Multicriteria optimization of interactions between the main and service subdivisions in oil companies

MICHAEL GERASKIN, OLGA MAZURMOVICH
The Faculty of Economics and Management
Samara State Aerospace University
34, Moskovskoe shosse, Samara, 443086
Russian Federation
Innovation@ssau.ru, Bugi@list.ru

Abstract: - Based on the analysis of integrated corporate structures of Russian oil industry and in view of multi-criteria modeling methodology the multi-objective optimization model of intra-corporate pricing of sectors in oil production, petroleum products refining and sales, as well as oil servicing sectors has been developed. Analysis of pricing mechanism optimization by corporation sectors in oil industry was developed and agreed in accordance with maximin principle structure of intra-corporate prices.

Key-Words: - multi-criteria optimization, transfer price, business process, integrated corporate system, oil servicing activities.

1. Introduction

Oil and gas industry plays an important role in the economy of the present-day Russia, [1] giving around 20 % of GDP (2013), 50 % of revenue to the federal budget, 67 % of export volume, 25 % of investment amount to capital assets. The major volume of oil production in Russia is provided by four corporations [2] (Fig. 1): OAO "OC "Rosneft" (23.4 % share in 2012 total oil production), OAO "OC "Lukoil" (18.5 %), OAO "OC "TNK-BP Holding" (14.1 %), OAO "OC "Surgutneftegas" (12.7 %). The refined oil product market is showing a steady tendency for growing during the last decade, however, the oil production build-up for the major oil-production companies in 2012 versus 2009 was seen only with OAO "OC "Rosneft" Oil Corporation (by 6.3 % with total of 115.8 MTA); the other companies have dropped in their oil production: OAO "Lukoil" – by 1.7% with total of 95.99 MTA; OAO "Surgutneftegas" - by 0.18% with total of 59.52 MTA.

The corporation included into oil-production complex (further we will consider the major oil production company, i.e. "OC "Rosneft") is presented by the vertically integrated complex that includes the oil-production companies, oil-refining companies, fuel stations that distribute refined petroleum products to the end-users, as well as various production servicing companies and affiliates, among which are the security service and fire-fighting service. Inside the oil company overheads there is a steady specific growth in service-providing activities (from 0.9 % in 2010 to 2.03 % in 2012), thus reflecting the importance of this business management from the stand-point of their influence upon the financial results of the industry. The large-scaled character of oil corporation industrial capacities, its multitude and functional variety of their affiliated companies, flexibility and high intensity of internal circulating stock and financial flows gives birth to actuality in optimization of interactions between the major and servicing activities within the frames of a corporation unified business-process.

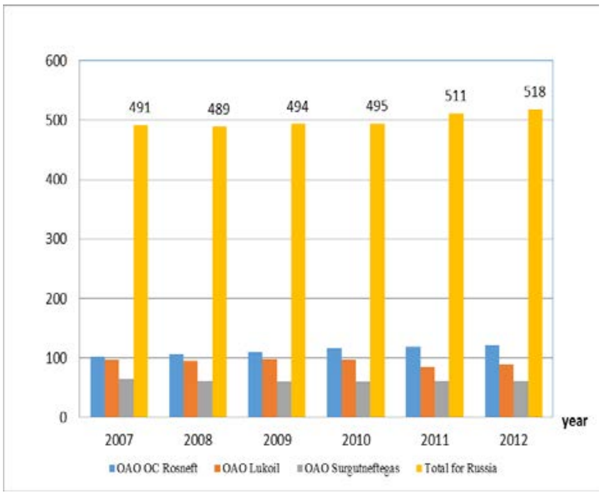

Fig. 1 – Dynamics of Oil Production in Russia by Oil Corporations (in MTA)

From the management theory position the oil-production corporation are presented by integrated structures [3-6], based upon the material integration, when the system of bilateral participation in the capital gives the way to the arrangement of such corms as holdings with affiliated and dependent societies, allocated holdings that have the main corporation as its center, and structures that mutually participate in the capital [7-8]. In this case they form the hierarchical system of corporations or the multi-agent system [9] that unites the individual activity assets where functions like internal corporation (transfer) pricing are sometimes controversial. Namely, in case with vertically integrated system of "oil-production - oil-refining - retailing" type this inconsistency comes out of the limited income (revenue) by the level of demands in end-product (service). In this case while simulating the coordination of the economic interest in hierarchy-type systems of the corporations it's reasonable to use the tool for theoretical multi-criteria optimization.

Concept of Multi-criteria Simulation

The models of multi-criteria optimization [10] formally have no single solution and this is based upon the availability of two approaches: the first one is related to the arrangement of numerous (Π) effective by Pareto solutions [11], that for the solutions for multi-criteria problems with u*, not dominated in other solutions from a stand-point of their complete multitude of criteria, that is

$$\Pi = \left\{ \begin{matrix} u^* \in U \mid \bar{\exists} u \in U : R_k[u] \geq R_k[u^*], \\ k \in K, u \neq u^* \end{matrix} \right\}, (1)$$

Where, u – is vector to manage the organizational/economic system of the corporation; U – is the admissible domain in managing; $R_k[u]$, $k = 1,...,K$ - is the vector for optimization criteria.

The arrangement of Pareto multitude as the first stage on the way to find the solution [12] was done by the methods [13] of consequent concessions, consequent ignoring for main criterion: at this, one of the individual criteria is presented in a form of restriction, i.e. in general the multi-criteria selection was not performed. The numeric application of this approach gives the iteration procedure [14], to a discretizable model with constant criterial functions.

The second approach is related to finding the single solution (as a rule from Pareto multitude) from the optimum conditions of some person who introduces this solutions and who is taking a decision (Decision-Maker), criterion (meta-criterion), and as a rule, is expressed in aggregation of initial criterion of the model, as meta-criterion is formed by way of some transformations with these criteria. The model of decision-making in this case is based upon the multi-criteria theory of utility [15-16], where the joint utility is defined as a weighted sum (aggregation criteria) of utility for the individual agents (specific utility). The various designed empirical methods in arranging the aggregated criteria [17-19]: method of major criterion where the criteria of a single agent is used as a meta-criterion; stimulating complex criteria where more important individual criteria is providing larger effect upon the complex criterion; surcharging complex criteria where the more important individual criteria is more significantly restricting the complex criterion; power-law (multiplication) complex criteria, where it is supposed to see the dependence of selection results for one individual criteria on the selection results for the other criterion, etc. The bench-marking of the weighted additive and multiplication aggregative criteria is presented in [20-25]. Man-machine options of aggregation are available in a form of Dayer-Geofrion procedure [26-28], where the Decision-Maker defines the gradient of meta-criterion and method of Zionts-Wallenius [29], based upon the opinion on the plurality of vector magnitudes for weighted factor as well as with the consideration of Decision-Maker preferences. The overview of the present-day status with man-machine procedures is presented in [30].

The specific class of aggregation methods that develop the penalizing-stimulating approaches is based upon the application of meta-criteria in a form of distance (as per some metrics) between Pareto-optimum values of criteria and the pre-defined by Decision-Maker values of criteria vectors: method of "ideal point" [31], that proposes to minimize the sum of squared deviation for the components of vector criteria from the given Decision-Maker "ideal" value of the vector; selection "as by sample" [32], where the normalized deviations from given values of criteria are minimized.

Moreover, the penalizing/stimulating approach is presented by meta-criteria in a form of maximin (minimax), at the basis of which the equation [33] is selected

$$u = \arg\max_{u\in U}\min_{k\in K} R_k[u]. \quad (2)$$

For the equations formed at the basis of maximin there is the substantiated Pareto-optimum [34] if the resulted solution is the only one. It's also proved [35], that if the individual criteria are normalized, as

$$\overline{R}_k[u] = \frac{R_k[u]}{R_k^*}, k\in K,\ R_k^* = \max_{u\in U} R_k[u] \quad (3)$$

then, the selected by condition (2) monitoring for positive and continuous criteria functions satisfies the condition on equal efficiency:

$$\overline{R}_i[u] = \overline{R}_j[u], i, j\in K. \quad (4)$$

Algorithm of Multi-Criteria Selection from Discrete Plurality of Monitoring

Let's compare the elements u_n^* and u_m^* of Pareto-Optimum monitoring value of u_k^*, formed as per the condition (3), with the help of relative build-up criteria:

$$h_k^{nm} = \frac{R_k[u_m^*] - R_k[u_n^*]}{R_k^*},\ \mathrm{n,m}\in K, \quad (5)$$

The complex comparative evaluation of monitoring is calculated as per formulae:

$$S^{nm} = \sum_{k=1}^{K} h_k^{nm} = \sum_{k=1}^{K}\frac{R_k[u_m^*] - R_k[u_n^*]}{R_k^*} = \sum_{k=1}^{K}\left(\overline{R}_k[u_m^*] - \overline{R}_k[u_n^*]\right),\ \mathrm{n,m}\in K \quad (6)$$

Some monitoring u_m^* is evaluated in complex by a sum of criteria relative build-up as compared to other elements of Pareto multitude:

$$T^m = \sum_{\substack{j=1\\ j\neq m}}^{K} S^{jm} = \sum_{\substack{j=1\\ j\neq m}}^{K}\sum_{k=1}^{K}\left(\overline{R}_k[u_m^*] - \overline{R}_k[u_j^*]\right) = \sum_{\substack{j=1\\ j\neq m}}^{K}\sum_{k=1}^{K}\overline{R}_k[u_m^*] - \sum_{\substack{j=1\\ j\neq m}}^{K}\sum_{k=1}^{K}\overline{R}_k[u_j^*] = (K-1)\sum_{k=1}^{K}\overline{R}_k[u_m^*] - \sum_{\substack{j=1\\ j\neq m}}^{K}\sum_{k=1}^{K}\overline{R}_k[u_j^*],\ \mathrm{m}\in K \quad (7)$$

Parameter T^m is the numerical characteristics of relative preference in monitoring u_m^* if compared to other Pareto-optimum monitors of $u_k^*,\ k\neq m, k\in K$. Compromising monitoring from Pareto multitude is selected as per the condition:

$$u^T = \arg\max_{m\in K} T^m[u]. \quad (8)$$

It's proved in [36], that in case with monitoring criteria equivalence the one selected per condition (8) follows the conditions of maximum (2) for continuous Pareto multitude, and in case with discrete Pareto multitude it is the foremost to condition (2) in the area of metrics (7).

Model of Multi-criteria Optimization of Internal Corporate Pricing

Let's consider the generalized model of transfer pricing optimization for the service companies that provide their oil servicing activities to oil-production corporations [37], that include the models of oil-production sector (referred by symbol "1"), oil-refining sector (as "2"), refined products sales (as "3"), as well as for the fire-safety sector (as "4") and security sector (as "5"). The model presents the formal description of Corporation main and servicing business-processes including the following phases: oil production sector (as "1") and transportation of crude oil to the refining process (as "2"), or sales to any third buyer, hand-over of resulted petroleum products (motor fuels of various types, bringing them to a reference type of fuels) or sector "3", that conducts the process of retailing, or to any third wholesale buyer; oil-servicing processes ensuring fire-safety (sector "4") and security (sector "5") as permanent stations at the objects included in sectors "1", "2" and "3", as well as inspection checks for the lines of sector "1". In order to organize the oil-servicing processes the companies from sectors "1", "2" and "3" rent out the production facilities and transportation vehicles to companies of sectors "4" and "5", as well as companies from sector "3" conducts the distribution of fuels to the latter. The internal corporate calculations are performed at the basis of economic independence of all the sectors, and planning of fire-safety and security processes is based upon the now-in-force codes of the Corporation.

The model has the view as:

$$\begin{cases} \max R^1 = TR^1 - C^1 = p_{01}^1 Q_{V1}^1 + p_{02}^{aver.} Q_{V2}^1 + \\ + p_{03}^{aver.} Q_{V3}^1 + p_{0F}^1 Q_F^1 - p_{01}^5 x_1^1 - p_{02}^5 x_2^1 - \\ - p_{01}^4 x_3^1 - C_F^1, \\ \max R^2 = TR^2 - C^2 = p_{0F}^2 Q_F^2 + \\ + \left(p_{01}^2 Q_{V1}^2 - p_{01}^1 Q_{V1}^1\right) + p_{02}^{aver.} Q_{V2}^2 + p_{03}^{aver.} Q_{V3}^2 - \\ - p_{01}^5 x_1^2 - p_{01}^4 x_2^2 - C_F^2, \\ \max R^3 = TR^3 - C^3 = p_{0F}^3 Q_F^3 + \\ + \left(p_{01}^3 Q_{V1}^3 - p_{01}^2 Q_{V1}^2\right) + p_{02}^{aver.} Q_{V2}^3 + p_{03}^{aver.} Q_{V3}^3 - \\ - p_{01}^5 x_1^3 - p_{01}^4 x_2^3 - C_F^3, \\ \max R^4 = TR^4 - C^4 = \sum_{j=1}^{2} p_{0Fj}^4 Q_{Fj}^4 + \\ + p_{01}^4 Q_{V1}^4 - p_{01}^3 x_1^4 - p_{02}^{aver.} x_2^4 - p_{03}^{aver.} x_3^4 - C_F^4, \\ \max R^5 = TR^5 - C^5 = \sum_{j=1}^{2} p_{0Fj}^5 Q_{Fj}^5 + \\ + p_{01}^5 Q_{V1}^5 + p_{02}^5 Q_{V2}^5 - p_{01}^3 x_1^5 - \\ - p_{02}^{aver.} x_2^5 - p_{03}^{aver.} x_2^5 - C_F^5, \end{cases} \tag{9}$$

$$\begin{cases} C^1 \ge C_{\min}^1 = C_F^1 + p_{01}^5 \sum_{k=1}^{K_1} \frac{t_{Ho_k}}{365} + \\ + p_{02}^5 \sum_{m=1}^{M_1} \frac{t_{Hu_m}}{365} + p_{01}^4 \sum_{j=1}^{J_1} \frac{t_{H_j}}{365}, \\ C^2 \ge C_{\min}^2 = C_F^2 + p_{01}^5 \sum_{k=1}^{K_2} \frac{t_{Ho_k}}{365} + \\ + p_{01}^4 \sum_{j=1}^{J_2} \frac{t_{H_j}}{365} \\ C^3 \ge C_{\min}^3 = C_F^3 + p_{01}^5 \sum_{k=1}^{K_3} \frac{t_{Ho_k}}{365} + \\ + p_{01}^4 \sum_{j=1}^{J_3} \frac{t_{H_j}}{365} \\ C^4 \ge C_{\min}^4 = \frac{N_{days.}^4}{N_{days.}^H} \cdot z_{aver} + \\ + F^4 \cdot \frac{n_a}{100\%} \cdot N_{a.c.}^4 + J \cdot t_H^{4\max} \cdot g_{aver} \cdot \\ \cdot r_{aver} \cdot p_{01}^3 + N_{a.c.}^4 \cdot p_{03}^{aver.} + \\ + S_r^{4\,prop.} \cdot p_{02}^{aver.}, \\ C^5 \ge C_{\min}^5 = \frac{N_{days.}^5}{N_{days.}^H} \cdot z_{cp} + F^5 \cdot \frac{n_a}{100\%} \cdot N_{a.c.}^5 + \\ + K \cdot t_H^{5\max} \cdot \left(r_{aver} + l_{aver}\right) \cdot g_{aver} \cdot p_{01}^3 + \\ + N_{a.c.}^5 \cdot p_{03}^{aver.} + S_r^{5\,prop.} \cdot p_{02}^{aver.}. \end{cases} \tag{10}$$

where we used the following symbols for the vectors of income, revenue, expenses and price: $R^1,\dots,R^5$, $TR^1,\dots,TR^5$, $C^1,\dots,C^5$ - for the values of income, revenue, expenses in respective sectors (symbol "min" defines minimum values, and the upper index – the sectors); $C_F^1,...,C_F^5$ – expenses for the acquisition of resources and payment for the services provided by the companies not being the members of the Corporation; $Q_F^1, Q_F^2, Q_F^3, Q_F^4, Q_F^5$ - volumes of refined products sales and services provided by the respective sectors to the Companies not being the members of the Corporation; $p_{0F}^1, p_{0F}^2, p_{0F}^3$ - prices for refined products sales to the companies not being the members of the Corporation; $p_{01}^1, p_{01}^2, p_{01}^3$ - prices for refined products to the companies being the members of the Corporation; $p_{0F1}^{4,5}, p_{0F2}^{4,5}$ - prices for the services provided by the fire-safety preventive jobs and inspection checks at the objects of the companies not being the members of the Corporation; $p_{02}^{aver.}$, $p_{03}^{aver.}$ - average lease rates for the property and transport vehicles for the companies integrated into Corporation; $p_{01}^{4,5}$, $p_{02}^{4,5}$ - prices for the services provided in the area of preventive fire-safety and inspection checks at the objects of the companies being the members of the Corporation; $Q_{V1}^1, Q_{V2}^2, Q_{V3}^3$ – amount of refined products sales to the companies being the members of the Corporation; $Q_{V2}^1, Q_{V2}^2, Q_{V2}^3$ – industrial areas rented to the companies being the members of the Corporation; $Q_{V3}^1, Q_{V3}^2, Q_{V3}^3$ – number of transportation vehicles rented-out to the companies being the members of the Corporation; x_1^1, x_1^2, x_1^3 – scope of services provided by security companies provided to sectors "1", "2" and "3" as object security; x_2^1, x_2^2, x_2^3 – scope of services provided by the security companies in a form of inspection checks for the pipelines; x_3^1, x_3^2, x_3^3 – scope of services provided by the companies in objects' fire-protection; $x_1^{4,5}, x_2^{4,5}, x_3^{4,5}$ - expenses for the fuels, rented areas and transportation vehicles by the companies from sectors "4" and "5"; $Q_{V1}^{4,5}$, $Q_{V2}^{4,5}$ - scope of services provided for preventive fire-safety and the inspection checks at the objects belonging to the companies being the members of the Corporation; $Q_{F1}^{4,5}$, $Q_{F2}^{4,5}$ - number of objects where preventive fire-safety measures and inspection checks are provided by the companies being not the members of the Corporation.

Planned technical and economic indices for the activities of security and fire-safety service companies are determined as follows:

$$N_{days.}^4 = \sum_{j=1}^{J} n_{O_j} \cdot t_{H_j} \cdot \tau_{H_j} ,$$

$$N_{days.}^5 = \sum_{k=1}^{K} n_{O_k} \cdot t_{Ho_k} \cdot \tau_{Ho_k} + \sum_{m=1}^{M} n_{u_m} \cdot t_{Hu_m} \cdot \tau_{Hu_m} ,$$

$$N_{a.c.}^4 = \frac{J \cdot t_H^{4\max}}{N_{days.}^H} ,$$

$$N_{a.c.}^5 = \frac{K \cdot t_H^{5\max}}{N_{days.}^H} ,$$

where, $N_{days.}^4, N_{days.}^5$ - planned working number of man/days per year; $N_{a.c.}^4$, $N_{a.c.}^5$ – planned number of transportation vehicles required to perform fire-preventive measures and security services; n_{O_j}, t_{H_j}, τ_{H_j} – standard number of personnel, return period (per year), standard duration of preventive fire-service provided (in days), J – total number of the fire-preventive objects; n_{o_k} – standard number of personnel required to arrange permanent security at object "K"; n_{u_m} – standard number pf personnel required to perform inspection checks for pipelines "M"; t_{Ho_k} , t_{Hu_m} – standard periodicity of permanent security for the objects and arrangement of inspection checks (per year); τ_{Ho_k} , τ_{Hu_m} – standard duration for the objects' security and inspection checks (in days); K, M - number of secured objects and pipelines in sectors "1", "2" and "3"; $t_H^{4\max}$,

$t_H^{5\max}$ – maximum periodicity for preventive fire-protection and security checks (per year); z_{aver} – average level of expenses for the personnel payments that work at the production premises of the Corporation (per year); $N_{days.}^H$ - standard number of working days (per year); n_a – depreciation rate for the transportation vehicles; F^4, F^5 – average cost for the unit of transportation vehicles rented by sectors “4” and “5”; l_{aver} – average duration of a pipeline (in km); r_{aver} - average distance to the object of servicing (in km); g_{aver} – specific fuel consumption (in l/km), $S_r^{4prop.}, S_r^{5prop.}$ - standard area of property rented by fire-safety and security sectors.

The monitoring parameters are presented by transfer prices for the services provided to the company, as well as the prices for the internal corporate turn-over in oil-production sector, in oil-refining sector, in refined products sales sector. The components of transfer prices vector are expressed using the ex-works prices:

$$P = \begin{Bmatrix} p_{01}^1, p_{02}^{aver.}, p_{03}^{aver.}, p_{01}^2, \\ p_{01}^3, p_{01}^4, p_{01}^5, p_{02}^5 \end{Bmatrix} \geq 0 . \quad (11)$$

The vector of prices should satisfy the following limitations. At first, the prices for the refined products and services are limited by the market level (having the symbol of “mark.”), and prices for by-products – by the prices of the following value:

$$\begin{aligned} & p_{01}^1 \leq p_{01}^2 \leq p_{01}^3 \leq p_{01}^{3prop.}, \\ & p_{02}^{aver.} \leq p_{02}^{prop.}, p_{03}^{aver.} \leq p_{03}^{prop.}, \\ & p_{01}^4 \leq p_{o1}^{4mark.}, p_{01,02}^5 \leq p_{o1,02}^{5mark.} \end{aligned} \quad (12)$$

Second, the rent costs for the sectors of fire-safety and security are limited by the average expenses in the first three sectors aimed at maintaining the operation of the rented objects:

$$p_{oj}^{aver.} \geq p_{oj}^{\min} = \frac{\sum_{i=1}^{3} C_{0ji}}{\sum_{i=1}^{3} Q_{Vj}}, \; j = 2,3 , \quad (13)$$

where, C_{0ij} - maintenance cost for the rented (by i-sector) property and transportation vehicles; Q_{Vij} - area of property and number of transportation vehicles, rented by i-sector.

Third, commercial activity of all the sectors should be loss-free:

$$R_1, R_2, ..., R_5 \geq 0 . \quad (14)$$

For oil production, oil-refining and sales sectors the coordination parameters for which are determined by the prices for the refined products, these loss-free limitations are defined by the major industrial indices:

$$\begin{cases} p_{01}^1 Q_{V1}^1 = C_F^1 \Rightarrow p_{01}^1 = \dfrac{C_F^1}{Q_{V1}^1}, \\ p_{01}^2 Q_{V1}^2 = p_{01}^1 Q_{V1}^1 \Rightarrow p_{01}^1 = p_{01}^2 \dfrac{Q_{V1}^2}{Q_{V1}^1}, \\ p_{01}^3 Q_{V1}^3 = p_{01}^2 Q_{V1}^2 \Rightarrow p_{01}^2 = p_{01}^3 \dfrac{Q_{V1}^3}{Q_{V1}^2}, \end{cases} \quad (15)$$

supposing, that the expenses for the servicing activities and negligible if compared to the overall expenses in view of speculation on their small effect [38], and for the sectors of fire-safety and security these loss-free limitations are defined by the equilibrium between the revenue and the minimum level of the expenses

$$TR^4 = C_{\min}^4 , \; TR^5 = C_{\min}^5 , \quad (16)$$

thus, stating the expenses for the servicing activities at the minimum standard level.

Mechanism of Pricing Optimization by Sectors of Corporation

The model of multi-criteria optimization for internal corporate interactions (11) - (16) presents a multi-criteria task where criteria (9) and limitations (10), (15) and (16) are linearly dependent on monitoring parameters. That’s why while optimizing the prices there is the change in limitations and this brings to a task with institutional monitoring [39] that required the necessity in stage-wise optimization.

Initially they define the monitoring parameters (vector of transfer prices) that maximize the optimum criteria for the mechanism (3). The sensitivity analysis for the sector criteria and limitations brings to the following optimization mechanism in pricing by sectors of the Corporation (Table 1).

At stage “1” there is the maximization of the price for the main product or the services of the optimized sector basing upon the limitations for the level of the market price:

$$p_{01}^{1} = p_{01}^{2}\frac{Q_{V1}^{2}}{Q_{V1}^{1}} = p_{01}^{3}\frac{Q_{V1}^{3}}{Q_{V1}^{2}}\cdot\frac{Q_{V1}^{2}}{Q_{V1}^{1}} = = p_{01}^{3}\frac{Q_{V1}^{3}}{Q_{V1}^{1}} = p_{01}^{3mark}\frac{Q_{V1}^{3}}{Q_{V1}^{1}},$$

$$p_{01}^{2} = p_{01}^{3}\frac{Q_{V1}^{3}}{Q_{V1}^{2}} = p_{01}^{3mark}\frac{Q_{V1}^{3}}{Q_{V1}^{2}},$$

$$p_{01}^{3} = p_{01}^{3mark},\ p_{01}^{4} = p_{01}^{4mark},\ p_{02}^{5} = p_{02}^{5mark}.$$

Table 1 - Pricing Optimization Mechanism by Sectors of the Corporation

Stage	Sectors: Oil production (1)	Oil refining (2)	Sales (3)	Fire safety (4)	Security (5)
1	$p_{01}^{1} = p_{01}^{3mark.}\frac{Q_{V1}^{3}}{Q_{V1}^{1}}$	$p_{01}^{2} = p_{01}^{3mark.}\frac{Q_{V1}^{3}}{Q_{V1}^{2}}$	$p_{01}^{3} = p_{01}^{3mark.}$	$p_{0}^{4} = p_{0}^{4mark.}$	$p_{0}^{5} = p_{0}^{5mark.}$
2	$p_{01}^{2} = p_{01}^{1}\frac{Q_{V1}^{1}}{Q_{V1}^{2}}$	$p_{01}^{1} = \frac{C_{F}^{1}}{Q_{V1}^{1}}$	$p_{01}^{1} = \frac{C_{F}^{1}}{Q_{V1}^{1}}$	$p_{01}^{1} = \frac{C_{F}^{1}}{Q_{V1}^{1}}$	
3	$p_{01}^{3} = p_{01}^{2}\frac{Q_{V1}^{2}}{Q_{V1}^{3}}$	$p_{01}^{3} = p_{01}^{2}\frac{Q_{V1}^{2}}{Q_{V1}^{3}}$	$p_{01}^{2} = p_{01}^{1}\frac{Q_{V1}^{1}}{Q_{V1}^{2}}$	$p_{01}^{2} = p_{01}^{1}\frac{Q_{V1}^{1}}{Q_{V1}^{2}}$	
4	$p_{02}^{aver.} = p_{02}^{mark.}$, $p_{03}^{aver.} = p_{03}^{mark.}$			$p_{02}^{aver.} = p_{02}^{\min}$, $p_{03}^{aver.} = p_{03}^{\min}$	
5	Calculation of $C_{\min}^{4}, C_{\min}^{5}$ as per formula (12)			$p_{01}^{3} = p_{01}^{2}\frac{Q_{V1}^{2}}{Q_{V1}^{3}}$	
6	Calculation of p_{01}^{4}, p_{01}^{5}, p_{02}^{5}, as per equations $TR^{4} = C_{\min}^{4}$, $TR^{5} = C_{\min}^{5}$, $C_{\min}^{i} = C_{V\min}^{i}, i = 1,2,3$			$p_{0}^{5} = p_{0}^{5mark.}$	$p_{0}^{4} = p_{0}^{4mark.}$

At stages “2” and “3” (while optimizing the main sectors) or at stages “2”, “3” and “5” (while optimizing the oil-service sectors) they define the prices for the products on non-optimized main sectors to the minimum possible level as basing upon their loss-free feature.

At stage “4” they define the prices for the services related to renting of main sector property moreover, while optimizing sectors “1” to “3” these prices are fixed at their maximum possible level with due consideration of market price levels, and while optimizing sectors “4” and “5” – at the minimum possible levels as based upon the average expenses of the sectors “1” to “3”.

At stage “5” the optimization of the main sectors calculates the minimum expenses of the oil-servicing sectors.

At stage “6” the optimization of the main sectors defines the prices for the oil-servicing activities as based upon the conditions of their loss-free, as well as during their execution as a balance of limitations for the expenses in main sectors. While optimizing each of the oil-servicing sectors they select the prices for the services of the other oil-servicing sector at the maximum market level as per the speculation on their goodwill [38], as the criteria on income for these sectors do not depend upon the prices from the other sector.

Further, as per algorithm (5) - (8) they perform the selection the coordinated vector in internal corporate prices, including the compromise as per the maximum principle.

Modeling of Multi-criteria Pricing Optimization

This simulation was done at the basis of 2013 technical and economic indices for the oil industry companies of Samara Region integrated into OAO “Rosneft” Oil Corporation and grouped by sectors: oil production sector (OAO “Samaraneftegas”), oil refining sector including Kuibyshev, Novokuibyshevsk and Syzran refineries, sector on petroleum refined products’ sales (OAO “Samaranefteproduct”), sector on providing fire-safety activities for the Corporation objects (OOO “RN- Fire-safety”), sector that provides security at the Corporation objects (OOO “RN-Security”).

Table 2 presents the results in pricing optimization by sectors of the Corporation as planned targets for 2014. The pricing vectors, optimizing criteria of the respective sector makes the grounding for reduction (or zero growth) in income for the outstanding sectors thus reflecting the controversy features of sector criteria.

Table 2 - Results in Pricing Optimization by Sectors of Corporation for 2014

Vector of prices, optimum for the sectors, and revenue of sectors at optimum prices	Optimized sectors				
	1	2	3	4	5
p^1_{01}, RUB	13 505	5 940	5 940	5 940	5 940
p^2_{01}, RUB	26 620	26 620	11 708	11 708	11 708
p^3_{01}, RUB	26 620	26 620	26 620	11 708	11 708
p_{02}^{aver}, RUB	21 600	21 600	21 600	12 000	12 000
p_{03}^{aver}, RUB	136 412	136 412	136 412	72 000	72 000
p^4_{01}, RUB	17 060	17 060	17 060	19 912	19 912
p^5_{01}, RUB	6 885	6 885	6 885	16 255	16 255
p^5_{02}, RUB	10 175	10 175	10 175	16 661	16 661
R_1, million RUB	16 214.5	15.9	15.9	3.3	3.3
R_2, million RUB	16 230.8	16 230.8	32.2	32.0	32.0
R_3, million RUB	0.0	0.0	16 198.6	0.0	0.0
R_4, million RUB	6.4	6.4	6.4	9.4	9.4
R_5, million RUB	0.9	0.9	0.9	8.4	8.4
R in 2013, million RUB	8 207.5	4 648.0	479.6	0.3	0.4

The calculation of total relative build-up criteria (7) for each vector of the price

$$T^1 = -5{,}77, T^2 = 1{,}44, T^3 = 2{,}43,$$

$$T^4 = 0{,}67, T^5 = 1{,}24,$$

is shown as including the condition (8), that the one coordinate is presenting the monitoring (vector of pricing), optimizing criteria of sector 3, that acts as a connecting element between the Corporation and end-user market, and also realizes the links of sectors ”1” and “2” with sectors “4” and “5”, as well as indicates the inter-relations of sectors “1” and “2” with sectors “4” and “5’ at the stage of fuel sales.

The revenue of Corporation sectors, calculated at the basis of coordinated transfer pricing vector is higher than the actual 2013 income of the Corporation in all the sectors except for sector 3, thus showing that this optimization initiated the re-distribution of income in refined product sales sector between the other subdivisions of the Corporation. The growth in total calculated income of the Corporation (as compared to 2013) is related with the reduction in expenses for oil-servicing as per the standards and revenue re-distribution due to optimization in transfer pricing, including the fact that during the optimization they have analyzed the indices for income and costs as related to the main activity of the sector not including the income (loss) from other operations.

Conclusion

We have developed the multi-criteria model to optimize pricing interactions inside multi-sector (multi-agent) system that interpret the oil industry corporation as a structure consisting of larger blocks in main and servicing areas of activities. The model reflects the system of cost-intensive processing method of pricing that is specific for major oil activity and the concept of standard pricing applied in the industry for rate-fixing the services provided, thus allowing, (with due consideration of economic individuality of Corporation member) to formulate the vector of transfer pricing as based upon revenue maximization in view of servicing expenses minimization up to standardized levels.

We have also formulated the mechanism of stage-wise pricing optimization by criteria in separate sectors of the Corporation as based upon the loss-free limitations and minimum required costs, as well as through the supposition on low effect of servicing activity indices upon the financial results of the main production activity. The application of stage-wise sector optimization mechanism enables to transform the model with limitations dependent on monitoring parameters (model of institutional monitoring) into a model with constant limitations and to form the set of vectors for transferring prices that optimize the criteria of the sectors. Basing upon the discrete multi-criteria selection algorithm we have determined the coordinated vector of prices that correspond to the minimum income loss for all the sectors of the Corporation. Moreover, there is the growth in oil-servicing sectors’ profitability thus increasing their interest towards internal corporate integration and have reduces the expenses for the servicing activities to the minimum require level. These all have resulted in cost-effectiveness growth for oil-service activities.

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