The modeling and forecasting of the technological and innovational development of a transition-economy country

Kononenko I., Repin A.
National Technical University "Kharkiv Politechnic Institute", Kharkiv, Ukraine

The rule of GDP change influence on the investment inflows into the country's economy for transition-economy countries has been found. The method for forecasting the innovational and scientific-technological development of a country, based on consequent use of simulation model of innovational and scientific-technological development of a country and of the method of forecasting the investment inflows into economy has been developed. The method was tested on the Ukrainian statistical data for 2000-2004.
FORECAST, SIMULATION MODEL, INNOVATION, INVESTMENTS

1. Introduction

In the year of 2004 the Government of Ukraine confirmed the State Program of Forecasting of Scientific-technological and Innovational Development for 2004-2006. While realizing the program the necessity of creating a method of forecasting of the country's development in educational, scientific and industrial spheres appeared.

As a rule to solve such a problem heuristic forecasting methods based on wide use of Delphi method and different scenarios development of object being investigated are used [1].

Is the application of this method only really enough for obtaining reliable forecasts? The experience of leading international organizations dealing with forecasting and medium-term development program preparation on the levels of industrial sphere and territory proves the appropriateness of supporting the results gathered when interviewing experts with other methods of obtaining forecasts [2]. Often it is more appropriate to apply formalized forecasting methods.

At the same time heuristic forecasting methods, simulation methods, methods of extrapolation are of limited accuracy. The further increasing of model adequacy and forecast accuracy can be achieved through synergistic effect which appears as a result of rational combination of the groups of methods pointed out into common methodology.

In the context of the State Program it is appropriate to make the alternative forecast by combining formalized methods and simulation methods. Simulation methods application allows considering complex interrelations between different spheres of activity and their common influence on scientific-technological and innovational development of Ukraine, that will increase forecast accuracy.

As an example of simulation models earlier developed in Ukraine can be given the model published in [3]

2. Work objective

The objective of this work is to develop and test a method of forecasting of major indicators of the country's development in areas of education, science and economics for medium-term and long-term perspective.

The main problem that appeared on the stage of method creation was identification of investment volume in a country's economy for each step of modeling. The investment volume in country's economy depends on numerous factors that are difficult to model. It concerns for instance the political situation in the country which can change several times during the modeling period, the investment situation, the geographical location etc. As the result no satisfactory variants have been found during final decision search.

To solve the given problem a hypothesis that GDP growth rate influences the dynamics of investment inflows into the country's economy was offered.

3. Rule of GDP growth rate change influence on the investment inflows into the country's economy

To support the suggested hypothesis we have analyzed the economic processes in transition-economy countries and those which were classified as such little while ago. The analysis was hold for transition-economy countries and those which were classified as such during the research period (1996-2004). We have also considered the economy of Greece.

Statistical data from 12 countries such as Bulgaria, Czech Republic, Estonia, Greece, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia and Ukraine have been analyzed in the process. The information for analysis was found on the Statistical Agency EuroStat official site [4], as well as in the Ukrainian annual statistical reference book [5]. Having analyzed the statistical data, we found the rule of the influence of GDP change on the volume of fixed capital investments for European transition-economy countries. The essence of the rule is as follows.

First of all, it is the investment increase into a country's economy with GDP growth rate over certain threshold value different for every country (3-4 % for the indicated countries). Moreover the investment inflows increase regardless of the direction of GDP growth rate change as long as this rate remains above the threshold level.

Secondly, the decline or stabilization of investment inflows can be expected if GDP growth rate decreases within the sub-threshold zone.

The third scenario deals with the situation when GDP growth rate increases within the sub-threshold zone subsequently entailing the growth or stabilization of investment inflows.

It should be noticed that the found rule can be violated under the influence of significant factors. For instance, for some political reasons external investments can be flown into a country's economy even when GDP growth rate declines within the sub-threshold zone.

If GDP growth rate increase occurs in the area of negative growth rate values, then this process can be followed by investment inflows decrease.

With the increase of GDP growth rate in the area of minor positive growth rate values the decrease of investment inflows can be also observed.

The rule has been established for dependencies between investment inflows into a country's economy and GDP growth rate indicator as for the same year, so as for a one year delay of the investment volume. In the latter case the dependency of the investment volume in the year t from GDP growth rate in the year t-1 is considering.

In the fig. 1 and in the tables 1 and 2 statistical data relating to the economy of Poland is shown. The presented graph shows the events in chronological order, i.e. one of the dots at the beginning of the curve relates to the year 1996, the other – to the year 2004.

Year	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
GDP	6,2	7,2	4,9	4,5	4,2	1,1	1,4	3,8	5,3

Table 1 GDP growth rate indicators of Poland against the previous year, %

Year	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Investments	119,7	145,6	166,3	177,6	182,4	166,5	156,7	154,1	163,8

Table 2 Volume of fixed capital investments in the economy of Poland against the year 1995, %

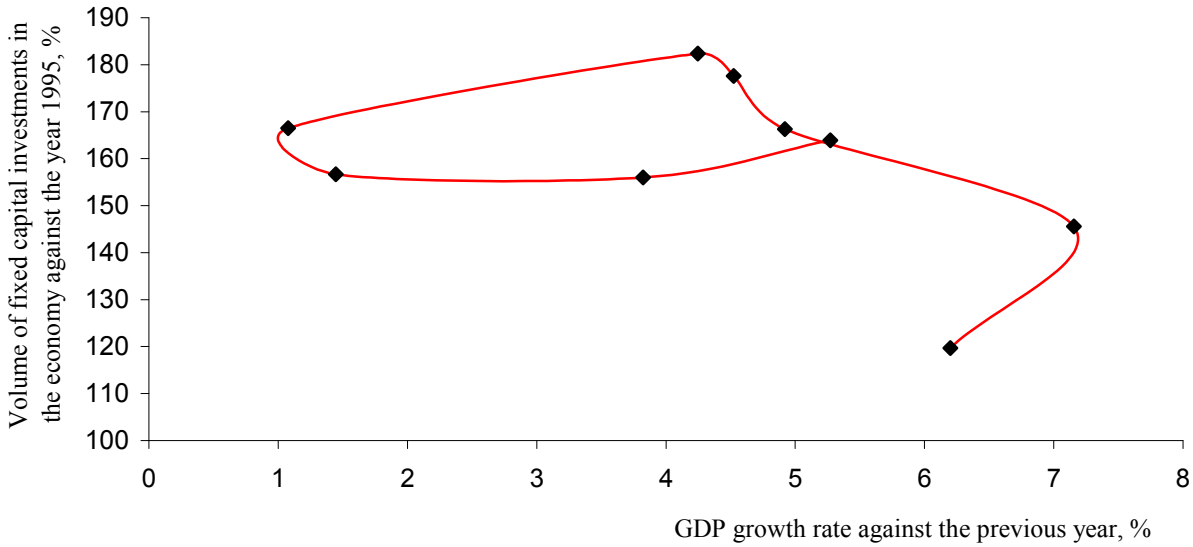

Figure 1 Investment inflows into the economy of Poland (1996-2004)

It is obvious from the figure that in the year of 1996 more than 6 % of GDP growth rate corresponded to investment volume growth rate of 19,7 %. During the next 4 years in spite of GDP growth rate fluctuations within 4,2–7,2 %, investment inflows into the economy were growing constantly, moreover with rather high values (more than 4,8 % annually). This is due to the fact that the annual GDP growth rate was higher than 4 %, that is considered to be high enough. However, later on because of GDP growth rate decrease to 1,1–1,4 % investment inflows began to decline. In 2001 investment inflows into the economy of Poland were 15,9 % lower than in 2000. GDP growth rate increase in 2003 to 3,8 % didn't lead to investment inflows growth. Only GDP growth rate of 5,3 %, that was achieved in 2004, allowed to increase fixed capital investments.

In the fig. 2 and in the tables 3 and 4 statistical data relating to the economy of Slovakia and the curve of investment volume change in dependence on GDP growth rate are shown. We can also observe the growth of investments in the years when GDP growth rate value made up more than 4 % per year (1996 – 1998). The similar to the economy of Poland GDP growth rate decline to 1 % and the following investment inflows into the state economy decrease are also observed (1999 – 2000). Further events are also similar. After GDP growth rate increase to 3,8 % we can see the growth of investment inflows. Finally, during the last years there is some kind of stabilization of investment inflows near 140 % relatively to 1995 to be marked.

Year	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
GDP	6,1	4,6	4,2	1,5	2,0	3,8	4,7	4,5	5,5

Table 3 GDP growth rate indicators of Slovakia against the previous year, %

Year	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Investments	129,1	148,4	164,7	132,5	122,9	140,0	139,2	137,1	140,6

Table 4 Volume of fixed capital investments in the economy of Slovakia against the year 1995, %

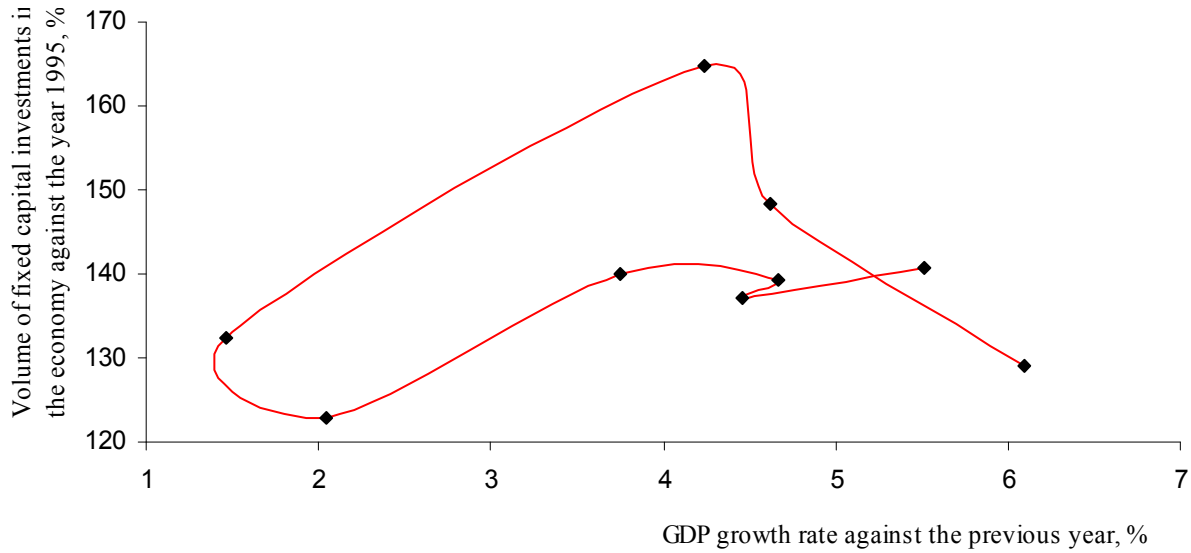

Figure 2 Investment inflows into the economy of Slovakia (1996-2004)

Let's have a close look on statistical data concerning Ukraine from 1991 to 2004, presented in the tables 5 and 6. Graphically this information is shown in the fig. 3. The analysis of the curve shown in the figure allows to certain of rightness of considerations according the dependency of investment inflows into the economy from the GDP growth rate in transition-economy countries. The falling of Ukrainian GDP at the beginning of 1990-s led to the decline of investment inflows into the country's economy. The turning point occurred in 1995 when GDP growth rate for the first time since 1990 was although negative but in absolute rate lower than in the preceding year. However, 3 years were needed for annual investment inflows into the state economy to increase. The first insignificant increase took place in 1998 and later on the economical situation in Ukraine began to develop similar to the economies of the above-mentioned countries. The significant increase began only in the years when GDP growth rates became higher than 5%. We can suppose the further growth of investment inflows into the state economy during the period when GDP growth rate is higher than 4 -5 percents. If the annual GDP growth rate values are lower the investment volume decline is the most probable, as we observed in the economies of Poland, Slovakia and other countries we considered.

Year	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
GDP	-8,7	-9,9	-14,2	-22,9	-12,2	-10	-3
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
GDP	-1,9	-0,2	5,9	9,2	5,2	9,6	12,1

Table 5 GDP growth rate indicators of Ukraine against the previous year, %

Year	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Investments	92,9	58,6	52,5	40,7	29,1	22,7	20,7
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Investments	21,9	22	25,2	30,4	33,1	43,5	55,7

Table 6 Volume of fixed capital investments in the economy of Ukraine against the year 1995, %

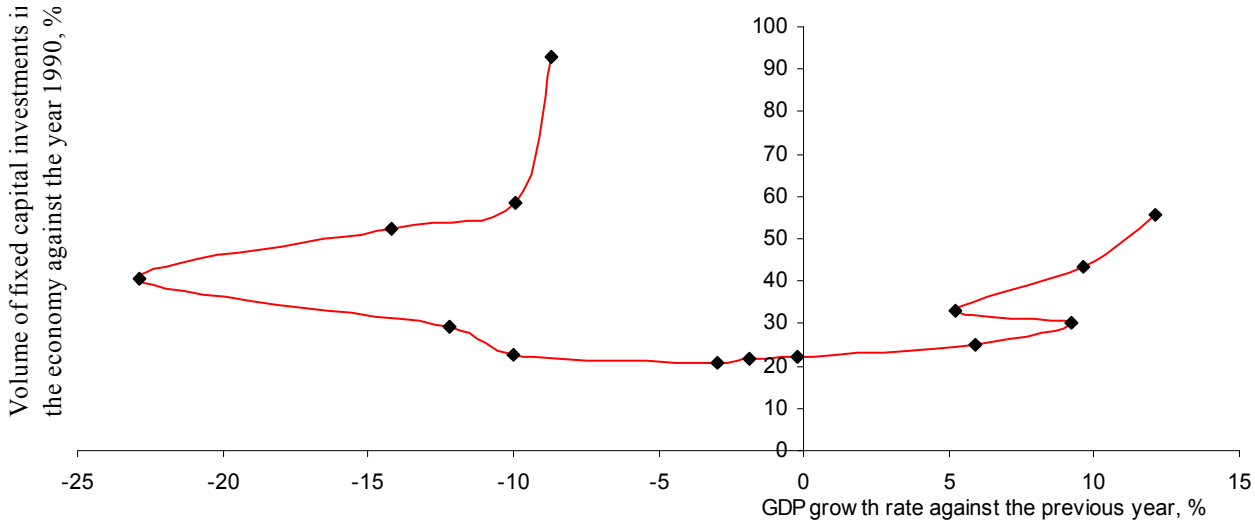

Figure 3 Investment inflows into the economy of Ukraine (1991-2004)

The found rule of GDP change influence on the investment inflows into the country's economy is proposed to use for forecasting of the country's development in educational, scientific and industrial spheres.

For solving the tasks pointed out we propose a method, the essence of which is in the following. Based on the statistical data the investment inflows into the country's economy for the last year of the prehistory are defined. With the use of simulation model the forecasts of production volume change in key industrial spheres for one year are made. In accordance to these forecasts an estimation of state GDP growth rate is defined. Considering the found rule of state GDP change influence on the investment inflows into its economy the forecast of investment volume for one year forward is made. Then the procedure is repeating during the period of forecast prediction. In the given method it is suggested to use the developed simulation model of innovational and scientific-technological development of a country. The main principles of such a model composition are presented in [6,7].

The structure of the simulation model is shown in the fig. 4.

In the fig. 4 the key interrelations between the main model blocks are shown. We pointed out four types of flows between the blocks – financial, personnel, technological and informational. The material flows in the simulation model are not modeled. The results of research engineering and experimental development areas activities are defined as financial indicators.

The financial flows connect the investors, represented by Government, national and foreign investors, with the spheres of state activity, into which, actually, the material means are invested, - industrial branches, spheres of research engineering and experimental development, education and trade. There exist reverse financial flows such as tax assessments to budget and investor's profits.

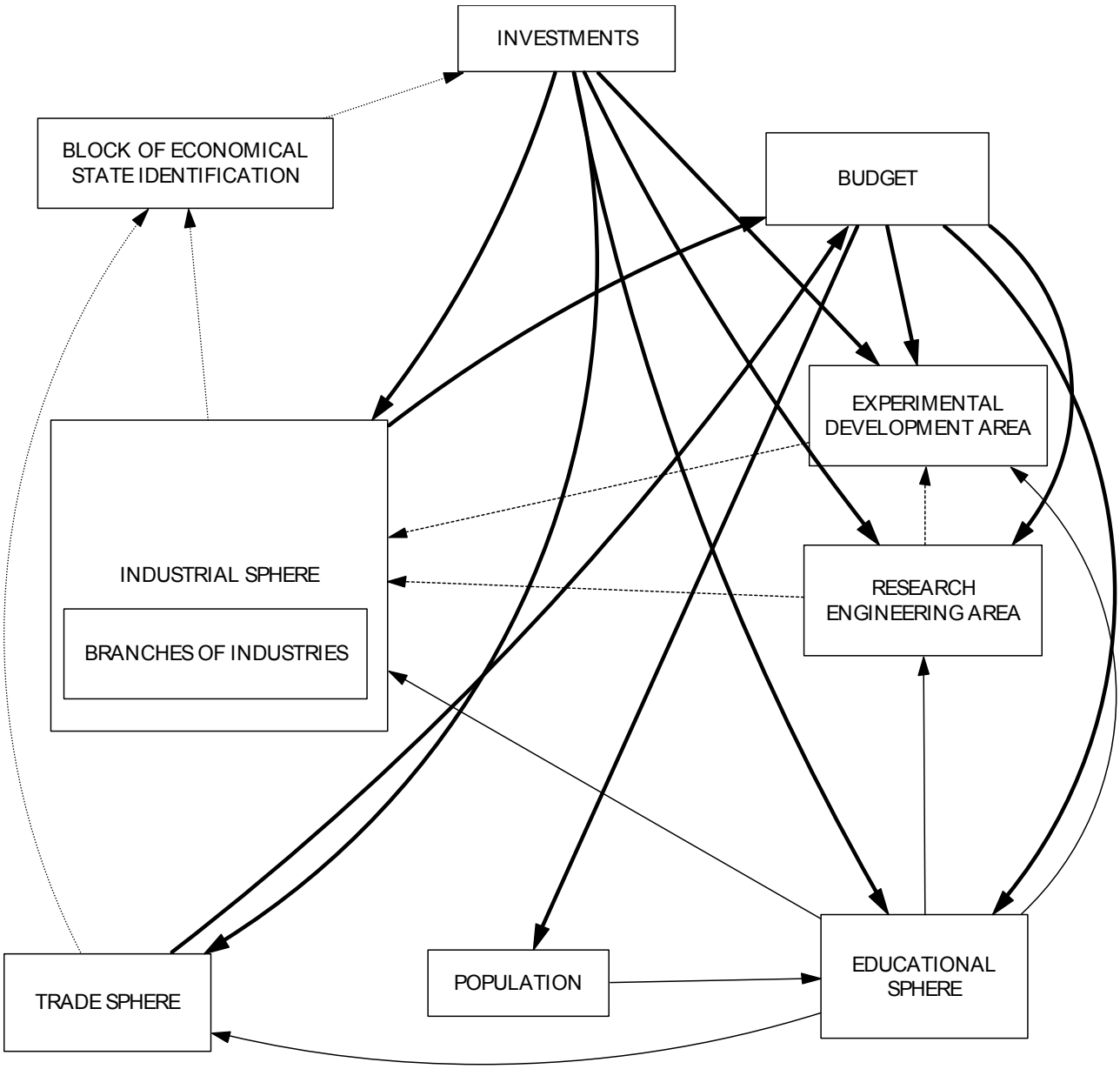

Figure 4 – Structure of simulation model of innovational and scientific-technological territory development

Personnel flows connect the educational sphere, where staff is being educated, with industrial sphere, research engineering area and experimental development area, trade sphere.

Technological flows connect research engineering area with experimental development area, so as these two areas with the industrial sphere.

Informational flows fill “Block of economical state identification” with information about effectiveness of industrial and trade spheres activities. This information serves as the basis for future investments into economy.

The common use of simulation model of innovational and scientific-technological development of a territory together with the found rule of GDP change influence on the investment inflows into the country’s economy, so as with the forecasting method [8] allowed to create the method for forecasting the technological and innovational development of transition-economy countries.

Setting the simulation model to the Ukrainian economy of 2000 allowed to obtain forecasts of indicators of interest for the period from 2001 to 2004. The average values of module of relative errors range from 0,5 to several percents.

For example we gave a forecast concerning the educational sphere, namely the situation with the full secondary education (fig. 5).

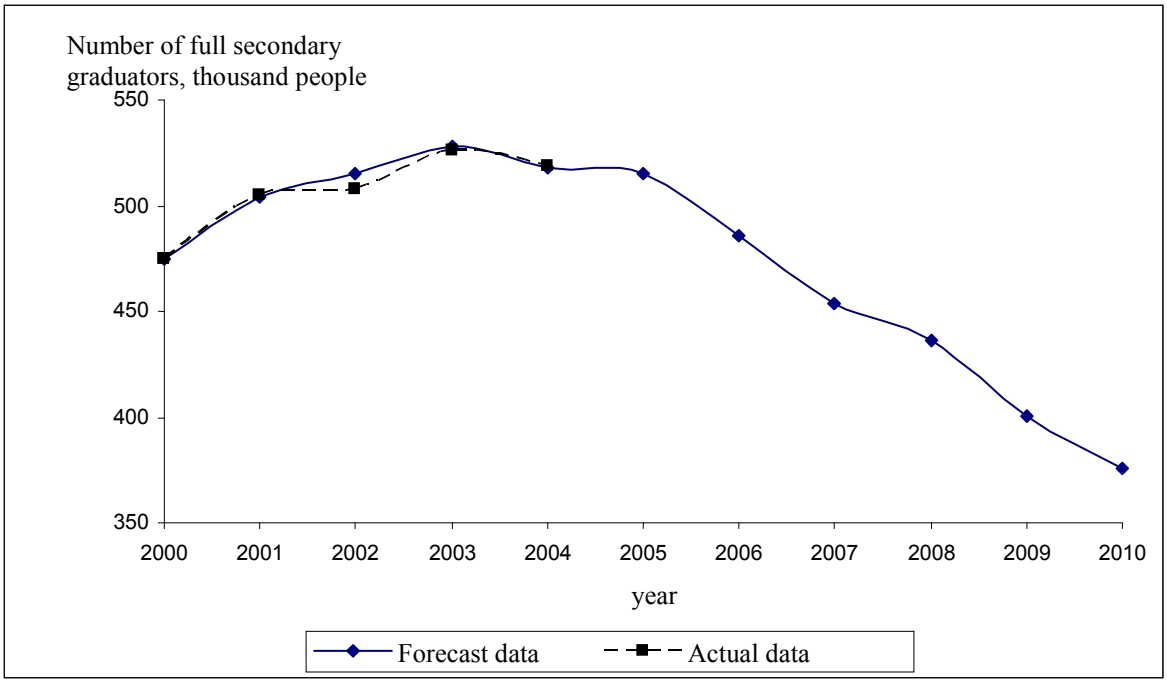

Figure 5 – Full secondary graduation in Ukraine, thousand people

As we can see from the figure, the forecast data is close enough to the actual data on the 3rd and 4th forecasting points.

4. Conclusions

Later on we plan to hold some additional work on the simulation model and realize its setting to the Ukrainian economy of 2004/2005 for obtaining forecasts of development of main indicators of interest for the period from 2006 to 2009. Making experiments with the simulation model will allow to discover main cause-effect relations and develop a number of recommendations for the governmental organizations.

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