



Development of an Effective Method of Tariff Formation for Rural Areas: The Case of Russian Federation

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Abstract. The conducted researches have shown that the features of the housing and communal sector do not allow talking about the possibility of calculating the “optimal” tariff rate. Also in the current conditions in Russia, tariff methods that are successfully used abroad (for example, the method of reinvested capital) cannot be used. The correct approach to housing and communal tariff formation is the calculation of compromise tariffs, the size of which takes into account the interests of consumers of services, resource-supply organizations, public authorities and investors. Development of an effective method of tariff formation for rural areas is particularly acute. The correct approach to housing and communal tariff formation is the calculation of compromise tariffs, the size of which takes into account the interests of services’ consumers, resource-supply organizations, public authorities and investors. Compromise approach for tariffs’ formation can also become an effective instrument not only in Russia: it can be applied in countries where it is sufficient to calculate housing and communal services’ social demand and its budget coverage (e.g. because of the increasing number of migrants).

Keywords: Housing and communal complex · Method of tariff formation · Compromise prices and tariffs · Social demand · Rural areas

1 Introduction

The issue of developing an effective methodology for tariff formation becomes important for rural areas, whose housing and communal complex is currently in the worst condition, according to experts, compared to the national average [1–3]. Due to the fact that ensuring the effective functioning of the agro-industrial complex is one of the highest priorities, methodological support of its activities (including the creation and maintenance of a sustainable housing and communal system) is of particular importance. It is also necessary to develop an effective algorithm that can be used to provide subsidies to the population and agro-industrial enterprises.

The use of the proposed methodology in the process of reorganization of the housing and communal complex of rural areas will form a basis for its further development. It must be noted that the housing and communal complex of rural areas is not only life-supporting for the population, but also is the basis for the functioning of agro-industrial enterprises.

The authors expect a further study on this topic, the main direction of which will be the finalization of the methodology, taking into account the emerging requirements for resource conservation.

2 Socio-Market Compromises

The compromise price modeling is very effective in different spheres [4–6]. Let us consider the mathematical model of the social and market compromise in the market of housing and communal services of Russian Federation.

Let N be the number of final consumers of the goods (for example, social groups of the population) that can be ranked by the amount of money d that they can allocate for the purchase of a certain product (service):

$$d_1 > d_2 > \dots > d_k > \dots > d_N. \tag{1}$$

Y_{Hk} is the minimum necessary rate of consumption of goods by one k -th consumer. In the case of a complex of goods, $Y_{Hk} = 1$.

At the price of the goods in the market $P^Y = P$, can delineate all final consumers of the goods (services) to solvent and insolvent. Those consumers for whom the minimum necessary amount of consumption of the goods (services) will be less than or equal to the amount of money that they are able to allocate for their acquisition ($Y_{Hk}P \leq d_k$), will be solvent. The number of both types of consumers is determined by the level of a fixed price.

Consumers can be considered as solvent if:

$$d_k \geq PY_{Hk}, k = 1, 2, \dots, N_1(P). \tag{2}$$

Insolvent are customers for whom:

$$d_k \leq PY_{Hk}, k = N_1(P) + 1, \dots, N. \tag{3}$$

The total amount of the regulatory requirement of all insolvent consumers of the goods is determined:

$$\hat{Y}(P) = \sum_{k=N_1(P)+1}^N Y_{Hk}, \tag{4}$$

as well as the total amount of payment means available to consumers on the market of the goods:

$$D_2(P) = \sum_{k=N_1(P)+1}^N d_k \tag{5}$$

With a fixed price P , it is possible to determine solvent consumers as a set N_1 ; consumers are ready to present their bankroll in the volume of $D_1(P) = \sum_{k=1}^{N_1} d_k$ on the services market. Insolvent consumers enter into the aggregate $(N - N_1)$ and are ready to present their bankroll in the market of services in the amount of $D_2(P)$. Solvent and insolvent consumers will present their bankroll in the following amount:

$$D' = \sum_{k=1}^N d_k. \tag{6}$$

Payment means and fixed compromise prices of the consumer market uniquely determine the means of payment and the prices of the general commodity market: $P^{\hat{X}} = P^{\hat{X}}(P)$.

In the commodity sector of the product (service) there are m enterprises that produce and sell goods (provide services) under various conditions and determine their production and economic parameters.

At a fixed price of goods (services) in the market $P^{\hat{X}}$, we can determine the values of I_l :

$$I_l = (P^{\hat{X}} - c_l)\bar{X}_l - D_{Hl}, \tag{7}$$

where $D_{Hl} = (3_{0l} + \mu J_l)(1 + \rho)$,

where ρ – the part of payments to budgets of all levels; $3_{0l} + \mu J_l$ – normative marginal income of the enterprise.

Then I_l is the excess income of the enterprise. Thus, the enterprises present in this economic sector and selling a specific product (providing a specific service) can be ranked in descending order I_l :

$$I_1 > I_2 > \dots > I_l > \dots I_m. \tag{8}$$

At a price P , those enterprises whose excess income will be different from zero ($I_l \geq 0$) can be considered as competitive.

The fixed price P also delineates all the enterprises present in the industry to competitive and uncompetitive. The quantity of both of them is regulated by the price level.

The enterprises can be considered as competitive if:

$$(P^{\hat{X}} - c_l)\hat{X}_l - D_{Hl} = I_l \geq 0, l = 1, 2, \dots, m_l(P). \tag{9}$$

Uncompetitive are those enterprises for which:

$$(P^{\hat{X}} - c_l)\hat{X}_l - D_H = I_l < 0, l = m_1(P) + 1, \dots, m. \tag{10}$$

The aggregate competitive producer at a fixed price P is defined as the set m_1 that has the following parameters:

$$c^1 = \sum_{l=1}^{m_1(P)} \frac{c_l}{m_l(P)}; \quad 3_0^l = \sum_{l=1}^{m_1(P)} 3_{0l};$$

$$J^l = \sum_{l=1}^{m_1(P)} J_l; \quad \bar{X}^l = \sum_{l=1}^{m_1(P)} \bar{X}_l;$$

$$D_H^l = (3_0^l + \mu J^l)(1 + \rho). \tag{11}$$

A set of uncompetitive producers at a price P can be defined as a cumulative uncompetitive producer with the following production and economic parameters:

$$c^2 = \sum_{l=m_1+1}^m \frac{c_l}{m_2}; \quad 3_0^2 = \sum_{l=m_1+1}^m 3_{0l};$$

$$J^2 = \sum_{l=m_1+1}^m J_l; \quad \bar{X}^2 = \sum_{l=m_1+1}^m \bar{X}_l;$$

$$D_H^2 = (3_0^2 + \mu J^2)(1 + \rho). \tag{12}$$

The market, generally “recognizes” only a solvent buyer and a competitive seller. At the same time, insolvent consumers are partially solvent and will bring their money $D_2(P)$ to the market. So the total amount of payment means will be equal to $D' = \sum_{k=1}^N d_k$.

Therefore, the model of a market-based trade-off between aggregate demand and aggregate supply in the consumer market will be as follows:

$$P^{XY} = P^*(P) = \max \left\{ \arg \max_P \left(\frac{D'}{P} - \frac{D_H(P)}{P - c(P)}; \frac{D'}{\bar{Y}^1(P)} \right) \right\}. \tag{13}$$

Here $D_H(P)$ is the minimum margin income of the aggregate competitive seller at the price P of the consumer market; $c(P) = P^{\hat{X}}(P) + 3 -$ the average cost of sold goods per unit; $\bar{Y}^1(P) = (E - \hat{A})\hat{X}^1(P)$; $\hat{A}(P)$ is the matrix of average coefficients of labor costs for competitive enterprises.

If it turns out that $N_1(P^*) < N$, then this will mean that $D_2(P^*) > 0$ and $\hat{Y}(P^*) - \frac{D_2(P^*)}{P^*} = Y_S > 0$, where Y_S is the social demand for the goods of insolvent consumers, which is also called non-marketable. The total volume of market and non-market demand will be:

$$Y_F(P^*) = Y^*(P^*) + Y_S(P^*) = \frac{D_1(P^*)}{P^*} + \widehat{Y}(P^*). \tag{14}$$

Coverage of social demand is possible only due to state regulation. The necessary budgetary allocations used to cover this demand can be defined as follows.

From the formula (15) it is possible to receive the sum of necessary payment means in the consumer market in that situation when the compromise volume of purchase and sale will make $Y^0 = Y_F(P^*)$:

$$D = D_H \frac{(1 + \sqrt{1 + 4 \frac{Y^0 c}{D_H}})^2}{4}; \tag{15}$$

$$D(P^*) = D_H^1 \frac{1}{4} \left(1 + \sqrt{1 + 4 \frac{Y_{all}(P^*) c(P^*)}{D_H^1}} \right)^2. \tag{16}$$

In this case, the amount needed to finance from the budget to cover social demand for services will be:

$$\Delta D = D(P^*) - D'. \tag{17}$$

It is obvious that state subsidies allocated to consumers from budgets of different levels to cover social demand can violate the compromise equilibrium that has developed in the market. In case when consumers present $D(P^*)$ payment means on the market, that is, they will provide demand in the amount of $Y_F(P^*)$ at the price of P^* , it may exceed the supply of the product due to limitations in the production capacities of enterprises which are competitive, and also because of the unfavorable fixed P^* for uncompetitive enterprises.

In case of occurrence of similar situations, the government should restore the broken balance by introducing in action various levers of state regulation (for example, budgetary and tax).

Let us consider possible situations.

If $Y_F(P^*) \leq \bar{Y}^1(P^*)$, then competitive enterprises at a fixed price P^* can cover social demand by using production facilities more fully. In this situation, enterprises can increase their marginal revenue by increasing the total number of provided services, which is beneficial to them. The government in this case will not conduct any additional procedures for regulation in the housing and communal sector.

If $Y_F(P^*) > \bar{Y}^1(P^*)$, the government should involve in the production-market process the capacities of uncompetitive enterprises at the price of P^* .

In this situation, two scenarios are possible.

1. $Y_F(P^*) - \bar{Y}^1(P^*) \leq \bar{Y}^2(P^*)$.

In this case, in order to cover the consumers' need for services, the government will be sufficient to attract uncompetitive enterprises with fixed price P^* into the industry. With the help of direct subsidies, the government will be able to increase

the attractiveness of the industry for previously uncompetitive enterprises, covering their current costs or providing tax incentives. The volume of additional production in this case will be:

$$Y_F(P^*) - \bar{Y}^1(P^*) = \Delta Y(P^*). \tag{18}$$

Let us denote the amount of direct government subsidies through $\Delta 3$, and the amount of tax benefits through $\Delta \rho$ ($0 < \Delta \rho < \rho$); in this case it is possible to obtain a condition under which uncompetitive enterprises can make a profit in the production of goods and services in the amount of ΔY :

$$(P^{*\bar{X}} - c^2)\Delta Y + \Delta 3 = (1 + \rho - \Delta \rho)(3_0^2 + \mu J^2). \tag{19}$$

$$\Delta Y(P^*) = \frac{(1+\rho-\Delta\rho)(3_0^2+\mu J^2)-\Delta 3}{P^{*\bar{X}}-c^2}. \tag{20}$$

Equating (18) and (20), taking into account (14) we obtain:

$$Y_F - \bar{Y}_1 = \frac{D_1(P^*)}{P^*} + \hat{Y}P^* - \bar{Y}_1 = \frac{(1+\rho-\Delta\rho)(3_0^2+\mu J^2)-\Delta 3}{P^{*\bar{X}}-c^2}. \tag{21}$$

$$\Delta 3 + \Delta \rho 3_0^2 + \mu J^2 = 1 + \rho 3_0^2 P^* + \mu J^2 P^* - P^* X - c^2 P^* D_1 P^* P^* X + Y P^* - Y_1(P^*). \tag{22}$$

Expression (22) allows to determine the amount of budgetary funds necessary to equalize the trade-offs of supply and demand at a fixed price P^* . The total amount of public funds needed to establish a social and market compromise will be:

$$\Delta D + \Delta 3 + \Delta \rho(3_0^2 + \mu J^2) = \left(D(P^*) - D' + +(1 + \rho)(3_0^2(P^*) + \mu J^2(P^*)) \right) - (P^{*\bar{X}} - c^2(P^*)) \left[\frac{D_1(P^*)}{P^{*\bar{X}}} + \hat{Y}(P^*) - \bar{Y}^1(P^*) \right]. \tag{23}$$

2. $\Delta Y_F(P^*) - \bar{Y}^1(P^*) > \bar{Y}^2(P^*)$.

In this situation, it is required to create new production capacities that will help to satisfy demand in the following volume:

$$\Delta \tilde{Y} = Y_F - \bar{Y}^1 - \bar{Y}^2. \tag{24}$$

Then, in addition to the amount of funds calculated with the help of formula (23), governmental appropriations or (and) preferential credits are needed to create these capacities in a particular sphere.

From formula (13) it is obvious that finding the parameters of the social-market compromise by determining the compromise price P^* requires an iterative procedure of calculations with the replacement of D' by $D(P^*)$ from formula (16). In addition, different procedures are needed in order to harmonize the compromise parameters of the commodity and consumer markets.

In this case the following calculation scheme can be proposed:

1. The decision process begins with a price of the consumer market P_0 for $D = D'$. At step k , using market matching procedures and solving the problem (4), we obtain the prices P_k^* and $P_k^{*\hat{X}}$;
2. Using formulas (9–11) with the price $P_k^{*\hat{X}}$, we determine the parameters of aggregate competitive and uncompetitive producers;
3. By the formula (14) we define $Y_F(P_k^*)$.
4. By the formula (16) we find $D(P_k^*)$.
5. By the model (13), we determine $P_{k+1}^*(P_k^*)$ for $D' = D(P_k^*)$ and the parameters from step 2.
6. If $P_{k+1}^* \neq P_k^*$, then go back to step 2. If $P_{k+1}^* = P_k^* = P^*$, then go to step 7.
7. By formulas (17), (22) and (23), the amounts of budgetary funds necessary for social and market regulation of the final consumer of the goods are calculated. Proceed to step 8.
8. End of calculations; results' analysis.

It is obvious that the government is limited in means of socio-economic regulation [7, 8]. In this regard, the general task of regulating final consumption should be formulated as the task of achieving maximum social effect with limited means.

If the government has a total amount of funds ΔD_G to ensure the social (non-market) demand in accordance with established consumption norms, the criterion for optimality of funds' distribution ΔD_G can be the minimum of the sum of squares of deviations in purchases of goods by insolvent consumers at compromise prices of the consumer market $\left\{P_j^*\right\}_{j=1}^n$ from the volume of needs according to the established norms of consumption, taking into account the relative weights of consumer's goods values.

If in all commodity sectors can be obtained data for determining the parameters of aggregate solvent and insolvent consumers and parameters of aggregate competitive and uncompetitive producers at each price level P_j , $j = 1, 2, \dots, n$, then the compromise price of the consumer market P_j^* and the sum of state subsidies to consumers ΔD_j can uniquely determine the amount of initially insolvent consumers' purchases:

$$Y_{2j}(P_j^*, \Delta D_j) = \frac{D_{2j}(P_j^*) + \Delta D_j}{P_j^*} = \frac{(D_{2j} + \Delta D_j)(D_j - D_{Hj})}{c_j(D_j + \sqrt{D_j D_{Hj}})}, \quad (25)$$

where $D_j = D_{1j}(P_j^*) + D_{2j}(P_j^*) + \Delta D_j$ is the amount of money from buyers on the market of the j -th product, taking into account state subsidies; Y_{2j} for fixed P_j^* is defined as a function of ΔD_j ; $\hat{Y}_j(P_j^*)$ is determined for a fixed price P_j^* in the form of constants.

The necessary subsidies for producers in all product segments are determined according to (18, 20, 22) as follows.

In those commodity segments for which there are not enough reserve capacities of competitive producers, the following condition will be fulfilled:

$$Y_j^*(P_j^*) > \bar{Y}_j^1 \text{ or } \Delta Y_j = Y_j^*(P_j^*) - \bar{Y}_j^1(P_j^*) > 0. \tag{26}$$

In this case, in order to involve capacities in the turnover through governmental regulation, the following condition must be fulfilled:

$$(P^{*\bar{X}} - c_j^2)\Delta Y_j + \Delta 3_j = (1 + \rho + \Delta\rho)D_{jH}^2. \tag{27}$$

Or:

$$\Delta Y_j = \frac{(1 + \rho + \Delta\rho)D_{jH}^2 - \Delta 3_j}{(P^{*\bar{X}} - c_j^2)}. \tag{28}$$

Equating (26) and (28) and solving the equation for the necessary sums of state financing of competitive enterprises, we get:

$$\Delta 3_j + \Delta\rho D_{jH}^2(P_j^*) = (1 + \rho)D_{jH}^2 - (P^{*\bar{X}} - c_j^2(P_j^*) - \bar{Y}_j^1(P_j^*)). \tag{29}$$

Then we can define the general problem of final production market’s regulation:

$$\begin{aligned} & \min_{\{\Delta D_j\}} \sum_{j=1}^n b_j^2 \left[Y_{2j}(P_j^*, \Delta D_j) - \hat{Y}_j(P_j^*) \right]^2 \\ & = \min_{\{\Delta D_j\}} \sum_{j=1}^n b_j^2 \left[\frac{(D_{2j}(P_j^*) + \Delta D_j)(D_j(P_j^*) - D_{Hj}^1(P_j^*))}{c_j^2(P_j^*) \left(D_j(P_j^*) + \sqrt{D_j(P_j^*) D_{Hj}^1(P_j^*)} \right)} - \hat{Y}_j(P_j^*) \right]^2 \end{aligned} \tag{30}$$

under conditions:

$$\sum_{j=1}^n \left[(1 - \rho)D_{jH}^2(P_j^*) - \left[P^{*\bar{X}} - c_j^2(P_j^*) \right] \left(Y_j^*(P_j^*) \right) \right] + \Delta D_j = D_{gov}; \tag{31}$$

$$\Delta D_j \geq 0, j = 1, 2, \dots, n.$$

The problem (31) is similar in structure to the following problem:

$$\sum_{i=1}^n b_i^2 \left(\frac{D_i(D_i - D_{iH})}{c_j(D_i + \sqrt{D_{iH}D_i})} - Y_i^0 \right)^2 = \min \quad (32)$$

under conditions:

$$\sum_{i=1}^b D_i = \bar{D},$$

$$D_i \geq D_{iH}, i = 1, 2, \dots, n.$$

However, its specific character lies in the dependence of its parameters on the compromise prices $\{P_j^*\}$.

3 Modeling of Compromise Tariffs for Housing and Communal Services

The authors developed a methodology for compromise tariff formation in the housing and communal sector [9], which is based on the principles of social and market compromise (Fig. 1).

Based on this methodology, it is planned to develop a decision support system, which will be used both at housing and communal enterprises. At housing enterprises, the proposed decision support system is designed to automate the following functions: ranking of consumers of services; ranking of service providers; searching for the most suitable to each other consumer and service provider; calculation of the trade-off tariff for the service; analysis of the received tariff.

In connection with the fact that the legislation in Russia establishes the right of homeowners to independently set the rates for housing services (taking into account the proposals of housing organizations), the developed methodology can be fully used by housing enterprises, in homeowners' associations and managing organizations.

The size of communal services' tariffs is set at the regional level; that's why it is impossible to fully use the proposed methodology at communal enterprises. However the decision support system can automate the following functions: ranking of services' consumers; ranking of services' providers; searching of the most suitable to each other consumer and service provider.

Also the decision support system, based on the developed methodology of compromise tariff formation can be used by government. At this level it is expedient to automate all the stages of the methodology within the framework of the subsystem; in this case the stages of determining social demand and calculating the amount of subsidies for each group of consumers should be given special attention.

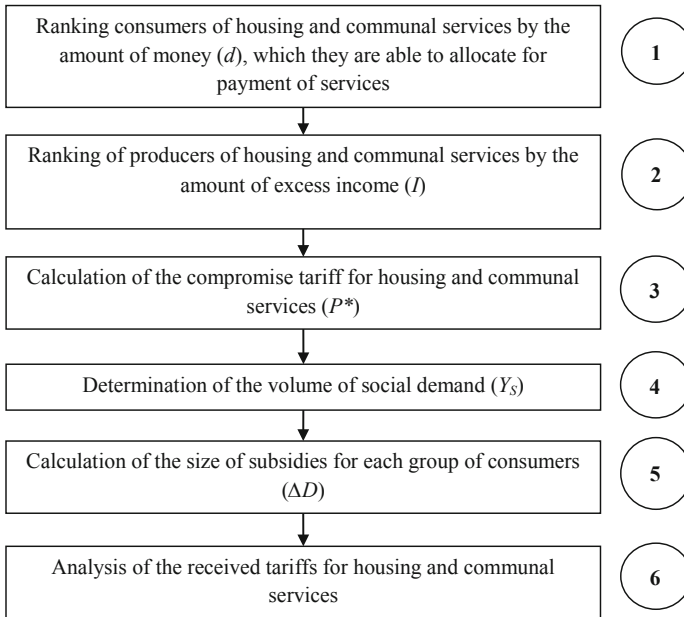


Fig. 1. Stages of a complex methodology of compromise tariff formation

The results of compromise tariffs’ intermediate calculations are given in Table 1.

Table 1. Results of tariff’s recalculation

Type of service	Cost price, rub.	Current rate, rub.	Rate of return, rub.	Buyer’s max bankroll, rub.	Compromise tariff, rub.
Cold water	13,6	21,14	2,2	21,0	20,11
Sewerage	7,44	12,47	1,5	12,0	11,51
Hot water	92,36	132,2	10,5	130,0	129,03
Heating	1296,34	1507,04	28,5	1505,0	1503,2
Garbage removal	0,4	1,71	0,7	1,5	1,26

4 Conclusion

The implementation of the developed methodology and the proposed decision support system into the work of the housing and communal services industry as well as the application of the developed methodological recommendations, will help to achieve the following results: release of additional funds for the modernization of the housing and communal services; improving the quality of provided housing and communal services;

increasing the investment attractiveness of the sector; general improvement of the social and economic situation in Russia.

The developed methodology of compromise tariff formation can be successfully applied not only in Russia, but also in countries where the calculation of the social demand and the size of the budgetary subsidies necessary for its coverage is needed.

Necessity in such technique can arise, for example, in countries with a large number of migrants, who are using various subsidies. The application of the methods and tools proposed by the authors will allow to substantially rationalize the calculation process of both tariffs for housing and communal services and the size of subsidies.

The developed methodology if necessary can be adapted for use in industries where social demand for goods and services should be taken into account and here it is also necessary to determine the amount of possible subsidies.

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