benchmark for the strategic development of both the countries and companies. For companies, the *macroconstant* value should indicate the lower border for firms' development.

This research provides additional insights on the development acceleration of economies for a select group of advanced countries. Additionally, we developed the methodology to group countries according to their development acceleration rate. As such, there is a group of countries with a patriarchal industrial complex and constant development acceleration close to zero. Additionally, there is a group of poor countries with high acceleration indexes of their economic development. For example, in the past 30 years, China demonstrated a statistically high correlation between the development acceleration rate of its economy with the factor of time. The correlation coefficient of this relation approaches a value of 0.8 (0.7962), which is ten times greater than the same type of relation for major developed countries.

The research findings can be useful for firms as well since they can use the proposed *macroconstants of development* as an indicator and a benchmark for the performance indices. Moreover, we can talk about long-term constants of development acceleration in various industries (sectors) of the economy. Furthermore, *macroconstants of development* can be applied for the long-term development of the different economic sectors. A high correlation of values of the development acceleration rate for different economies was demonstrated.

Overall, the contribution of this research is a proposed new direction to study the development of the worlds' economic systems at the micro, meso and macro levels. As a result, the new advanced method will be available to policy makers for economic development decisions under the market conditions.



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