

# Bifurcation Points Analysis Application in Economic Studies

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## ABSTRACT

The article reflects bifurcation points analysis for Ukrainian economy since 2005. Development of Ukrainian economy is atypical both for developed and emerging countries. The case is related with significant changes in politics situation and economic life of Ukraine, including, mass riots, soft revolution, war and annexation of part of the territory. In conditions of instability, the requirements for economists education quality increase. Economists for decision-making must fully understand the situation. The authors of the article shows case study of Ukraine, how to combine traditional mathematical approach and situation observation for analysis of regional development. The research is an example of method of training and practical application of the analysis of the situation in changing conditions.

## CCS Concepts

• Computing methodologies → Modeling and simulation → Model development and analysis → Model verification and validation

## Keywords

Gross regional product; econometric models; regional analysis; balance of export and import; average monthly salary; educational and medical subventions; Ukraine.

## 1. INTRODUCTION

In changing conditions for bifurcation points analysis first task is to define the points. Second task is to understand reasons that changed the situation. The first task requires economists to have a knowledge of statistics, quantitative methods and econometrics. The second task requires analytical skills and experience in studying of research object. The paper consist form two parts, in the first on statistic basis econometrical models was developed for Ukrainian regions, bifurcation points was determined. In the

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second part based on experts opinions study, the authors analyze development of Ukrainian regions and conclude about main influential factors. The research is an example how to combine quantitative and qualitative methods in economy analysis.

## 2. MATHEMATICAL APPROACH

Ukrainian regional science considers today economic zoning as a means of managing economic structures in the territorial context and as a basis for the development and implementation of state regional policy. Generalization of literary sources on economic zoning allows to consider this economic category from the theoretical point of view at least in three aspects [1]: zoning as a process, comes objectively and does not depend directly on the will of people; zoning as a procedure of delimitation of economic regions; zoning as a "means of spatial regulation of economic and geographic information". Currently, in Ukraine there are usually nine economic regions with their industrial specialization [1].

For each economic region, we will use a multifactor regression model, taking into account the socio-economic status of each region. It is possible to construct an economic and mathematical model of dependence of a random value of Y (Gross Regional Product (GRP) per person) on random values X1 (balance of export and import of goods and services), X2 (average monthly salary) and X3 (educational and medical subventions).

Thus, for the Capital Region, the model looks as follows:

$$Y = 2.2X_1 + 13.9X_2 - 0.0003X_3 - 6,208.9 \quad (1)$$

For the Northeast Region, the multifactor regression model has the following form:

$$Y = 758,389.5 - 269.4X_1 - 106.1X_2 - 0.02X_3 \quad (2)$$

For the Pridneprovskiy region the multifactor regression model has the following appearance:

$$Y = 33.1X_1 + 80.4X_2 - 0.004X_3 - 437,507.0 \quad (3)$$

For the Central Region, the multifactor regression model has the following form:

$$Y = 34,378.1 - 24.1X_1 + 5.0X_2 + 0.0014X_3 \quad (4)$$

For the Podolskiy region, the multifactor regression model has the following form:

$$Y = 8.8X_1 + 10.6X_2 - 0.0003X_3 - 9,856.9 \quad (5)$$

For the Carpathian region, the multifactor regression model has the following form:

$$Y = 10,535.2 + 1.9X_1 + 4.9X_2 + 0.0001X_3 \quad (6)$$

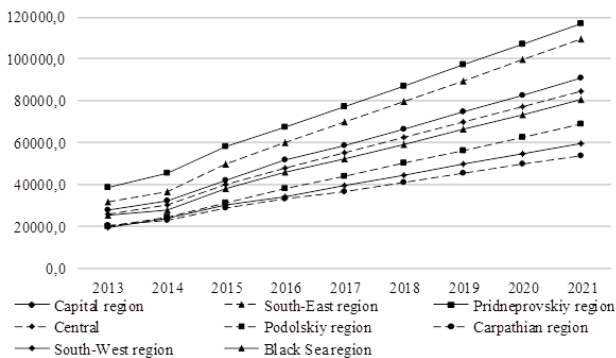
For the North-Western region, the multifactor regression model has the following form:

$$Y = 7.0X_1 + 10.9X_2 - 0.0002X_3 - 8,262.9 \quad (7)$$

For the Black Sea region, the multifactor regression model has the following form:

$$Y = 2.3X_1 + 13.3X_2 - 0.001X_3 - 14,713.6 \quad (8)$$

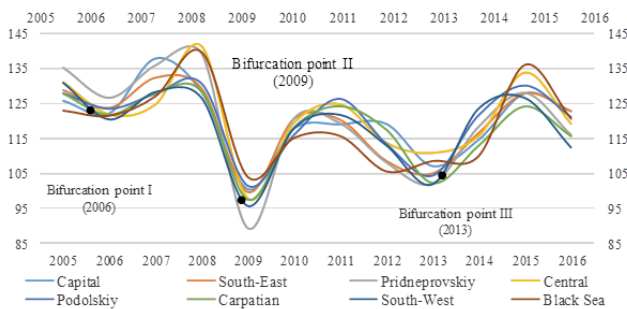
Fig. 1 shows multifactor regression models for all economic regions of Ukraine.



**Fig. 1. Econometric models of dependence of gross regional product on the main socio-economic indicators of development of Ukrainian regions. Source: authors' own development.**

According to the results of the study, it can be concluded that there is a strong correlation between GRP per capita, the balance of exports and imports of goods and services, average monthly wages and the volume of educational and medical subventions. This share of GDP generates tax revenues of the consolidated budget and is the result of the distribution of GDP value among economic entities, is mobilized into the consolidated budget in an almost unchanged way - in the time interval under consideration there is its polynomial extrapolation. In 2011-2015, there were significant changes in the elasticity of tax revenues relative to the macroeconomic indicators of Ukraine's development.

We will see the regularities of GRP dynamics per person in the context of economic regions of Ukraine. The nature of GRP dynamics per capita reflects the change in GRP growth rates. The analysis shows that over the last 10 years there have been several critical periods (bifurcation points), during which there have been significant declines (Fig. 2).



**Fig. 2. Growth rate of gross regional product per person, in actual prices. Source: built by the authors.**

The analysis revealed that all economic regions of the country had roughly the same time of acute bifurcation unrest. Thus, the first bifurcation point was observed in 2006, the second in 2009 and the third in 2013. Let us consider the factors that caused the bifurcation riots and positive structural changes in the economic regions of Ukraine.

### 3. ANALYTICAL APPROACH

Thus, the first bifurcation point is observed in 2006, which is conditioned by such data [2-3]: the three main sectors - industry, agriculture, investment - largely determine the state of the country's economy, in which about half of the GDP is created.

In industry, judging by official indices, the total volume of production in Ukraine as a whole in 2005 amounted to 95% of the pre-crisis level of 1990. According to the results of 2006, it means that 15-16 years have been lost in the development of the most important industry for the country. If we look at this sector in terms of regions, there are very large, difficult to explain and unjustified differences in growth rates. It turns out that in 10 of them industrial production has already reached and exceeded the level of 1990, in 11 of them it is between 76 and 100% and in 6 of them it constitutes 75% of the pre-crisis level and less. The difference between the maximum (Sevastopol - 236%) and minimum (Kherson region - 56%) indexes reaches 4.2 times. Such differences can be partially explained by the transition from 2000 to a new classification of economic activities, which led to incomparability of internal industrial sector indices before and after 2000. And in 2004, a new nomenclature of industrial products was adopted. It makes it possible to make comparisons of production in kind with previous years only for electricity. It should also be noted that for this 15-year period there are no complete and comparable data even on the number of employees in the industry. They cover only employees, excluding, as indicated in the notes to the relevant tables, "employees of statistically small enterprises and employed by citizens-entrepreneurs". And if we compare the index of industrial production in Kiev (168% in 2004 to 1990) with the reduction of the number of employed people - from 452 to 175 thousand people, or two and a half times (up to 41%), it turns out that the productivity of labour in the industry of the city in 1990-2004 increased by 4.1 times.

In agriculture, indices for household production are based, as in all other countries, on sample surveys. Unlike industry, there are no qualitative, constructive changes in the products of this sector. The entire range of agricultural products does not exceed hundreds of species, and five or seven of its main products - grain, meat, milk, potatoes, sunflower, sugar beet - form at least 70-85% of the products, which are calculated directly - by multiplying the quantity by comparable prices. By 2005, the agricultural output of Ukraine is gradually pulled up to the level of two thirds of the 1990 level. However, there are differences between the regions, but they are not so significant, the indicators are more heavy than in industry. It should be added that regional differences in this sector may to some extent be conditioned by natural and climatic conditions. In 2005, Zakarpatye turned out to be the closest to the level of production in 1990 - 91%. However, the share of Ukrainian agricultural production is small - it is only 2.2%, surpassing only Chernivtsi region (1.9%). The top five largest agricultural producers in 2005 were Kyivska - 6.5%, Dnipropetrovska - 6.3, Kharkivska - 5.9, Vinnitsa and Donetsk regions - 5.7% each (together - 30.1%).

Significant interregional differences exist in terms of investments in fixed assets (capital investments). In 2005, the average per capita figure for Ukraine was close to 2 thousand hryvnias (1984 hryvnias). In six predominantly agricultural, non-industrial regions, it is less than a thousand hryvnias. Again, the highest figures in Kyiv are 3.7 times higher than the average Ukrainian and almost nine times higher than in Chernivtsi oblast. A significant part of investments is directed to housing construction.

In absolute terms, they are in second place (11.6% in 2004) after investments in industry (37.2%). As with most other indicators, the undisputed leader is the city of Dnipropetrovsk. Kiev. In 2005, the capital commissioned 1,201,000 m<sup>2</sup> of total housing area - 15.4% of the total Ukrainian housing construction (with 5.6% of the population of Ukraine).

GRP in Ukraine within the framework of the International System of National Accounts has been calculated since 1996. With regard to per capita production of national income and GRP, it is clear that the interregional differences were much smaller in 1990. Then the ratio of maximum to minimum was 159%. In 1996, this difference increased to 268%, exceeding the 1990 difference by a factor of 1.7. But the results of 2004 are particularly striking - 658%, or two and a half times more than eight years earlier. As for the average Ukrainian per capita GRP, this indicator in Kyiv was 1.4 times higher in 1996 and 3.2 times higher in 2004.

It should also be noted that the highest per capita GRP produced in the capital is not only characteristic of Ukraine. Thus, in Russia this index per capita in Moscow was 2.9 times higher than in Russia as a whole (2003), and in Washington - 2.3 times higher than in the USA as a whole (2001).

The second very serious bifurcation point is observed in 2009, with the largest sagging observed in the Dnieper region, and the smallest - in the Black Sea region. Despite some differences, it is possible to identify the main trends inherent in all economic regions of the country [4-6]:

1. Ukraine experienced a decade of decline, with GDP falling to 40.8% and barely 74.1% of its 1990 level in the following nine years of growth. Compared to 1991, real disposable income first fell to 32.9% in 1999 and then rose to 101.3% in 2008. Consequently, 18 years for the growth of incomes of the population as a whole were lost.

2. The possibility of cardinal targeted structural changes for building a socially oriented market economy, civil society and an effective political system in Ukraine was not properly used under the conditions of economic growth in 2000-2008, when financial resources for such transformations appeared. The crisis of 2009 provided a third chance for transformation.

3. A separate problem of the Ukrainian economy is its extreme burden of social payments. Even during the transformational crisis, the rapid decline in incomes and living standards of the majority of the Ukrainian population led to the expansion of social protection guarantees and increase in the number of recipients of social transfers. That is why the share of social spending in total government spending and GDP has been steadily increasing. Unfortunately, this continued during the economic recovery. In particular, the share of social expenditures in the total state expenditures increased from 17% in 1999 to 27% in 2008.

4. The fall of the Ukrainian economy in 2009 was a natural result of the quality of economic growth in the pre-crisis period, which was mainly due to two factors. These were the growth of prices for Ukrainian exports as a result of the accelerated growth of the global economy, as well as high domestic demand, which was stimulated by the soft monetary policy and a significant increase in bank lending at the expense of foreign capital. Deterioration of the economic situation in the world is natural, given the high level of vulnerability of the Ukrainian economy, has led to the deployment of a systemic economic crisis in our country. A

significant decrease in production volumes occurred in all major sectors of the economy, except agriculture.

5. Increase in wages in Ukraine is one of the most urgent and acute problems at this stage of socio-economic development. It was objective and was caused by a significant lagging behind the standards of developed countries and the overwhelming majority of countries with emerging markets. At the same time, the level of wages cannot be considered in isolation from changes in the main macroeconomic proportions, the level of optimality of which determines the general economic dynamics. It can be stated that in Ukraine there is a hypertrophied increase in wages, which causes deformation of the macroeconomic proportions of GDP and limits the opportunities for further economic development.

6. In recent years, the real sector of the Ukrainian economy has been characterized by a stable trend of inter-sectoral redistribution both in the production of goods and services and in the creation of added value in favour of construction and service industries. But such structural changes do not contribute to qualitative structural changes in industry, which is the main component of the real sector, and in agriculture. At the same time, industry remains the leading backbone sector of the real sector of the economy of our country, retaining the largest share in its structure (in 2008 it accounted for 46.1% of gross output of goods and services and 31.3% of gross value added).

7. Own production provides only 2/3 of the country's commercial resources for industrial products, the rest is imported from abroad. However, if exports are mainly material and energy products of low processing level, imports, on the contrary, consist of high-tech products of advanced processing and final consumption goods. This has led to a steady decline in the coefficient of export coverage of imports in Ukraine from 1,126 in 2004 to 0,8 in 2008. At the same time, the growing deficit of the trade balance was financed from external sources, as a result of which the gross external debt of Ukraine, expressed as a percentage of exports of goods and services, increased from 74.2% in 2004 to 120.6% in 2008.

8. The consequences of the crisis affected almost all types of industrial activity, but to a different extent: the food industry lost the least of all, where the decline in production in 2009 was 6.8%. The largest losses were incurred by machine-building (-52.2%), metallurgical production (-39.0%), production of other non-metallic products (-44.7%), chemical and petrochemical industry (-31.9%). The drop in industrial output had an impact on the performance of transport companies, which in 2009 transported 30% less cargo than in the corresponding period of the previous year. The liquidity deficit led to a decrease in the volume of construction works in all regions and all major types of construction activities, which in 2009 as a whole amounted to 53.6% of the corresponding period of the previous year.

9. The transformational crisis of the last decade of the last century almost completely stopped the investment process in agriculture. The volume of investments in fixed assets of the branch in 2000 made only 4.2% of the level of 1990. Since 2001, agrarian investments had positive growth rates and for 8 years increased almost 8 (7.85) times. The most successful year was 2008, when the annual growth of this indicator reached 43.2%, while the total investment in the national economy decreased by 2.6%. However, in the first half of 2009 there was a significant drop in the volume of investments in fixed assets both in the national economy as a whole (56.7% of the level of 2008) and in the agricultural sector (54.3%). The situation in the sphere of foreign investment is

slightly better. In 2008 direct foreign investments in agriculture grew by 45%, in food industry - by 5.8%. In the first half of 2009 the foodstuffs production retained its investment attractiveness: direct foreign investments increased by 6.3%.

10. Statistical analysis shows the strengthening of the trend of technology acquisition in 2006-2007 and slowing down of this process in 2008. According to official statistics, the total number of new technologies purchased in Ukraine in the period from 2000 to 2007 was 5633. At the same time, the results of own research and development over the past seven years accounted for an average of 13.6% (764 technologies) of the total number of technologies acquired. This indicator is extremely low for the country declaring its innovation and investment path of development and transition to the fifth and sixth technological modes, provided that the appropriate infrastructure of the national innovation system is created. Licensing was 5.6% (314), which indicates a very low level of awareness of the importance of protecting one's own inventions. Leasing of technologies equals 0.3% (16) by 2006, i.e. this instrument is practically not used. Technology purchase agreements accounted for 15.2% (859 units) by 2007 and 44.5% (2504 units) by 2007, a total of more than 59.8% of the total amount of technology received, which indicates that Ukraine is somewhat dependent on imported technologies.

11. Since the shadowing of Ukraine's economy in the context of the financial and economic crisis has acquired a total character, both individual experts and researchers estimate its volume within the limits of up to 60% of GDP, it represents a real threat to the national security of the state at the present stage.

The third bifurcation point is observed during the difficult period for the Ukrainian economy in 2013. Thus, the greatest sagging is observed in the North-Western and Dnieper economic regions, the least - in the Central, and the Black Sea region has managed to avoid the lowest value. The main factors that hinder the stabilization and growth of the economy are [7-13]:

- slowing down the growth of the real sector of the economy;
- decrease in the purchasing power of households;
- growing external debt;
- sharp reduction of gold and foreign exchange reserves;
- the need for external financing;
- insufficient diversification of energy supplies, high cost of Russian gas;
- reduction of external investments.

It should also be noted the reduction of industrial production, foreign direct investment, unstable external demand, a significant decline in capital investment. Artificial containment of inflation and natural exchange rate fluctuations in the currency market, increasing regulatory role of the state - all this has led to a reduction in the number of Western companies in the market and deterioration of the investment climate in Ukraine.

Without denying the need for comprehensive monitoring and evaluation of the socio-economic situation in the territories, it is necessary to take into account many other important factors, including those that cannot be quantified. We should not forget about the political crisis in Ukraine, which is taking place in all three bifurcation points: the policy of forced European integration, significant improvement of relations with the Russian Federation,

adoption of laws on the non-block status of the state and regional languages, signing of the Agreement on the creation of the CIS Free Trade Zone. In November 2013, the process of preparation for the signing of the Association Agreement was suspended at the initiative of the Ukrainian government "in order to take measures to ensure the national security of Ukraine, a more detailed study and elaboration of a set of measures to be taken to restore the lost production volumes and directions of trade and economic relations with the Russian Federation and other member states of the Commonwealth of Independent States, the formation of an appropriate level of domestic market [14]. This decision led to a mass protest action in the centre of Kiev, as well as in other cities of Ukraine, which was called "Euromaidan" in social networks and media by analogy with the events of 2004, when there was a broad campaign of peaceful protests, rallies, pickets, strikes (Orange Revolution). It is also connected with the armed conflict in the east of Ukraine and the annexation of the Autonomous Republic of Crimea to the Russian Federation.

At the moment, in most economic regions of the country there are such problems as:

- there is an acute shortage of investment resources for modernization and technological renewal of production due to the decrease in credit activity of banks and limited foreign investments;
- high level of energy intensity of housing and communal services;
- deterioration of the quality of agricultural land;
- mismatch between the professional structure of the labour force and the needs of the market;
- slow rates of repayment of wage and tax debt to the budgets of all levels;
- regional problems of attracting effective investments into the economy of the region (insufficient development of infrastructure to support investment activities; insufficient number of properly developed investment proposals that take into account the interests of territorial communities of the region and the interests of potential investors and which, primarily, are an instrument of attracting investments; low interest of domestic investors, lack of effective mechanisms to stimulate domestic investment at the regional level; not enough);
- dominance in the structure of export of raw materials with an insignificant share of added value;
- low competitiveness of certain types of export products for production and technical purposes and consumer goods;
- low activity of regional business in participation in international and regional image and exhibition events;
- inadequate interaction between scientific institutes and production enterprises. Most of the research topics of local scientists do not meet the strategic priorities of the region's social and economic development. Significant depreciation of equipment and obsolete material and technical base;
- lack of financial resources and poor development of technology transfer infrastructure. Imperfect and insufficient information support for innovation activities of enterprises;
- decrease in industrial production rates in certain industries, in particular, in the production of basic pharmaceutical products and

pharmaceuticals and the production of rubber and plastic products, other non-metallic mineral products;

- difficult soil and climatic conditions and radiation contamination of a significant part of the Polesye zone require the establishment of a differentiated approach to the state budget support of agricultural producers in the region to ensure the competitiveness of their agricultural products.

- illegal logging. Excessively regulated procedure of bringing violators to responsibility and improper registration of evidence of illegal actions of forest destroyers by law enforcement agencies;

- lack of necessary resources for the development of trade in rural areas and in some villages with a small population;

- labour migration from the city, shadow employment, youth unemployment;

- outdated system of professional education;

- unbalanced filling of children's educational institutions and general educational institutions in terms of their design capacity;

- lack of a system of comprehensive rehabilitation of children with special needs;

- mismatch between the capabilities of modern digital technologies and the technical condition and informational and analytical support of education;

- complex medical and demographic situation;

- refusal of private carriers to service urban routes;

- depreciation and significant energy intensity of buildings of budget-funded institutions, housing stock, and engineering infrastructure of cities;

- insufficient attention to the creation of conditions for the protection, preservation and promotion of cultural heritage.

The solution of the above mentioned problems will allow avoiding the next point of bifurcation, will allow the formation of sustainable development of economic regions of the country, and should also contribute to the solution of problems of ensuring equal opportunities for the introduction of economic activity for the population, business and stimulation of the competitive basis of the economy, reduction of disproportions and development of small towns, cities, regions and economic regions of the country.

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