Use of the Modified Hurwitz Method for Developing a Corporate Innovative Strategy

Sergey N. Yashin
Doctor of Economics, Professor, Head of the Innovation Management Department
Nizhny Novgorod State Technical University n. a. R. Y. Alekseyev
Russia

Egor V. Koshelev
PhD in Economics, Associate Professor, State and Municipal Management Department
Lobachevsky State University of Nizhny Novgorod
Russia

Abstract

The game method of developing a global corporate innovative strategy, including developing product-type innovation strategy, production modernization strategy and equipment repair modernization is presented. For developing a global corporate innovative strategy it is offered to use modified Hurwitz method which first updating consists in ranging of preferable Hurwitz functions of taking into account risk significance criterion (factor), and the second – in drawing up of the mixed innovative strategy.

Keywords: Corporate Innovative Strategy, Product-type Innovation Strategy, Production Modernization Strategy, Equipment Repair Modernization, Modified Hurwitz Method, Risk Significance Criterion, Mixed Innovative Strategy

1. Introduction

The process of developing an innovative strategy implies consideration of the uncertainty factor in relation to the effectiveness of the decision made by the corporate governance. The reasons for such uncertainty consist in the fact that it is impossible to predict precisely to what extent the new modernized product will meet the customer's demands and will be respectively popular in the market. If a company decides to enter the market with a new product, there appears a necessity to adapt the existing production technology. In this case, it is required either to modernize already existing equipment, including its repair, or to procure new equipment. In addition, manufacturing a new product may imply development or procurement of new manufacturing technologies, including also application of new robotic equipment and most advanced, again adapted to the new production demands, computer software required, for instance, for management of a new automated process line.

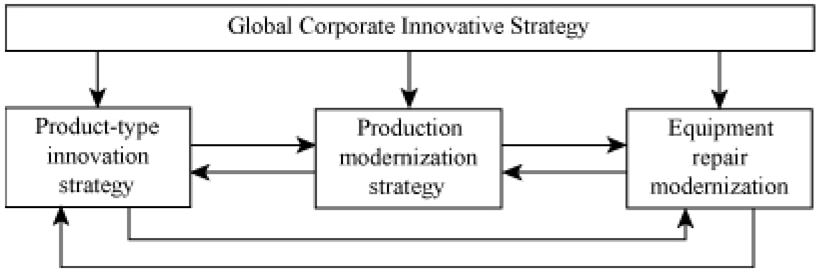
But if a company decides to modernize the manufacturing process without developing a new product, then such strategy also implies an uncertainty as in this case, it is required to most efficiently settle the issue of the optimal modernization method. It is possible, for example, to 1) repair the existing equipment, 2) partially retool it or simply 3) purchase new one. The economic efficiency and the relative risk-freedom of each of these alternatives must be calculated on an individual basis.

Finally, the company management is always risk averse to a greater or lesser degree and, therefore, may decline some innovative strategies if they appear too risky to it, even though they promise a significant growth of the business efficiency in money terms. In this case, the company management may opt a less risky development strategy with the assumption that it is less efficient, but more reliable and stable.

2. Innovative Strategy Development Areas and Stages

For comprehensive solution of the designated problems, it is possible to propose the following diagram of areas to develop an innovative strategy (Figure 1).

Figure 1: Areas of Developing a Global Corporate Innovative Strategy



The double arrows between the lower units of the diagram show that they may be interrelated. For instance, a product-type innovation strategy may necessitate production modernization (technological innovations) in order that the new modernized products might be manufactured on the company equipment. Or else the required modernization of already outdated equipment, which also relates to technological innovations, may enable the company to develop production of new products, i.e. result in product-type innovations.

In order to identify stages of developing a global innovative strategy, it is required to include in the analysis such performance indicators of the selected strategy which would to the largest extent reflect the economic effect of its implementation. Any business in the first place implies earning money from it in the form of proceeds and revenues, however, for estimated money value of innovation efficiency, it will be more prudent to use indicators suggested by Krylov, Vlasova and Zhuravkova (2006) since economic efficiency of innovations consists not only in earning, for instance, profits, but also in obtaining monetary funds required for further development of the equipment and human resources. As such indicators, one can, following recommendations of the above authors, use: 1) income, 2) net income, 3) added value, 4) net added value.

Let us present the mechanisms of building these four indicators in Figures 2 and 3. It should be noted that we have changed the designations of these indicators for other ones to simplify the principle of their construction.

Using the designations introduced in Figures 2 and 3, we can obtain the formulas to calculate indicators of added value and net added value:

$$\mathrm{UPD} = U + \mathrm{PD} = U + P + D\,; \quad \mathrm{UNPD} = U + \mathrm{NPD} = U + \mathrm{NP} + D\,.$$

After selecting the financial performance indicators of the selected innovative strategy in money terms, let us formulate stages of developing a global corporate innovative strategy (Figure 4).

Figure 2: Mechanism of Building Indicators of Income and Added Value

+ Income before provision for income tax (P)
  Depreciation of fixed assets and intangibles (D)

+ Income (PD)
  Labor costs with allocations for social needs (U)

Added value (UPD)

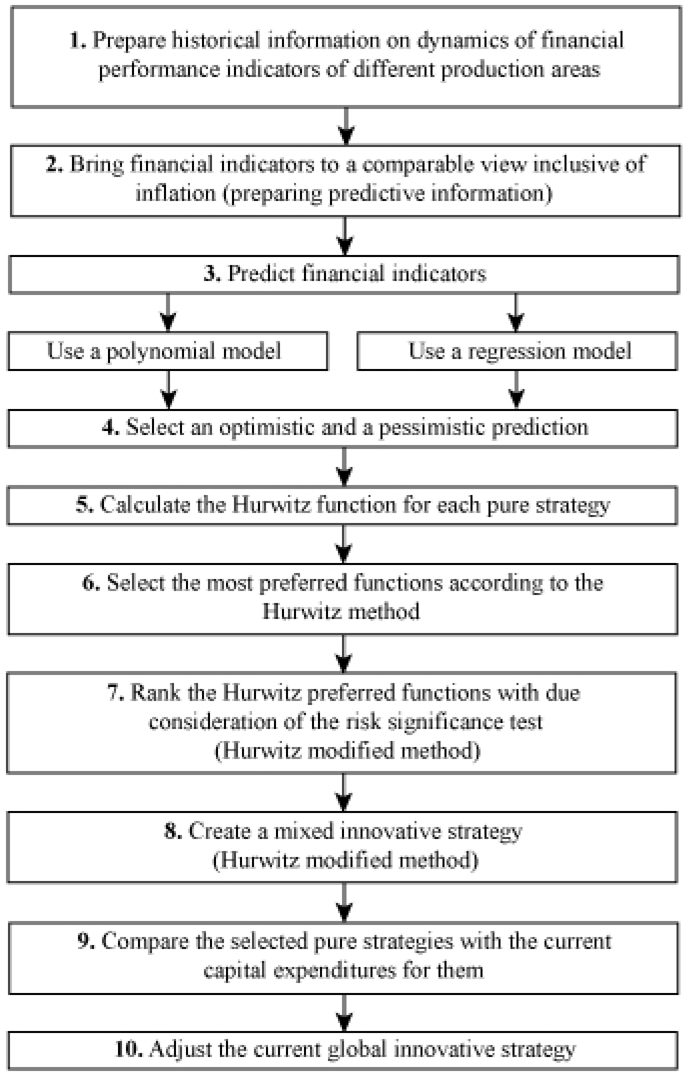
Figure 3: Mechanism of Building Indicators of Net Income and Net Added Value

+ Net profit forwarded to accumulation, consumption and social funds, to reserve capital and for payment of dividends (NP)
  Depreciation of fixed assets and intangibles (D)

+ Net income (NPD)
  Labor costs with allocations for social needs (U)

Net added value (UNPD)

Figure 4: Stages of Developing a Global Corporate Innovative Strategy



Pure strategies in Figure 4 may mean, for example, individual areas of production modernization (technological innovations). These may be areas, such as ‘Procurement (Introduction) of Machines and Equipment’, ‘Procurement (Introduction) of New Technologies’, ‘Procurement (Introduction) of Software Tools’, etc. If, however, for instance, individual areas of products and production modernization are considered, they may be represented by productions of different types of goods. Let us say, these may include productions of the following types of goods in the machine-building industry: ‘Motor Cars’, ‘Buses’, ‘Diesel Engines’, ‘Motor Trucks’, ‘Road-Building Machinery’ and others.

A combination of a certain number of pure strategies will be exactly a global mixed corporate innovative strategy. At the same time, a priority of selected pure strategies is identified, i.e. they are ranked starting with the most profitable one and ending with the least profitable but necessary one.

3. Modified Hurwitz Method of Developing Technological Innovation Strategies

In this paragraph, let us go through five stages of developing a corporate innovative strategy according to the diagram shown in Figure 4. In particular, using a certain conventional industrial enterprise as an example, let us analyze stages 4-8 in Figure 4. This will enable us to clarify the developed modification of the Hurwitz method known from the theory of statistical games.

Let us assume that the industrial enterprise is developing a production modernization strategy (technological innovations). The individual alternatives (of pure strategies) include as follows:

1. Procurement of machines and equipment (strategy 1).
2. Procurement of new technologies (strategy 2).
3. Procurement of software tools (strategy 3).

Let us suppose that for each of the three strategies, there is a pessimistic and an optimistic prediction in respect of net value added which may be attained for the next three years (Table 1).

Table 1: Pessimistic and Optimistic Predictions for Attaining Net Value Added (UNPD) for the Next Three Years ('000 RUB)

Pure Strategies	Pessimistic Prediction ($\lambda = 1$)	Optimistic Prediction ($\lambda = 0$)
1	3,135,596	3,537,211
2	3,161,308	3,402,803
3	2,793,223	3,838,133

To select the most preferred strategy, one may use an instrument of the theory of statistical games. For this purpose, let us consider any changes occurring in the engineering product market as a statistical game, i.e. a nature game (Kuznetsov, 1994). The term 'nature' will mean a complex of unidentified market factors affecting the efficiency of decisions rendered.

For detailed evaluation of data of the statistical game matrix (Table 1), we will use the Hurwitz criterion (Kuznetsov, 1994) which is a pessimism-optimism criterion. According to this criterion, an optimal strategy shall be deemed a strategy for which there is the following formula:

$$\max_i G_i = \max_i \left(\lambda \min_j a_{ij} + (1 - \lambda) \max_j a_{ij} \right), \qquad (1)$$

where a_{ij} - statistician's gains if it uses strategy A_i (rows of Table 1) under state of nature N_j (columns of Table 1). The value of parameter λ is taken within $0 \le \lambda \le 1$. At $\lambda = 0$, we have a criterion of extreme optimism, and at $\lambda = 1$ - Wald's pessimism criterion (Kuznetsov, 1994):

$$\alpha = \max_i \min_j a_{ij}.$$

At the value of λ close to 0, let us consider an aggressive investor's strategy, i.e. who is prone to risk, and at λ close to 1 - a conservative investor's strategy, i.e. who is not prone to risk.

According to the Hurwitz method (Koshelev, Trifonov, Yashin, 2012), for each i^{th} strategy ($i = \overline{1,3}$) using formula (1), we can construct the Hurwitz function (G_i). To do this, let us draw a line through points $\lambda = 0$ and $\lambda = 1$. As a result, we get the following functions:

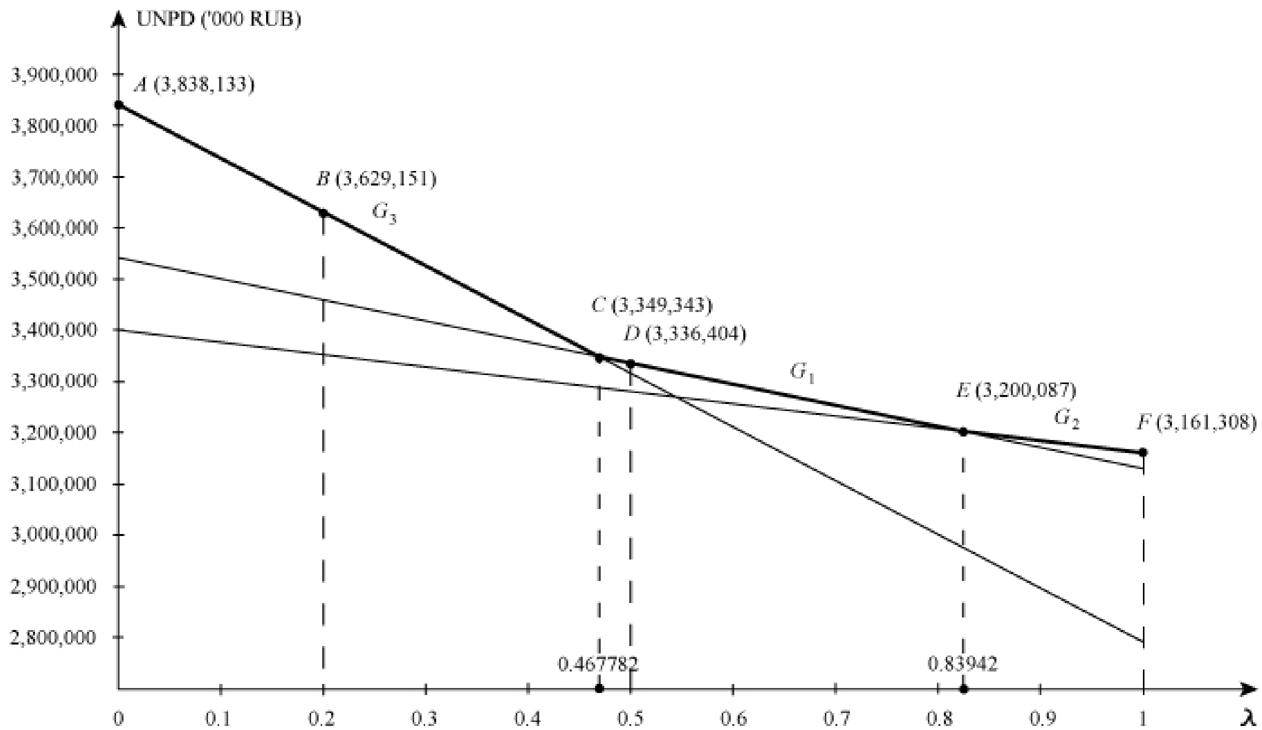
Strategy 1: $G_1 = 3{,}537{,}211 - 401{,}615\lambda$;

Strategy 2: $G_2 = 3{,}402{,}803 - 241{,}495\lambda$;

Strategy 3: $G_3 = 3{,}838{,}133 - 1{,}044{,}910\lambda$.

Let us show the Hurwitz functions obtained in the graph (Figure 5). Following the Hurwitz method, it is possible to identify most profitable strategies in Figure 5. Since the G_i functions are maximized, let us draw envelope line *ACEF*. Then let us compare the distances along axis λ between points *A* and *C*, *C* and *E*, *E* and *F* respectively. These distances correspond to functions G_3, G_1 and G_2.

Figure 5: Hurwitz Function Graphs



Consequently, we obtain the following distances along axis λ:

under graph G_3: 0.467782;

under graph G_1: 0.371638;

under graph G_2: 0.16058.

According to the Hurwitz method, the most profitable strategy is that relating to the largest distance along axis λ. Then the preferences in respect to the strategies under review will be as follows:

$3 \succ 1 \succ 2$.

However, such classical approach has a serious drawback. Parameter λ characterizes the risk value of the appropriate strategy. At λ close to 0, the strategy is very risky, and at λ close to 1, the strategy is almost risk-free. Then based on the results obtained by us, it is possible to conclude that it is more profitable for a decision-maker to implement most risky strategy 3, less profitable to implement somewhat less risky strategy 1, and finally, almost risk-free strategy 2 is least profitable.

As a matter of fact, the decision-maker will, despite its rational wish to carry out modernization, unlikely wish to implement most risky projects. However, it understands at the same time that there is no modernization without any risk whatsoever. Then there appears the question: how should such decision-maker's preferences be quantitatively considered in terms of risk?

To resolve this problem, we can propose a certain author's modification of the known Hurwitz method. Namely, let us first divide the whole interval along λ from 0 to 1 by three smaller ones introducing for this purpose risk significance test (factor) F_S. Then

1. Let us assign the value $F_S = 0.2$ to the interval from 0 to 0.2.

2. Let us assign the value $F_S = 0.3$ to the interval from 0.2 to 0.5.
3. Let us assign the value $F_S = 0.5$ to the interval from 0.5 to 1.

The introduced risk significance factor reflects the degree of importance of the relative strategies for the decision-maker. In such a manner, we obtain that the closer the value λ is to 1 on the Hurwitz function graphs relating to some strategies, the more attractive are these strategies for the decision-maker in terms of risk minimization.

Then, since we seek to maximize the Hurwitz functions, let us calculate trapezia areas under the envelope curve graph referring to the identified strategies, adjust them, i.e. multiply by the risk significance factor, and then calculate the largest area out of those obtained. Let us illustrate such approach by the same example.

1. Significance 0.2:

Adjusted area under the graph of function G_3:

$$S(G_3) = \frac{1}{2}(3838133 + 3629151) \cdot 0.2 \cdot 0.2 = 149346 .$$

2. Significance 0.3:

Adjusted area under the graph of function G_3:

$$S(G_3) = \frac{1}{2}(3629151 + 3349343) \cdot (0.467782 - 0.2) \cdot 0.3 = 280307 .$$

Adjusted area under the graph of function G_1:

$$S(G_1) = \frac{1}{2}(3349343 + 3336404) \cdot (0.5 - 0.467782) \cdot 0.3 = 32310 .$$

3. Significance 0.5:

Adjusted area under the graph of function G_1:

$$S(G_1) = \frac{1}{2}(3336404 + 3200087) \cdot (0.83942 - 0.5) \cdot 0.5 = 554654 .$$

Adjusted area under the graph of function G_2:

$$S(G_2) = \frac{1}{2}(3200087 + 3161308) \cdot (1 - 0.83942) \cdot 0.5 = 255378 .$$

Then the obtained values of adjusted areas for each Hurwitz function are summed up as follows:

$$\sum S(G_1) = 586964 ; \quad \sum S(G_2) = 255378 ; \quad \sum S(G_3) = 429653 .$$

The largest sum of adjusted areas ($\sum S(G_i)$) is indicative of the maximum preferableness of the respective i^{th} strategy with an allowance for risk. Then the preferences in respect to the strategies under review will be as follows:

$$1 \succ 3 \succ 2 .$$

These are actually more rational preferences than those obtained using the classical Hurwitz method. A decision-maker prefers a modernization strategy containing quite a moderate risk, i.e. a strategy having the value λ close to 0.5 but at the same time somewhat more than 0.5 and promising reasonably high, though not largest, net value added (UNPD). It is strategy 1. Somewhat less preferable may be a strategy having a high risk but the highest net value added. For it, the value λ is close to 0. It is strategy 3. Finally, the least preferable for the decision-maker may be an almost risk-free strategy (λ is close to 1) but at the same time promising the least net value added. It is strategy 2.

Consequently, according to the degree of attractiveness for a decision-maker, the pure production modernization strategies under review may, subject to the Hurwitz modified method, be arranged as follows:

1. Procurement of machines and equipment (strategy 1).
2. Procurement of software tools (strategy 3).
3. Procurement of new technologies (strategy 2).

If the decision-maker is focused on some one pure strategy, then it should procure new machines and equipment. But if it intends to combine four strategies into one mixed strategy, then during planning capital expenditures, they should be ranked as stated above. To determine a quantitative preference degree, let us introduce another modification of the Hurwitz method.

As it is known from the theory of games, an optimal mixed strategy ($\vec{p}^{\,*}$) implies a set of probabilities with which m of pure strategies are selected (Kuznetsov, 1994):

$$\vec{p}^{\,*} = \left(p_1^*, \ldots, p_m^*\right).$$

To identify these probabilities, we suggest the following method. Each sum of adjusted areas ($\sum S(G_i)$) quantitatively characterizes a possibility to obtain the net value added (UNPD) with an allowance for risk significance for the decision-maker. The total value of all sums of adjusted areas $\sum S(G_i)$ will be 100% of all possibilities to obtain UNPD. In money terms, it will be 1,271,995 thousand rubles. If we compare each $\sum S(G_i)$ with this total value, we will obtain shares that will exactly be probabilities with which the relevant pure strategies should be selected:

$$\vec{p}^{\,*} = \left(p_1^*, p_2^*, p_3^*\right) = \left(0.461451; 0.20077; 0.337779\right).$$

This means that having such shares, it is required to redistribute the total value of planned capital expenditures for production modernization activities, i.e. 0.461451 of all available monetary funds should be spent for procurement of machines and equipment, 0.20077 of all funds - for procurement of new technologies and 0.337779 of all funds - for procurement of software tools.

In such a context, there is quite a characteristic question: is it any use implementing exactly a mixed strategy during production modernization? In terms of diversification, it is naturally reasonable. However, in some situations, a decision-maker should be geared to implementing some one pure strategy. In this case, it will be procurement of machines and equipment. An example of such situation may be the scantiness of financial resources for implementation of the entire mixed production modernization (technological innovation) strategy.

4. Developing a Global Corporate Innovative Strategy

In this chapter, we will be developing a general innovative strategy of OAO Gorky Automobile Plant (GAZ) for a period of three years, which strategy will comprise all the three areas designated, in particular, in Figure 1 (paragraph 2). These areas include:

1. Develop a product-type innovation strategy.
2. Develop a production modernization strategy.
3. Analyze equipment repair management systems.

It should be noted that we will be developing a product-type innovation strategy, production modernization strategy and equipment repair modernization in the same areas, i.e. in production of five basic types of products.

4.1. Preparing Predictive Information on Financial Performance Indicators of Different Lines of Activity

As was already stated in paragraph 2, it is reasonable to use income (PD), net income (NPD), added value (UPD) and net added value (UNPD) as financial performance indicators of innovations.

Relying on OAO GAZ IFRS financial statements for three years (2008-2010), we can single out for further analysis indicators of income and capital expenditures for five types of products (Tables 2 and 3).

In Table 2, according to the financial statements, the term 'Segment Result' means profit before tax for each segment respectively, i.e. type of products. Income indicators can be calculated in Table 3 on the basis of information contained in Table 2, i.e. summing up profit before tax (*P*) and depreciation (*D*).

Table 2: Financial Indicators for Five Types of Products for Three Years ('000 RUB)

Financial Indicators	Vehicles	Buses	Diesel Engines, Fuel Injection Equipment	Trucks	Road Construction Vehicles
	1	2	3	4	5
2008					
Segment result	2,085,101	1,696,694	1,721,479	-80,759	594,509
Depreciation	2,051,602	196,776	448,792	299,340	148,068
Capital expenditure	1,194,425	104,991	675,454	107,958	90,763
2009					
Segment result	4,239,114	2,450,418	2,202,073	744,872	1,018,401
Depreciation	2,277,060	183,939	321,880	298,248	120,944
Capital expenditure	3,553,897	383,045	987,874	227,320	396,895
2010					
Segment result	4,354,300	1,862,790	3,516,193	2,387,801	1,811,080
Depreciation	2,619,343	266,776	396,643	272,601	177,978
Capital expenditure	4,988,480	692,594	3,678,913	170,339	834,550

Table 3: Income Indicators (PD) for Five Types of Products for Three Years ('000 RUB)

Years	Types of Products (Pure Strategies)				
	1	2	3	4	5
2008	4,136,703	1,893,470	2,170,271	218,581	742,577
2009	6,516,174	2,634,357	2,523,953	1,043,120	1,139,345
2010	6,973,643	2,129,566	2,912,836	2,660,402	1,989,058

Numbers 1-5 in the columns of Tables 2, 3 and further denote numbers of pure innovative strategies.

In order to make the data from Table 3 comparable in money terms, it is required to adjust it in view of the inflation rate. For this purpose, we will evaluate all income indicators in prices applicable to 2010. As annual inflation rate, let us take 25%, which is, in our opinion, in line with the actual inflation in Russia during the crisis of 2008-2010. In the long run, we will obtain analysis data shown in Table 4.

Table 4: Real Income Indicators (FV(PD)) for Five Types of Products for Three Years ('000 RUB)

Years	Types of Products (Pure Strategies)				
	1	2	3	4	5
2008	6,463,598	2,958,547	3,391,048	341,533	1,160,277
2009	8,145,218	3,292,946	3,154,941	1,303,900	1,424,181
2010	6,973,643	2,129,566	2,912,836	2,660,402	1,989,058

According to Figure 4 (paragraph 2), one of the following stages of developing a general innovative strategy includes preparation of an optimistic and a pessimistic forecasts of development of different lines of production, i.e. types of products. We will prepare the forecasts using a polynomial and a regression models.

A polynomial model (Berezin, Zhidkov, 1962) is used where there is insufficient historical information on changes of a particular indicator. In our situation, there are three periods under review; therefore, it is reasonable to use a polynomial model. At the same time, such forecast implies either exponential indicator growth denoting accelerated growth or its parable decline denoting transition of the product maturity stage into the stage of its decline in demand on the market.

In this case, either stage of a product life cycle is described by a second order polynomial:

$$\mathrm{FV(PD)} = a_0 + a_1 t + a_2 t^2, \qquad (2)$$

where a_0, a_1, a_2 - parameters of a polynomial model; t - year number starting from 0.

For instance, analyzing changes in the real income indicator as per pure strategy 1, let us consistently put the observation data from Table 4 into this equation to find out the parameter values (instead of time points t equal to 2008, 2009 and 2010, let us take 0, 1 and 2 respectively). In the long run, we will obtain a system consisting of three equations:

$$\begin{cases} a_0 = 6{,}463{,}598; \\ \mathrm{a}_0 + a_1 + a_2 = 8{,}145{,}218; \\ \mathrm{a}_0 + 2a_1 + 4a_2 = 6{,}973{,}643. \end{cases}$$

Solving the system, we receive the following parameters of the polynomial model: $a_0 = 6{,}463{,}598$; $a_1 = 3{,}108{,}217.5$; $a_2 = -1{,}426{,}597.5$. Putting these values into equation (2), we will get a polynomial model suitable for prediction:

$$\mathrm{FV(PD)} = 6{,}463{,}598 + 3{,}108{,}217.5t - 1{,}426{,}597.5t^2.$$

To find out the real income values in 2011, 2012 and 2013, let us put into the obtained model values t equal to 3, 4 and 5 respectively.

The results for all pure strategies are shown in Table 5 and in Figure 6. Please note that the actual data in the figure is shown by solid lines, and the forecasting data is shown by dashed lines.

Table 5: Forecasting Polynomial Real Income Indicators (FV(PD)) for Five Types of Products in Next Three Years ('000 RUB)

Years	Types of Products (Pure Strategies)				
	1	2	3	4	5
2011	2,948,873	-531,593	2,664,733	4,411,039	2,854,908
2012	-3,929,092	-4,690,531	2,410,632	6,555,811	4,021,731
2013	-13,660,252	-10,347,248	2,150,533	9,094,718	5,489,527

Let us further predict the real income indicators for five types of products using a regression model for this purpose (Zamkov, 2001). Based on the data from Table 4 and using the least-squares method, it is possible to obtain the following linear regression equations:

Strategy 1: $\mathrm{FV(PD_1)} = 6{,}939{,}132 + 255{,}021.75t$;

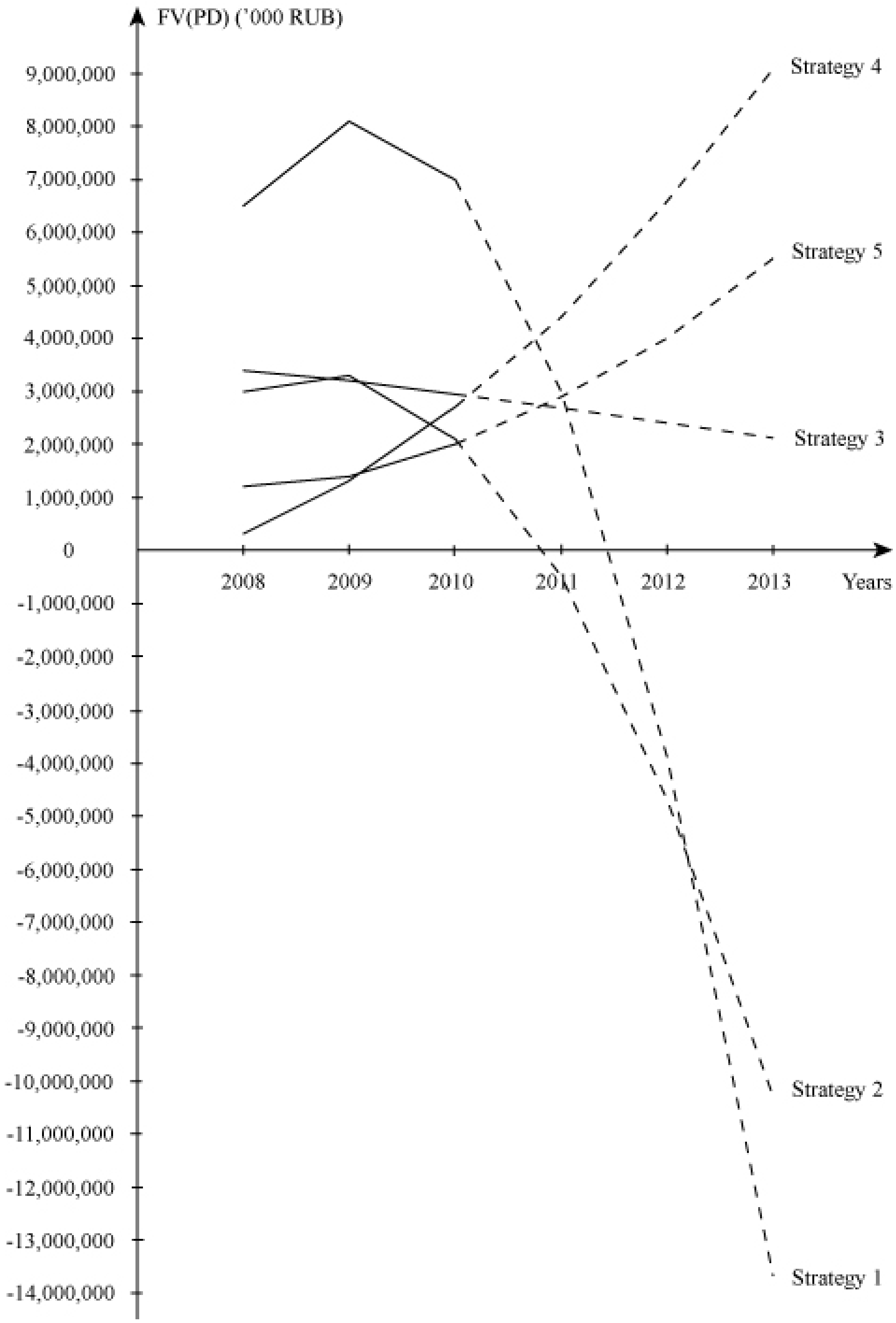
Strategy 2: $\mathrm{FV(PD_2)} = 3{,}208{,}176.5 - 414{,}490.375t$;

Strategy 3: $\mathrm{FV(PD_3)} = 3{,}392{,}048 - 239{,}106.125t$;

Strategy 4: $FV(PD_4) = 275{,}843.875 + 1{,}159{,}434.5t$;

Strategy 5: $FV(PD_5) = 1{,}110{,}115 + 414{,}390.4375t$.

Figure 6: Actual and Forecasting Polynomial Indicators of Real Income for Five Types of Products



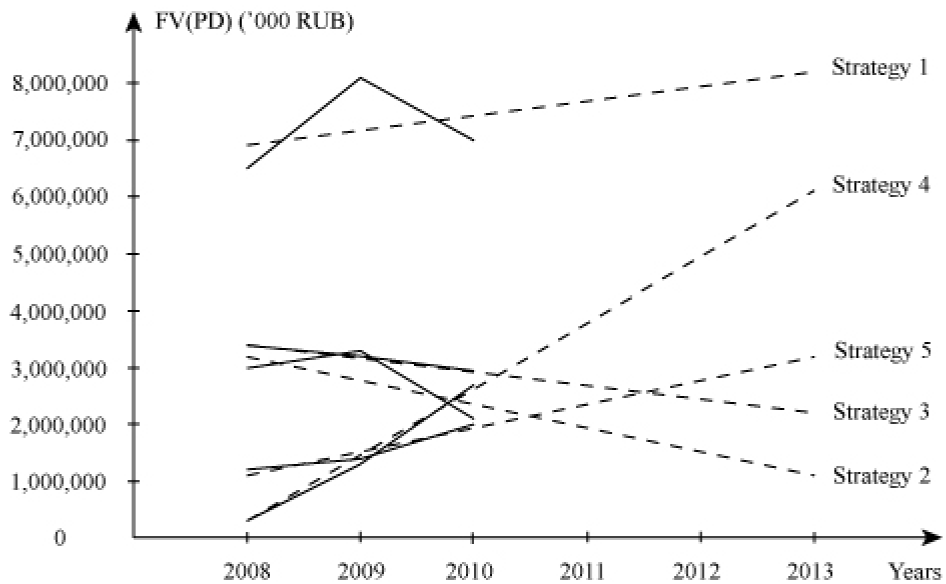
In these equations, t is also year number starting from 0.

Using the obtained correlations, let us predict the real income indicators for all pure strategies. The results are shown in Table 6 and in Figure 7. The actual data in the figure is shown by solid lines, and the forecasting data is shown by dashed lines.

Table 6: Forecasting Regressional Real Income Indicators (FV(PD)) for Five Types of Products in Next Three Years ('000 RUB)

Years	Types of Products (Pure Strategies)				
	1	2	3	4	5
2011	7,704,197	1,964,705	2,674,730	3,754,147	2,353,286
2012	7,959,219	1,550,215	2,435,624	4,913,582	2,767,677
2013	8,214,241	1,135,725	2,196,517	6,073,016	3,182,067

Figure 7: Actual and Forecasting Regressional Indicators of Real Income for Five Types of Products



Based on the data from Tables 5 and 6, we can calculate the total value of predicted real income for the next three years, from 2011 through 2013, for polynomial and regression models respectively. The results are shown in Table 7.

Table 7: Forecasting Indicators of Total Real Income for Next Three Years ($\sum FV(PD)$) for Five Types of Products ('000 RUB)

Forecasting Model	Types of Products (Pure Strategies)				
	1	2	3	4	5
Polynomial	-14,640,471	-15,569,372	7,225,898	20,061,568	12,366,166
Regressional	23,877,657	4,650,645	7,306,871	14,740,745	8,303,030

Table 8: Pessimistic and Optimistic Forecasts of Obtaining Total Real Income for Next Three Years ($\sum FV(PD)$) for Five Types of Products (Pure Strategies) ('000 RUB)

Pure Strategies	Pessimistic Forecast	Optimistic Forecast
1	-14,640,471	23,877,657
2	-15,569,372	4,650,645
3	7,225,898	7,306,871
4	14,740,745	20,061,568
5	8,303,030	12,366,166

Using the data from Table 7, we can designate a pessimistic and an optimistic predictions for obtaining the total real income for the next three years in respect of each pure strategy (Table 8). We are going to use these forecasts in future to develop a general innovative strategy of OAO GAZ.

4.2. Developing a Global Corporate Innovative Strategy Using the Modified Hurwitz Method

In Table 8 (paragraph 4.1), for each of the five pure innovative strategies under review, we have obtained a pessimistic and an optimistic forecasts in relation to the total real income ($\sum \mathrm{FV(PD)}$) which may be attained for the next three years (2011-2013).

According to the Hurwitz method (Koshelev, Trifonov, Yashin, 2012), we can build the Hurwitz function (G_i) for each i^{th} strategy ($i = \overline{1,5}$) using correlation (1) (paragraph 3). To do this, let us draw a straight line through points $\lambda = 0$ and $\lambda = 1$. The value $\lambda = 0$ corresponds to the pessimistic forecast in Table 8, and the value $\lambda = 1$ corresponds to the optimistic forecast. As a result, we obtain the following functions:

Strategy 1: $G_1 = 23{,}877{,}657 - 38{,}518{,}127\lambda$;
Strategy 2: $G_2 = 4{,}650{,}645 - 20{,}220{,}017\lambda$;
Strategy 3: $G_3 = 7{,}306{,}871 - 80{,}973\lambda$;
Strategy 4: $G_4 = 20{,}061{,}568 - 5{,}320{,}823\lambda$;
Strategy 5: $G_5 = 12{,}366{,}166 - 4{,}063{,}136\lambda$.

Let us show the obtained Hurwitz functions in graphs (Figure 8). Following the Hurwitz method, it is possible to determine most profitable strategies in Figure 8. Since the functions G_i are maximized, let us draw envelope line *ABE*. It corresponds to functions G_1 and G_4.

Then let us use the modified Hurwitz method (paragraph 3) to quantitize the decision-maker's preferences in relation to risk. To do this, let us divide the entire λ interval from 0 to 1 by three smaller intervals introducing for this purpose a risk significance criterion (factor) F_S.

Further, since we seek to maximize the Hurwitz functions, we are going to calculate the areas of the trapezia under the envelope line graph corresponding to individual strategies, adjust them, i.e. multiply by the risk significance factor and then calculate the largest area.

Then the obtained adjusted areas are summed up for each of the two Hurwitz functions:

$$\sum S(G_1) = 498{,}059; \quad \sum S(G_4) = 5{,}982{,}660.$$

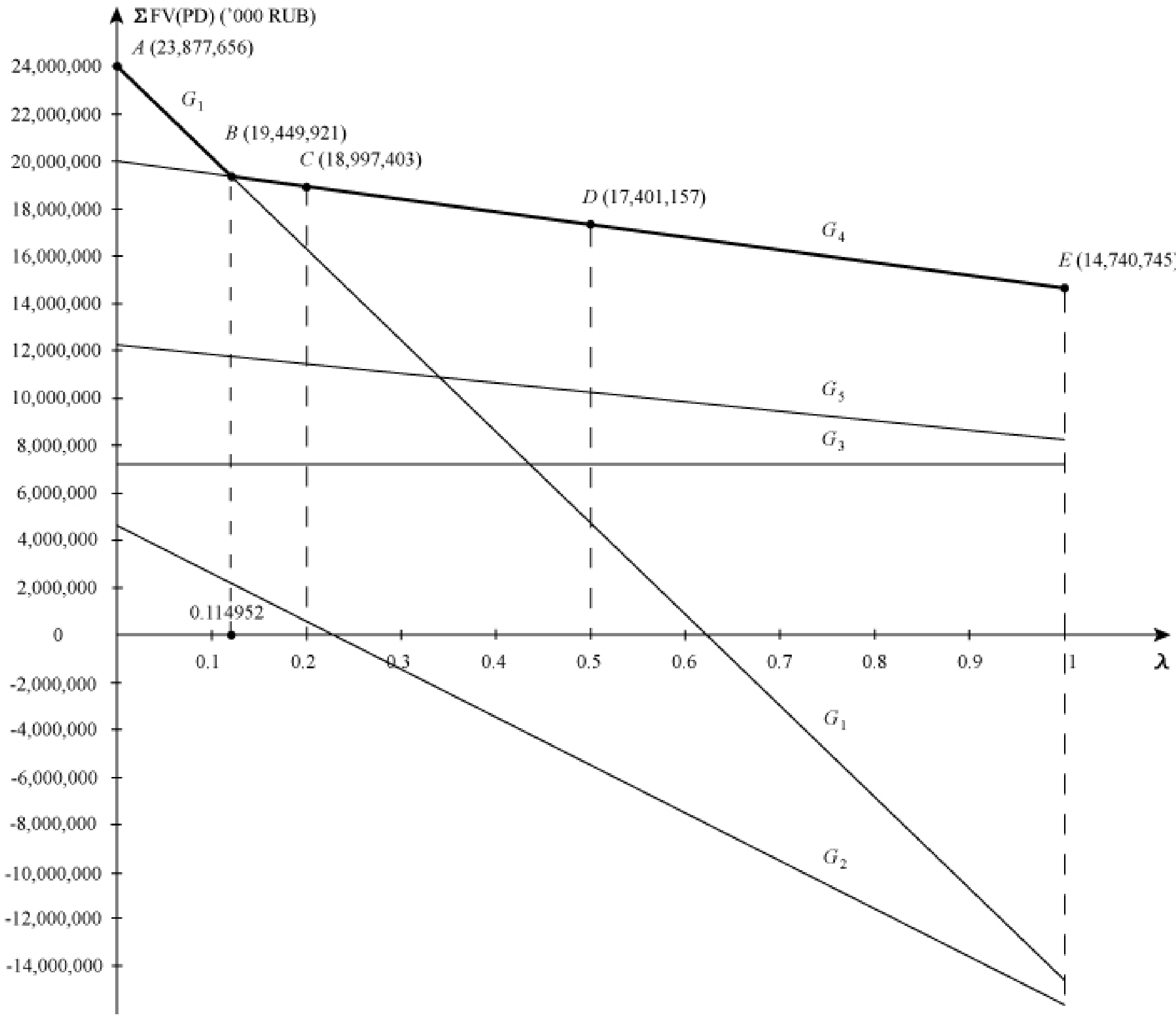
The largest sum of adjusted area ($\sum S(G_i)$) is indicative of maximum preferableness of corresponding i^{th} strategy with an allowance for risk. Then the preferences in respect of the strategies under review will be as follows:

$4 \succ 1$.

Therefore, in terms of the degree of attractiveness for the decision-maker, the pure innovative strategies under review may be arranged as follows based on the modified Hurwitz method:

1. Trucks (Strategy 4).
2. Vehicles (Strategy 1).

Figure 8: Hurwitz Function Graphs



If the decision-maker is focused on any one pure strategy, then it should upgrade the products 'Trucks', the technology of their manufacture and the technology of repairing equipment used for manufacture. But if it is going to combine pure strategies into a single mixed strategy, then during planning capital expenditures, it should give preferences over them in the specified order.

It is obvious, however, that diversification of business is necessary, that is why it is better to combine the selected pure strategies.

To determine the quantitative degree of preference for these strategies, we are going to use the second modification of the Hurwitz method. Let us identify probabilities with which one should select pure strategies to form a mixed innovative strategy. Each sum of the adjusted areas ($\sum S(G_i)$) quantitizes a possibility of obtaining the value of the total real income ($\sum \text{FV(PD)}$) for the next three years in view of risk significance for the decision-maker. The total value of all sums of adjusted areas $\sum S(G_i)$ will be 100% of all possibilities of obtaining the total real income. In money terms, it will be 6,480,719 thousand rubles. If we correlate each $\sum S(G_i)$ with this total value, we will obtain shares that will exactly be probabilities with which one should select the relevant pure strategies:

$\vec{p}^* = (p_1^*, p_2^*, p_3^*, p_4^*, p_5^*) = (0.076852;0;0;0.923148;0)$.

This means that having such shares, it is required to redistribute the total value of planned capital expenditures for innovations, i.e. 0.076852 of all available monetary funds should be directed to innovations in the area of the 'Vehicles' business and 0.923148 of all funds - to innovations in the area of the 'Trucks' business.

In addition, it is clear from Figure 8 that it may happen so that the next required innovative area will include 'Road Construction Vehicles' (Strategy 5) as the Hurwitz function graph G_5 corresponding to this strategy is located high enough, i.e. this line of business promises quite a high positive value of the total real income for the next three years. In order to ascertain it with a high degree of reliability, it is required to adjust the mixed innovative strategy a year later using the described method for this purpose. There is a possibility that this pure strategy will be included into the mixed innovative strategy a year later. Therefore, this promising line should not be disregarded. It is required to continue its financing at the level of mere production maintenance to snatch this quite probable future opportunity.

Figure 8 also shows that the 'Buses' business line should be phased out altogether as it primarily predicts a negative value of the total real income for the next three years. Notably, its positive value may be in an extreme optimistic case only where λ is close to 0. However, the data from Table 2 (paragraph 4.1) is indicative of the fact that OAO GAZ, to the contrary, has been facing significant capital expenditures for development of this line of production in the last three years (2008-2010). Moreover, they have greatly increased for this period.

4.3. Current Innovative Strategy Performance Evaluation

After the most preferable general mixed innovative strategy has been determined for OAO GAZ for the next three years (2011-2013), one should compare it with a current strategy to make a conclusion on the efficiency of the current strategy. If such strategy is different from that recommended by us, then it is required to adjust it. In order to carry out the most rational adjustment, it is necessary to work out appropriate recommendations. A method of working out such recommendations is just described in this paragraph.

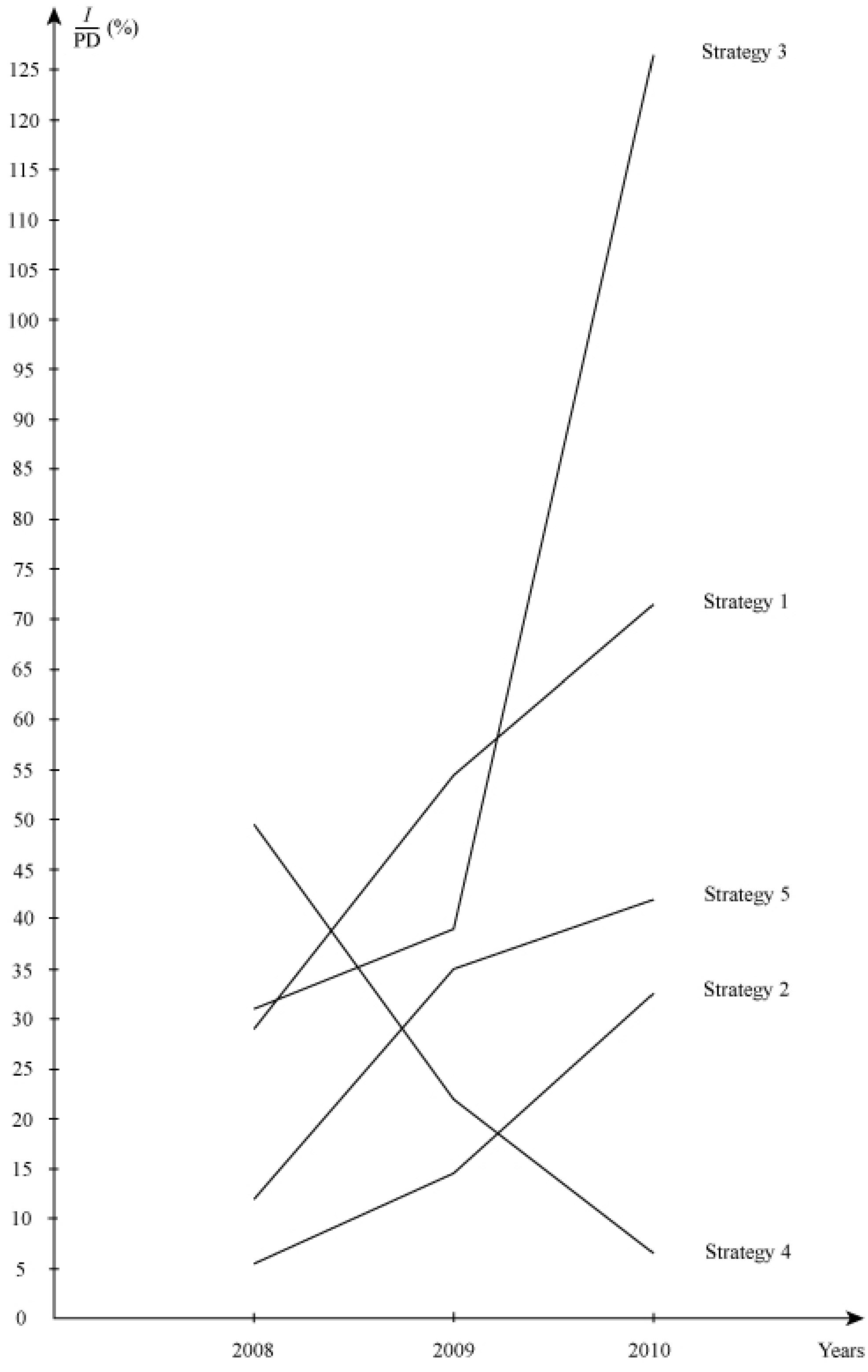
Thuswise, based on the data from Tables 2 and 3, let us consider the dynamic relation of current capital expenditures (*I*) to current income (PD) for three years (2008-2010) for each of the five types of products manufactured at OAO GAZ. The calculation results are shown in Figure 9 and in Table 9.

Based on Figure 9 and Table 9, one can come to the following conclusions on the state of the current innovative strategy at OAO GAZ:

Strategy 1 – 'Vehicles'. The share of capital expenditures in income was consistently growing in the last three years, which share was already 71.5% in the last year of 2010. Therefore, this type of production shows an inadequate effect from capital expenditures.

Strategy 2 – 'Buses'. The share of capital expenditures in income was growing by leaps and bounds. It reached already 32.5% in 2010. In the previous paragraph, we discovered that this type of production should be phased out. In other words, this is useless production merely consuming capital expenditures.

Figure 9: Dynamics of Relation of Capital Expenditures to Income for Five Types of Products for Three Years (%)



Strategy 3 – 'Diesel Engines, Fuel Injection Equipment'. This type of production is not included in the developed mixed modernization strategy and is not even attractive in the longer term. However, it showed an expansive growth of the share of capital expenditures in income from 39% to 126% in 2010.

Consequently, this is problematic production in which it is required to reduce capital expenditures significantly as they produce no acceptable income. At the same time, it will be required to decide in future whether it should be closed since it is not included in the mixed strategy, or it should be left as is so far for diversification purposes.

Table 9: Dynamics of Relation of Capital Expenditures (*I*) to Income (PD) for Five Types of Products for Three Years (%)

Years	Types of Products (Pure Strategies)				
	1	2	3	4	5
2008	28.874	5.545	31.123	49.39	12.223
2009	54.54	14.54	39.14	21.792	34.835
2010	71.533	32.523	126.3	6.403	41.957

Strategy 4 – 'Trucks'. We established in the previous paragraph that this was the most attractive area of innovations at the enterprise. However, the share of capital expenditures in income in this type of production steadily declined and reached 6.5% in 2010. But we discovered that within the frameworks of the mixed strategy, it was required to direct a larger portion of capital expenditures exactly to this line of business. Therefore, the enterprise may and has to increase capital expenditures for modernization of these products and their production facilities.

Strategy 5 – 'Road Construction Vehicles'. Analyzing the dynamics of the share of capital expenditures in income, it is possible to draw a conclusion that OAO GAZ has so far opted a correct strategy with regard to this type of production. This share grows, but at the same time the growth rate declines. It reached 42% in 2010. This is enough so far as we determined earlier that it would probably be a future phase of the enterprise business development.

Eventually, the current innovative strategy of OAO GAZ may be characterized as follows. This strategy requires a serious adjustment in view of the results obtained in the previous paragraph.

5. Conclusion

This study has revealed that we can use the game method for developing a global corporate innovative strategy, including developing product-type innovation strategy, production modernization strategy and equipment repair modernization. For developing a global corporate innovative strategy we offer to use modified Hurwitz method which first updating consists in ranging of preferable Hurwitz functions of taking into account risk significance criterion (factor), and the second – in drawing up of the mixed innovative strategy.

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