Mathematical models to support the formation of effective options for compromise income tax rates for regional enterprises

Yu V Bondarenko\(^1\), I V Goroshko\(^2\), T V Azarnova\(^1\) and O S Gus’kova\(^1\)

\(^1\)Department of Applied Mathematics, Informatics and Mechanics, Voronezh State University, 1, University Square, Voronezh, 394018, Russia
\(^2\)University of the Prosecutor’s Office of the Russian Federation, Moscow, Azovskaya ulitsa, 2, Russia
E-mail: bond.julia@mail.ru

Abstract. The article is devoted to the development of a set of mathematical models and algorithms to support the formation of income tax rates in the regional budget, which provide a compromise for the interests of regional authorities, business leaders and the public. To support the formation of effective options for compromise income tax rates, a two-level algorithm is proposed based on mathematical models and methods. The proposed models differ in the level of aggregation of enterprises in the region’s economic system. At the upper level, options for income tax rates in the regional budget for enterprise groups are determined. Rates are formed on the basis of the principle of harmonizing tax revenues to the regional budget, the number of jobs and profits of the group’s enterprises. At the lower level, optimization models are proposed for targeted adjustment of the income tax rate for socially significant enterprises in the region. The software implementation of the proposed models and algorithms allows a reasonable calculation of income tax rates using statistical information.

1. Introduction
The formation of effective mechanisms for managing the socio-economic system (SES) of the region is impossible without taking into account its priority system characteristics. Currently, in connection with the intensive development of information technology, one of the most significant characteristics of the socio-economic region is the activity of its elements — both enterprises (represented by their leadership) and the population. At the same time, activity is understood as the presence of one’s own interests and goals, as well as the ability to manifest and realize them within the framework of a single socio-economic space [1, 2]. The successful development of such a system is largely determined not only by the positive dynamics of its individual elements, but also by the ability of regional authorities to accumulate and efficiently (deeply analyzing, carefully considering and coordinating the economic interests of enterprises and the social interests of the population) redistribute resources in the direction of solving the problems that are paramount for the region.

One of the main tools for redistributing resources in the region is taxes. Tax regulation of enterprises directly affects the conflicting interests of all the basic elements of the socio-economic
system of the region — enterprises, people and government. On the one hand, each enterprise is a subject of taxation and one of the sources of replenishment of not only the federal, but regional budgets. Naturally, in this case, in order to solve social problems important for the region, the authorities are interested in receiving the largest possible amount of tax deductions. On the other hand, it is in the interests of both regional authorities and enterprise management to receive the greatest net profit, which can subsequently be invested in the development of production and the creation of new jobs, and provide an opportunity to increase wages. The latter is especially relevant for the economically active population.

The described contradiction is objective and fairly global in nature, and in line with its solution lies the urgent task for the regions — the development of mechanisms for generating profit tax rates in the regional budget that provide a compromise of interests. Naturally, the process of reconciling interests presupposes the interaction of bearers of interests, however, the subject of such a discussion should be effective, logically and mathematically sound concrete proposals. The aim of this study is to develop mathematical tools to support the formation of a set of Pareto-efficient options for compromise income tax rates for regional enterprises.

This study is based on works devoted to the problem of the formation of a tax regulation system that satisfies certain conditions of "justice". The experience of various countries in fiscal policy is analyzed in [3–5]. Theoretical approaches to optimizing the tax system, its coordination with the pricing policy of the industry and wages in enterprises, are presented in [6, 7].

The calculation of the numerical values of the parameters of tax regulation is based in the literature on the use of mathematical models and methods. So, for example, in [8] methods for assessing the impact of tax policy on the activities of small enterprises and models for optimizing income tax rates are presented.

General mechanisms for reconciling interests in economic systems at various levels, including through tax regulation, are presented in the works of V. N. Burkov, D. A. Novikov et al. [9, 10]. In the work of E. V. Orlova [11] proposed simulation models for reconciling the interests of the enterprise and tax authorities. Mathematical models and mechanisms for reconciling interests in the region to achieve environmental homeostasis are presented in the works of G. A. Ougolnitsky, O. I. Gorbaneva [12].

General approaches and mechanisms for harmonizing social and economic indicators of the development of the region are described in the works of I. V. Goroshko, Yu. V. Bondarenko et al. [2, 13, 14]. This article is a logical continuation of these studies in the direction of concretization of mechanisms for the coordination of interests, taking into account modern features of the functioning of Russian regions.

This article proposes a set of mathematical models to support the formation of income tax rates in the region’s budget, which provide a compromise between revenues to the regional budget, the region’s net profit and social indicators of the region’s development, such as nominal wages and population employment. Models differ in terms of aggregation of enterprises in the region. At the upper (aggregated) level, income tax rates are determined in the regional budget for groups of enterprises (industries, types of economic activity (TEA)). The size of rates is formed on the basis of the principle of coordination of revenues to the budget of the region, the number of jobs and profits of the enterprises of the group. At the lower level, there is an address adjustment of the received income tax rate for socially significant enterprises in order to coordinate indicators of their economic activity (in particular, profit) and such social indicators as the number of labor resources and the average nominal wage. It should be noted that the presented models are based on the use of statistical information on types of economic activity and large (city-forming) enterprises of the region, which makes their practical implementation possible.
2. Materials and methods

This study is based on a formal presentation of the socio-economic system of the region as a combination of the following interrelated elements:

- regional authorities (regional administration);
- economic system of the region;
- social system of the region.

The economic system of the region is presented in the work as a set of interacting enterprises engaged in economic activity in the region. We believe that the region’s enterprises can be united into homogeneous groups (classes) so that for enterprises of one group the income tax rate in the regional budget should be the same (except in special cases) and possibly different from the rate of another. These classes may be industries or economic activities.

We assume that the enterprises of the region are divided into $M$ groups that are homogeneous by some criteria. Representation of the economic system as a set of classes will be called *aggregated*.

Among the special cases we will include enterprises that are most significant for the socio-economic development of the region (as a rule, these are large, city-forming enterprises). For such enterprises, the income tax rate may differ from the lower rate of other enterprises of their aggregated class.

The social system of the region in this study will be considered as its population.

Naturally, each element of the socio-economic system is interested in a high level of socio-economic development of the region as a whole. But at the same time, in the development vector, each of the elements has its own priority interests.

In this study, we will consider that the priority interests of the elements of the socio-economic system of the region are:

1) the priority interests of enterprise management — obtaining the largest net profit;
2) the priority interests of the economically active part of the population are the availability of a sufficient number of jobs in the region and the achievement of a high level of wages;
3) the priority interests of regional authorities — increasing the budget revenues (including through tax deductions) as a financial source for solving the socio-economic problems of the region.

We believe that the income tax rate of each enterprise consists of two terms:

$$\alpha_i = \alpha^{fed}_i + \alpha^{reg}_i,$$

where $i$ — company serial number, $\alpha^{fed}_i$ — income tax rate to the federal budget, the same for all enterprises in the region; $\alpha^{reg}_i$ — income tax rate to the regional budget (regional component), which takes values from a given interval $\underline{\alpha} \leq \alpha^{reg}_i \leq \bar{\alpha}$.

Corporate income tax rates in the regional budget are set at the level of regional authorities, and determining the set of their values is one of the main tasks of the tax policy of the region. The practical solution to this problem, as a difficult decision-making task, consists in peer review and discussion by a group of qualified experts (expert community) of various options for tax rates. At the same time, the number of alternatives (rates) to be discussed should be quite small, but each of them should be logically justified from the standpoint of the interests of all elements of the socio-economic system.

In this regard, we consider the task of forming regional authorities a set of options for reasonable values of the regional component of the corporate income tax rate. Moreover, we believe that each of the options must satisfy the following conditions:

- to ensure the coordination of interests of the heads of enterprises, regional authorities and the population of the region;
- have sufficient versatility (to be the same for the enterprises of each of a fairly small number of groups);
– allow tax incentives (lower rates) for significant enterprises in the region (mainly city-forming and large) in order to increase the number of jobs and the average nominal wage at these enterprises.

A system of income tax rates satisfying the above conditions will be called a *compromise*.

If, at the same time, the regional component of the income tax rate is effective in the sense that there is no other acceptable rate that ensures to a greater degree the satisfaction of the interests of each participant in the approval process, then we will talk about an *effective compromise rate option*.

To solve the problem of finding effective options for a compromise system of income tax rates for enterprises in the region, a *two-level algorithm for generating effective options for compromise income tax rates* is proposed, consisting of two enlarged stages:

**Stage 1.** Formation of effective options for a compromise system of income tax rates for each group of enterprises, ensuring coordination of interests of the management of the group enterprises, regional authorities and the population of the region.

**Stage 2.** Formation of a compromise system of preferential income tax rates for enterprises significant for the region, ensuring coordination of the economic interests of the management of these enterprises and the social interests of the population.

Stage 1 corresponds to the upper (aggregated) level of the algorithm, and Stage 2 corresponds to the lower.

The basis for the implementation of each stage is mathematical models, which are optimization problems. Let’s move on to a formal description of each stage and a mathematical approach to their implementation.

At the first stage, we will consider the economic system in aggregate, in the form of $M$ homogeneous groups. The serial number of each group is denoted by $m$, where $m = 1, \ldots, M$.

For enterprises of each group, the same value of the regional component of the income tax rate is determined $\alpha_{reg}^m$.

If in the planning period (year) the total profit of the group of enterprises $m$ before tax is equal to $P_m$, the regional budget will replenish by $R_m = \alpha_{reg}^m \cdot P_m$. Accordingly, the profit of the group’s enterprises, net of tax, will amount to $Z_m = (1 - \alpha_m) \cdot P_m$, where $\alpha_m = \alpha^{fed} + \alpha_{reg}^m$.

We assume that the regional authorities (possibly, together with the management of enterprises of group $m$) determined:

- the lower limit of tax revenues to the regional budget $R_m$;
- acceptable for the successful functioning of the value of the net profit of a group of enterprises $Z_m$;
- acceptable for the region the number of jobs at enterprises of the $m$-th group $L_m$.

Based on the priority interests identified above of the elements of the socio-economic system, it is possible to form a set of indicators to assess the results of applying tax benefits (rate $\alpha_m$) from the position of each of the interested parties:

- $Z_m(\alpha_m)$ — net profit of a group of enterprises;
- $L_m(\alpha_m)$ — the number of labor resources of a group of enterprises;
- $R_m(\alpha_m)$ — the amount of the region’s budget revenues generated by the corporate group tax.

We will say that the income tax rate $\alpha_m$ is a *compromise* (ensures the coordination of interests), if it:

1) is valid, i.e. $\alpha \leq \alpha_{reg}^m \leq \sigma$;
2) corresponds to the interests of regional authorities:

\[ R_m(\alpha_m) \geq \overline{R}_m; \]  

(1)

3) ensures the satisfaction of the interests of the population:

\[ L_m(\alpha_m) \geq \overline{L}_m; \]  

(2)

4) allows enterprises in the planning period to obtain sufficient profit for the successful functioning:

\[ Z_m(\alpha_m) \geq \overline{Z}_m. \]  

(3)

Obviously, many trade-off bets may contain more than one value.

A compromise income tax rate will be called effective if it belongs to the set of effective (Pareto optimal) solutions to the vector optimization problem, which in general can be written as follows:

\[ Z_m(\alpha_m) \rightarrow \max; \]  

(4)

\[ L_m(\alpha_m) \rightarrow \max; \]  

(5)

\[ R_m(\alpha_m) \rightarrow \max; \]  

(6)

under restrictions (1)–(3).

The complexity of the formation of an effective compromise income tax rate is due to the need to build functional dependencies used in the goal functions and the model constraint system (4)–(6). We propose to analyze the impact of tax policy on the amount of profit of a group of enterprises, the number of labor resources and the amount of tax revenues to the regional budget on the basis of specifying models (4)–(6). For its formal presentation, we assume that the region’s administration knows the following information aggregated by enterprises of group \( m \) obtained over the last reporting period (year):

- \( L^0_m \) — number of employees (labor resources);
- \( K^0_m \) — volume of capital (fixed assets);
- \( \gamma_m \) — fixed assets liquidation ratio; \( \lambda_m \) — fixed assets renewal rate;
- direct cost ratios \( a_{mj} \) and \( a_{jm}, j = 1, \ldots, M; \)
- \( \rho_m \) — share of deductions from the wage fund.

Based on statistical and expert information can be calculated:

- \( B^0_m \) — own funds of group enterprises that can be invested in the development of production;
- \( f_m(K_m, \omega, L_m) \) — production function of a group of enterprises, the arguments of which are the amount of capital (fixed assets) \( K_m \) and labor force \( L_m, \omega \) — average annual nominal wage.
- \( \beta_m \) — the average cost of creating one job at the enterprises of the group \( m \);
- \( Q_m \) — projected value of the final demand for the products of a group of enterprises;
- projected output values of groups of enterprises (industry of TEA) \( y_1, y_2, \ldots, y_{m-1}, y_{m+1}, \ldots, y_M \).

Based on the general description of model (4)–(6) and taking into account the known information, we will form an aggregated model for the formation of effective options for a compromise income tax rate for a group of enterprises:

\[ Z_m \rightarrow \max, \]  

(7)
subject to restrictions:

- production technology of a group of enterprises:
  \[ y_m = f_m(K_m, \omega \cdot L_m); \]  
  \[ (10) \]

- needs of the region for products of a group of enterprises:
  \[ y_m \geq \sum_{j=1}^{M} a_{mj}y_j + Q_m; \]  
  \[ (11) \]

- change in fixed assets due to their liquidation, updating and expansion by the amount \( \Delta K_m \):
  \[ K_m = (1 - \gamma_m + \lambda_m)K_m^0 + \Delta K_m; \]  
  \[ (12) \]

- change in the number of labor resources through the creation of new jobs in the amount of \( \Delta L_m \):
  \[ L_m = L_m^0 + \Delta L_m; \]  
  \[ (13) \]

- profit generation:
  \[ P_m = y_m - \left( \sum_{j=1}^{M} a_{jm}y_m + \frac{1}{1 - \rho_m} \omega \cdot L_m + \lambda_m K_m^0 \right); \]  
  \[ (14) \]

- financial restrictions:
  \[ \Delta K_m + \Delta L_m \cdot \beta_m \leq B_m^0 + Z_m; \]  
  \[ (15) \]

- conditions for the coordination of interests (compromise):
  \[ L_m \geq L_m, \quad Z_m = \frac{1}{100} (1 - \alpha^{fed} - \alpha^{reg})P_m \geq Z_m, \quad R_m = \frac{1}{100} \alpha^{reg} \cdot P_m \geq R_m; \]  
  \[ (16) \]

- variable restrictions:
  \[ \Delta L_m \geq 0, \quad \Delta K_m \geq 0, \quad y_m \geq 0, \quad \alpha \leq \alpha^{reg} \leq \alpha. \]  
  \[ (17) \]

Model (7)–(17) belongs to the class of vector optimization problems, and can be reduced to an equivalent problem with variables \( \Delta L_m, \Delta K_m, \alpha^{reg} \). The allowable set of tasks contains trade-offs for income tax rates.

It is proposed to search for effective betting options through an algorithm based on the weighted sums method and including the following steps:

1) Generating a set of vectors of weighting coefficients of the objective functions (7)–(9):
   \[ \Lambda = \{ \lambda^j = (\lambda^j_1, \lambda^j_2, \lambda^j_3) : j = 1, \ldots, J \}, \]

where \( J \) — given number of vectors, \( \lambda^j_1, \lambda^j_2, \lambda^j_3 > 0, \lambda^j_1 + \lambda^j_2 + \lambda^j_3 = 1, j = 1, \ldots, J. \)

2) Solving \( J \) scalar optimization problems with constraints (10)–(17) and a goal function of the following form:
   \[ \lambda^j_1 \cdot Z_m + \lambda^j_2 \cdot L_m + \lambda^j_3 \cdot R_m \rightarrow \max, \]
where \( j = 1, \ldots, J \).

Each of the tasks of this stage in the general case is a nonlinear mathematical programming problem, for the practical implementation of which the Sobol method is reasonably chosen.

The result of the algorithm is a lot of effective options for compromise income tax rates for the aggregated group \( m \) of enterprises in the region:

\[
A_m = \left\{ (\alpha^{\text{reg}}_m)^1, \ldots, (\alpha^{\text{reg}}_m)^J \right\}.
\] (18)

Model (7)–(18) is formed and solved for each group of enterprises \( m, m = 1, \ldots, M \).

Thus, the result of the implementation of the first stage of a two-level algorithm for the formation of effective compromise income tax rates is a set of sets:

\[ A = \{A_1, \ldots, A_M\} \]

Various combinations of options for income tax rates of the set \( A \) are analyzed and discussed by the expert community, based on the decision of which the option that is most suitable for the region is selected:

\[ e = (e_{\text{reg}1}; e_{\text{reg}2}; \ldots; e_{\text{reg}M}); \]

The implementation of the second stage of a two-level algorithm for the formation of effective options for compromise income tax rates is expedient when enterprises important for its development function in the region. The administration of the region is ready to go on tax breaks for such enterprises in order to stimulate the creation of new jobs and increase the nominal wages of employees.

We single out one of these enterprises for consideration. Suppose that it belongs to group \( m \) and the income tax rate for the calculations of the first stage for this enterprise is

\[ \bar{\alpha}_m = \alpha^{\text{fed}} + \alpha^{\text{reg}}_m. \]

Omitting for convenience the index of the enterprise, we will assume that the region’s administration considers it acceptable to reduce the income tax rate of this enterprise to the region’s budget by an amount not exceeding a given \( \Delta \). In this case, the possible income tax rate of the enterprise \( \alpha \) may vary from the next interval:

\[ \bar{\alpha}_m - \Delta \leq \alpha \leq \bar{\alpha}_m, \]

where \( \Delta \) — maximum rate reduction for a given enterprise.

We will say that the income tax rate \( \alpha \) ensures the coordination of the economic interests of the enterprise and the social interests of the population (is a compromise) if the following conditions are met:

\[ P \geq \bar{P}, \]
\[ L_{\text{new}}^{\text{new}} \geq \bar{L}_{\text{new}}^{\text{new}}, \]
\[ \omega \geq \bar{\omega}, \]

where \( P \) — enterprise profit; \( \bar{P} \) — the smallest acceptable value for the successful functioning of the profit of the enterprise; \( L_{\text{new}}^{\text{new}} \) — number of new jobs created at the enterprise; \( \bar{L}_{\text{new}}^{\text{new}} \) — the smallest number of new jobs at the enterprise needed to solve the social problems of the region; \( \omega \) — average nominal wage in an enterprise; \( \bar{\omega} \) — the minimum value of the average nominal wage at this enterprise, necessary to achieve acceptable indicators of regional development.

As a mathematical support for the informed choice of a compromise corporate income tax rate, a model is proposed for determining the optimal compromise corporate income tax rate.

To describe the model, we believe that the regional authorities are aware of the following information about the enterprise received over the last reporting period (year):
\[ L_0 \] — number of employees (labor resources);
\[ K_0 \] — fixed assets;
\[ \omega_0 \] — average annual nominal wage;
\[ \gamma \] — fixed assets liquidation ratio, \( \lambda \) — fixed assets renewal rate;
\[ \rho \] — share of deductions from the wage fund.

Based on statistical and expert information can be calculated:

\[ B_0 \] — own funds of the enterprise, which can be invested in the development of production;
\[ \beta \] — the average cost of creating one new job;
\[ c \] — material costs for the production unit;
\[ y = f(K, \omega \cdot L) \] — enterprise production function, where \( y \) — output volume, \( K \) — fixed assets, \( L \) — labor force.

The criterion for optimality of the model is the maximization of tax deductions.

\[ \alpha \cdot P \rightarrow \max. \tag{19} \]

Restrictions take into account:

- technological capabilities of the enterprise:
  \[ y = f(K, \omega \cdot L); \tag{20} \]
- change in fixed assets by the amount of \( \Delta K \) labor resources by the amount of \( L^{\text{new}} \) and wages by the amount of \( \Delta \omega \):
  \[ K = (1 - \gamma + \lambda)K_0 + \Delta K; \tag{21} \]
  \[ L = L_0 + L^{\text{new}}; \tag{22} \]
  \[ \omega = \omega_0 + \Delta \omega; \tag{23} \]
- financial constraint:
  \[ \Delta K + \beta \cdot L^{\text{new}} + \lambda \cdot K_0 \leq B_0 + P; \tag{24} \]
- profit generation:
  \[ P = y - \left( c \cdot y + \frac{1}{1 - \rho} \omega \cdot L + \lambda \cdot K_0 \right); \tag{25} \]
- the condition for consistency of interests:
  \[ P \geq P, \quad L^{\text{new}} \geq L^{\text{new}}, \quad \omega \geq \omega; \tag{26} \]
- variable restrictions:
  \[ \bar{\alpha}_m - \Delta \leq \alpha \leq \bar{\alpha}_m, \tag{27} \]
  \[ \Delta K \geq 0, \quad \Delta \omega \geq 0. \tag{28} \]

The model (19)–(28) described above belongs to the class of optimization problems and can be reduced to an equivalent problem with variables \( \alpha, \Delta K, L^{\text{new}}, \Delta \omega \). It is proposed to implement the model in practice using nonlinear optimization methods (for example, the Sobol method). The calculated optimal value of the income tax rate due to model limitations ensures the coordination of interests.

Thus, on the basis of a two-level mechanism, a system of compromise income tax rates for enterprises in the region is formed. Wherein:
• if an enterprise does not have a status of special significance for the region, then its income
tax rate coincides with the rate of the group of enterprises to which it belongs, calculated
on the basis of an aggregated model for the formation of effective options for a compromise
income tax rate for a group of enterprises;
• for enterprises especially significant for the region, the preferential income tax rate is
calculated as a solution to the model (19)–(28).

3. Results and discussion
For practical implementation of the algorithm, a software package in C# was developed. The
structure of the complex includes: a database containing statistical data on the region and
indicators of a number of enterprises of the Voronezh region; a computing unit containing
methods for solving nonlinear optimization problems. The algorithm was tested on training
and real data.

Consider the results of the first stage of the algorithm for the formation of effective options for
compromise income tax rates. The calculations were carried out on the basis of aggregated data
of 2017 for the electric power enterprises of the Voronezh region officially provided by the Federal
Statistics Service. These enterprises relate to the type of economic activity ”Production and
distribution of electricity, gas and water”, section ”Production, transmission and distribution of
energy”.

Table 1 shows a fragment of the main data for an aggregated model for the formation of
effective options for a compromise income tax rate for energy enterprises.

| Indicator Name                              | Units       | Value  |
|--------------------------------------------|-------------|--------|
| Average annual number of employees         | thou. people| 31.5   |
| Fixed assets (end of year)                 | mil. rub.   | 274 361|
| Fixed assets renewal rate (at the end of the year) | in % of the total value of fixed assets | 60.2 |
| The liquidation ratio of fixed assets (end of year) | in % of the total value of fixed assets | 0.2 |
| The share of deductions from the wage fund  | %           | 30     |
| Average annual nominal wage                | thou. rub.  | 504    |
| Profit before tax (retained earnings)      | mil. rub.   | 2124.9 |

To carry out practical calculations for the TEA ”Production and distribution of electric
energy, gas and water” based on official statistics for the period 2004–2015. in the Voronezh
region received the production function of the following type:

\[ y = \left( 0.967 \cdot [K]^{-0.0016} + 0.0373 \cdot [\omega L]^{-0.0016} \right)^{-61.15}. \]

The lower bounds of indicators for the billing period: \( L = 33 \) thou. people, \( Z = 1200 \) mil. rub.

The maximum value of the income tax rate is 20 \%. The income tax rate in the Federal
budget of the Russian Federation is 3 \%, and in the regional budget varies from 12.5 \% to 17 \%.

A fragment of the results of software calculations of three effective options for compromise
solutions is shown in table 2.
Table 2. The results of the calculation of effective options for compromise solutions.

| No | Income tax rate in the regional budget (%) | Volume of products (mil. rub.) | Labor resources (thou. people) | Net profit (mil. rub.) | Tax deductions (mil. rub.) |
|----|------------------------------------------|-------------------------------|-------------------------------|-----------------------|--------------------------|
| 1  | 15.10                                    | 32004.4                       | 33.2                          | 1275.8                | 192.64                   |
| 2  | 13.45                                    | 34000.7                       | 35.0                          | 1447.7                | 194.72                   |
| 3  | 12.70                                    | 34879.1                       | 36.7                          | 1375.2                | 174.61                   |

Discussion of the calculation results with representatives of the regional authorities and energy companies led to conclusions about their joint interest in implementing the second option, corresponding to a regional tax rate of 13.45%.

According to expert opinion, additional tax benefits at the enterprises of this type of economic activity are not required.

The study showed the advantages of using mathematical methods to solve complex urgent problems at the regional level — the coordination of the interests of regional authorities, people and enterprise management. The software calculation of effective options for compromise solutions with different evaluations according to the criteria allows increasing not only the objectivity of the decisions made, but also their quality characteristics.

The aggregated model proposed in the study was repeatedly discussed with representatives of regional government and business, its limitations were adjusted taking into account the comments made. The composition of the model’s constraint system, its detailing, was largely determined by the available information in order to make it practically feasible. As it becomes possible to more carefully take into account the characteristics of enterprises, model limitations can be supplemented.

Discussion of the research results determined the ways of its further development in the expansion of mathematical tools. This direction involves the study of the dynamic case, when a compromise solution is determined for several periods. The practical side of supporting the solution of the problem of reconciling interests may be the expansion of algorithmic and software tools by formalizing strategies for the behavior of participants in the discussion of compromise options and negotiating.

4. Conclusion

The approach proposed in this paper to solving the urgent problem of regional development — achieving a high quality of life — is based on an understanding of the need to develop coordinated management decisions (including in the field of tax regulation) that take into account the interests of all elements of the socio-economic system. It is proposed to seek a solution to the difficult task of creating effective options for a compromise profit tax rate for a region based on an aggregated model for creating effective compromise income tax rates for a group of enterprises.

The introduction of the proposed mathematical and software tools in management practice, discussion and analysis of the calculation results not only justified the feasibility of applying various tax benefits as a tool for reconciling interests, but also determined the directions for further research.
References

[1] Gavrilova I A and Makarov A D 2017 Fundamental’nye issledovaniya (Fundamental research) 4-1 133–137
[2] Bondarenko Y V, Goroshko I V and Kashirina I L 2019 Journal of Physics: Conference series 1203 012037
[3] Campbell L and Wren-Lewis S 2005 Oxford Review of Economic Policy 21 (4) 584–597
[4] Maskin E S 2008 American Economic Review 98 (3) 567–576
[5] Lysunets M V 2016 Nalogi i nalogoooblozenie (Taxes and taxation) 2 209–215
[6] Grabarov S V 2015 Jekonomika i matematicheskie metody (Economics and mathematical methods) 51(1) 80–97
[7] Arkin V I and Slastnikov A D 2016 Jekonomika i matematicheskie metody (Economics and mathematical methods) 52 (3) 78–92
[8] Belenky V Z and Egorova N E 2002
[9] Burkov V N, Kuznetsov V N and Pavlov V A 2009 Teoriya aktivnyh sistem: Tr. Mezhduunar. nauchno-praktich. Konf. (The Theory of Active Systems: Works of International Scientific and Practical Conf.) vol 1 (Moscow, Russia) pp 55–58
[10] Novikov D A 2007 Teoriya upravleniya organizacionnymi sistemami (Theory of Management of Organizational Systems) (Moscow: Publishing house of physical and mathematical literature)
[11] Orlova E V 2017 Proceedings of the Mathematical Modeling Session at the International Conference Information Technology and Nanotechnology (MM-ITNT 2017) 1904 1–6
[12] Gorbaneva O I and Ougolnitsky G A 2018 Automation and Remote Control 29 (7) 1319–1341
[13] Bondarenko Y V and Goroshko I V 2016 Sovremennaja jekonomika: problemy i reshenija (Modern Economics: Problems and Solutions) 83 (11) 8–18
[14] Bondarenko Y V, Sviridova T A and Averina T A 2019 IOP Conference Series: Materials Science and Engineering (A. V. Aho and M. R. Garey and J. D. Ulman) 537 042045