An application of Ramsey model in transition economy: a Russian case study

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Abstract

This case study uses the Ramsey model to analyze whether the current electricity prices charged by the natural monopoly *Novosibirskenergo* in a major industrial region of the Russian Federation are socially optimal. Our estimates of demand elasticities for two major groups of consumers, namely households and industrial users, show that prices are not socially optimal. A decrease in price for industrial users and an increase in price for households would bring the prices closer to socially optimal.

JEL Classifications: D4; L9; P5.

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1. Introduction

After many years of chaotic market reforms, Russia has developed a unique industrial organization. Although it has departed radically from the centrally planned system of the communist period, it is still quite different from what can be found in a market economy at a comparable level of development. Natural monopolies, including the *United Energy System* in the generation and transmission of electricity, *Gazprom* in the production and distribution of natural gas, and the *Ministry of Railroads* in transportation dominate the newly emerging industrial structure. Pricing in most of these natural monopolies is a rather peculiar combination of federal and local government regulations and classical monopolistic rent seeking.

The focus of our case study is two fold: first, to investigate whether the current prices used by the regional affiliates of the world's largest public utility, *United Energy System,* are socially optimal. and second, to evaluate if the current prices could be chosen better. It is well known that socially the most optimal pricing is marginal cost pricing. However, it is not appropriate in the case of a natural monopoly because marginal-cost pricing results in deficit or losses due to high fixed costs. Hence, in practice, a cost-plus pricing is used in Russia. Different consumers pay different prices. The prices for households and the agriculture are set lower than for industrial users. Such price discrimination results in cross-subsidies - - some consumers or groups of consumers subsidize the others. The industrial users pay almost one and a half times more than the residential users, which is in sharp contrast with western Europe, where industrial tariffs are on average two-thirds of the price charged to households, reflecting the relative costs of supplying to these two customers.

For a natural monopoly, prices based on the Ramsey model are considered optimal because prices are set to maximize social welfare and at the same time, to allow the natural monopoly to cover the total cost. If the prices were set at cost-recovery levels, there would be an increase in efficiency. The increased efficiency should occur in both the residential sector and industry. The households will have incentive to regulate their energy consumption, while the industrial users will invest in energy-efficient production methods. In the Ramsey model, fixed costs are covered largely by the consumers who are willing to pay and by those consumers who are more costly to serve. Thus, Ramsey pricing provides a second-best solution. The use of Ramsey pricing has been analyzed for natural monopolies in postal services and transportation industry (see, for example, Scott, 1986, Cuthbertson and Dobbs, 1996 and Train, 1997).[1]

In practice, the Ramsey pricing model has two limitations. First, the regulating agency (in the case of Russia the Russian Energy Commission, REC) must have information about demands for different users and the cost function of the electric utilities. Second, the Ramsey model maximizes consumer surplus without taking into consideration the distribution of consumer surpluses among different groups of users. However, the distribution of consumer surplus may be just as important for the society, especially when the subsequent redistribution is difficult. Our case study shows that, in spite of its limitations, the Ramsey model can be useful in analyzing a regional monopoly.

Most of the existing studies of natural monopolies in the Russian transition economy focus on institutional changes related to re-organization and the partial privatization of utilities in the 1990s (see Ordover *et al*., 1996; Slay and Capelic, 1998; Kryukov, 1998; Galiev, 2000, 2001). Other studies focus on technical aspects of efficiency of utilities, such as trends of energy consumption per unit of GDP and the role of the energy sector in economic development (see Suslov, 1996; Brock, 1999; Kerr, 1999; Melamed and Suslov, 2000). A recent study by the European Bank of Reconstruction and Development (2001) surveys energy policy issues in the former USSR and other East European countries.

The paper is organized as follows. Section 2 provides a brief description of Russian electricity markets. Section 3 focuses on the pricing of electricity and its regulatory environment.

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[1] For a theoretical discussion see Vicussi, Vernon and Harrington (2000).

Section 4 provides estimations of demand functions and an analysis of the costs of a regional electric utility. Section 5 uses the Ramsey model to check the optimality of prices. Section 6 concludes.

2. Production and distribution of electricity in Russia

This section provides a brief overview of the electricity markets in Russia. The government, which maintains a controlling interest in natural monopolies in energy sector, views these monopolies as more than just producers. Following the historical patterns developed under central planning, the government also considers them as agents of social support for the population at large. Forced by the government to perform multiple functions unrelated to their primary role as producers, the Russian natural monopolies often have to sacrifice profitability and efficiency in their operations.

2.1. Suppliers of electricity in Russia

From the former USSR, Russia inherited a considerable portion of the power generation facilities and distribution networks previously known as the United Energy System.[2] Currently, the Russian territory is divided into 72 regional electricity markets, most of which are connected by a common power grid. The grid is managed jointly by a Central Dispatch Office in Moscow and the respective regional dispatch offices. Inter-regional electricity sales are estimated at 10% of the total output, although this figure is higher in some regions.[3] Between 35-40 power networks generate electricity internally that do not meet local demand, while 15-20 networks have surplus. The remaining networks generally meet their regional demand. Networks with a surplus in power generation sell their power to the unified grid at a relatively higher price compared to the tariffs they charge to their local consumers.

[2] A good historical review of the development of the Soviet energy system is offered in Campbell (1980) and Nove (1983).
[3] For example, in Western Siberian regions of Altai, Omsk, and Novosibirsk.

In 1992, the government started privatization and began to restructure the electricity suppliers. Regional energy companies, the so-called regional *Energos*, were incorporated. Among the multiple shareholders of each regional company were both the local government and industrial enterprises. To preserve the integrity of the electrical supply system, the federal government created a holding company, *United Energy System of Russia* (UES), at the national level. The UES retained the national power grid and most of the higher capacity power plants of various regional Energos.

A Board of Directors, which includes a Chair appointed by the federal government and several regional representatives, controls operations of the UES. The federal government owns 52% of UES and has transferred up to 30% of the rest to the regional governments. The UES owns between 49-100% of regional Energos. This complicated ownership and operational relationship between UES and regional Energos represents a compromise between the central and regional interests.[4]

For the most part, the restructuring enabled the government to preserve the integrated nature of the Russian electricity supply system. However, UES does not have monopoly control over all of its major assets. Some politically and economically influential provinces were able to retain all of their power-generating plants under the control of their own Energos thus limiting their relationship with UES to only rental payments for the usage of power plants and other equipments. Most of the nuclear power plants were transferred to the *Rosenergoatom*, a separate government holding company at the federal level under the Ministry of Atomic Energy. Thus at present, the main suppliers in the Russian electricity sector are:

- The joint stock company, Unified Energy System of Russia *(RAO-EES Rossii)* ;
- The 72 Regional Distribution Companies *(Energos); and*

[4] For a more detailed description of the United Energy System and its organization, see Suslov (1996); Melamed and Suslov (2000).

- The nuclear power operator, *Rosenergoatom*.

Tables 1 and 2 below show the capacity and generation of electricity in Russia.

Table 1. Electricity generating capacity in Russia (in million of kW) by energy sources for 1980-2001.

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Table 2. Production of electricity in Russia by (in billion of kWh) by energy sources for 1980-2001.

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2.2. Consumers of electricity in Russia

The major groups of consumers with their respective shares of consumption of electricity (based on 1992-97 period) are as follows.

- Industrial enterprises (50-55%);
- Transportation companies (more than 10-15%);
- Service sector enterprises (10-15%);
- Residential sector/households (10-15%); and
- Farmers and agriculture sector (8-12%).

In the 1990s, the overall output of electricity in Russia decreased compared to earlier periods. This decrease can mainly be attributed to the decline in industrial production. Only the household sector posted an increase in consumption in the 1990s. But this increase in household consumption was not large enough to reverse the general downward trend.

2.3. Inefficiency in the Russian power-generating system

The overall decrease in output of electricity in the 1990s resulted in under-utilization of the most cost-efficient hydroelectric power plants (see Brock, 1999). At present, they operate on average at 40-43% of capacity, while the more costly thermal plants have capacity utilization of 48-50%. The aggregated operational loss in thermal electricity production is estimated at 1,474 billion rubles, the equivalent of 21.4% of all electricity sales.

Another aspect of inefficiency is the continuing increase in employment in the industry in spite of the fact that electricity production is declining. Between 1990 and 2001, production of electricity in Russia dropped by 18%. At the same time the number of employed in the electricity generation sector increased from 545,000 to 942,000, or by 72% (see Table 3).

Table 3. Indicators of electricity sector in the Russian economy for 1980-2001

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In an effort to increase efficiency in the industry in the late 1990s, the UES developed a number of proposals aimed at restructuring the existing system of production and distribution of electricity. In the summer of 2001 the government approved the preliminary version of a restructuring plan. The plan calls for the full privatization of energy generation capacities and the separation of energy generation from the "pure" natural monopoly functions—transmission and distribution of electricity. The declared goal of the plan was to develop a competitive electricity market in Russia in the next three to four years. Further development of the program, however, called for overcoming the conflicting interests of UES and its regional affiliates (see Galiev, 2000, 2001; Rubchenko, 2001). After a long search for a compromise in February 2003, the Russian Duma approved the government plan of reform in the electric power generating industry. When the implementation of this plan begins, the tariffs will still be regulated. Retails sales (to the final users) of electric power will remain a monopoly and will be regulated by the government agency. It is possible, however, that several retail companies will be allowed to operate in the same region.

3. Pricing of electricity

3.1. Pricing policies and government regulation in electricity markets

The pricing of electricity by natural monopolies in Russia is affected by both federal and local government regulations. Although tariffs remain *uniform* for the same type of users (e.g., agriculture, industrial or residential users), different tariffs are charged to different users. Effectively, price discrimination combined with regional cross-subsidization is practiced.

In response to a general deregulation of prices in 1992, the regional Energos began to charge tariffs with the aim to fully recover the costs of electricity generation. At this point, they also started to purchase surplus electricity in the *wholesale* market instead of receiving it through central plan allocation, the practice used prior to 1992. In the same year, to regulate wholesale tariffs of electricity, including the power generated by the nuclear power plants, a Federal Energy Commission was established under the Ministry of Economy. The Federal Energy Commission also serves as a Board of Appeals to resolve regional tariff disputes (Kryukov, 1998; Slay and Capelic, 1998; Melamed and Suslov, 2000).

The regulation of *retail* electricity tariffs was relegated to the Regional Energy Commissions established by the regional governments. In theory, these Regional Energy Commissions are supposed to follow the directives of the Federal Energy Commission in Moscow. In practice, however, the regional governments usually control the retail tariffs.

Regional differences in electricity tariffs are significant. The highest tariffs are found in the Far East of Russia, where both fuel and fuel transportation costs tend to be relatively high. The lowest-cost regions are generally ones where hydroelectric plants are located. In some regions, low-cost hydroelectric power plants meet over half of the regional demand. The differences in tariffs between different types of customers are also considerable, and cross-subsidization is widespread. However, peak load pricing is generally not used.

Actual tariffs charged by utility companies are significantly affected by non-monetary transactions and non-payments. Since the start of market reforms in 1992, the three primary non-monetary means of payment have been barter, inter-firm arrears (or offsets) and promissory notes (veksels). According to various sources, prior to the devaluation of ruble in 1998, barter accounted for 30-80% of inter-firm transactions (Aukutzionek, 1998; Karpov, 1997; Gaddy and Ickes, 1999). Anecdotal evidence suggests that natural monopolies were heavily engaged in barter (Guriev, and Kvasov, 2001). In the mid 1990s, UES reported cash receipts as low as 10% of total revenue. After the 1998 devaluation of the ruble, the problem of non-payment has subsided and the share of cash revenues for UES has gone up to 40%. The remaining 60%, however, is still being paid in promissory notes and in barter. Since 1994, the government allows the Energos to cut off power for non-paying customers. However, the current regulation specified by the Federal Energy Commission provides for numerous exceptions. These exceptions include residential, communal, military, and other types of customers. Many local administrations have also opposed interruptions of electric service because of the risk of social unrest.

3.2. Electricity market in the Novosibirsk region

The region of Novosibirsk (population 2.9 million), which is the focus of this study, is one of the more industrially developed Russian regions east of the Ural Mountains. Having relatively few mineral resources of its own, the Novosibirsk region specializes in manufacturing primarily machine tools, chemicals, non-ferrous metallurgy, construction materials, and food processing. The city of Novosibirsk (population 1.6 million) is the third largest city in Russia (after Moscow and St. Petersburg). It serves as the main transportation and trade center for the entire Siberian region and is considered the unofficial capital of Siberia.

The regional utility company *Novosibirskenergo* is a joint stock company. The electricity generated by *Novosibirskenergo* covers about two thirds of the needs of business and residential consumers in the area. The rest of the electricity supplied is purchased from the neighboring Krasnoyarsk region, one of Russia's energy surplus regions in Eastern Siberia. *Novosibirskenergo* controls 100% of the regional distribution of electricity and about 50% of the production and the distribution of heat. In this paper our focus is only on electricity (see Section 4.4 below).

As is typical in other regions of Russia, regional tariffs for electricity in Novosibirsk are set through a bargaining process between the regional administration and the federal electricity monopoly, United Energy System (UES). Nominally, the Regional Energy Commission and the Federal Energy Commission, an administrative body within the Ministry of Economy, conduct negotiations.

Prices are set separately for six types of consumers: (i) industrial enterprises (large and small); (ii) households (urban and rural); (iii) railways and urban transportation companies; (iv) the agricultural sector; (v) non-industrial enterprises (health care, educational, cultural and government facilities); and (vi) wholesalers. Significant regulatory control and a complex market structure make efficient nonlinear pricing strategies difficult to design and implement. Because the Ramsey model requires estimates of elasticities of demand for various users, we estimate demand functions to get the estimates of elasticities.

4. Estimation of elasticity of demand

Theoretically, with the Ramsey model, it is more appropriate to maximize social welfare in the long-run by using long-run demand elasticities. In the long-run, efficiency in energy usage due to changes in the number and quality of electric appliances can be incorporated. However, existing data do not allow us to capture many of these long-run changes. Therefore, we are limited to estimating only the short-run elasticity, which reflects consumers' reaction to changes in prices in the first few months. However, it is reasonable to suggest that consumers who are more inclined to save energy in the short-run would also be inclined to use the more energy-saving appliances in the long-run. On the other hand, as long run changes in energy-saving appliances can be expensive and may take years to acquire, it may not be feasible to incorporate many such effects in the rapidly changing environment of a transition economy. Therefore, it may be justified to focus on maximizing social welfare in the short-term. A study focusing on the long run effects would be an important extension of our work.

4.1 Data sources

The data cover the period from December 1992 to June 2000. Monthly data on tariffs and electricity consumption for different users in the Novosibirsk region are obtained from the internal records of Novosibirskenergo. Table 4 and Figure 1 provide some descriptive statistics related to electricity consumption in the region. Monthly and quarterly data for production costs of the energy are also obtained from internal records of Novosibirskenergo. Monthly data for inflation level, industrial prices and real household income in the region are obtained from the published sources of the Novosibirsk Statistical Bureau.

Table 4. Electricity consumption and prices in Novosibirsk region: 1995:03-2000:06

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Figure 1. Shares of different users in total electricity consumption in Novosibirsk Region, 1992-99 (total consumption =1)

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Electric power consumption data are seasonally adjusted. Seasonal adjustment was done using methods such as the Eviews-Census XII package, the ratio of moving averages, and by utilizing seasonal dummy variables. The results turned out to be essentially the same.

All time series were found to be non-stationary. Therefore, we measure increments in first differences in logarithms, which is generally considered stationary. Although we have data from December 1992 through June 2000, percentage changes in price show a much greater dispersion from December 1992 to November 1995 than in the remaining period. As a result, the variance of the price variable was found to be not constant. Because of this problem with the data, we use data only for the later period, starting from December 1995. During this period, percentage changes in power consumption exhibit the following behavior: a decrease in any preceding month is followed by an increase in the following month. This pattern suggests that aggregate power consumption returns to a certain “normal” level, which appears to be influenced by many factors such as the type and condition of home appliances, living conditions, and habits. This tendency is clearly reflected in the data. We model this pattern using lagged-dependent variable. Besides the effect of price, this approach allows us to capture the influence of changes in other factors on the changes in consumption, not just from the initial moment of change but over several periods. Thus, the overall cumulative impact of price changes and other factors on consumption can differ from the initial.

4.2. Estimation of elasticity of demand for households

We specify the following model.

$$logE_t = logE_t^* - AlogE_{t-1} - logE^*_{t-1} + B(L)logP + D(L)logI.$$

Where, E_t is the current level of consumption, E_t^* is the ‘normal’ level of consumption, B(L) and D(L) are lagged-polynomials. The relative price $P = P_h/P_c$, where P_h is the nominal price of electricity for households , P_c is the consumer price index, and I is the real income of households. Because the increments are measured in first differences in logarithms, the above specification is modified as:

$$dlogE_t = dlog(E_t^* + A\ logE^*_{t-1}) - A\ dlogE_{t-1} + B(L)dlogP + D(L)dlogI.$$

Data for (E_t*) is not available. However, if we assume that it varies at a constant rate then a constant C can replace the first term on the right-hand side. The level of household electricity consumption goes up slightly at the end of 1997, and falls slightly from the beginning of 1998. It is impossible to explain this by using the dynamics of prices and incomes alone. So we introduce a dummy variable C1, which equals 0 up to December 1998 and equals 1 since January 1998.

The final equation for estimation becomes a dynamic regression given below:

$$dlogE_t = C + C1 - A\ dlogE_{t-1} + B(L)dlogP + D(L)dlogI \qquad (1)$$

Table 5 gives the results of estimation.

Table 5. Estimation of elasticity of demand for households

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Results of the estimation show that price changes influence electricity consumption without a lag, while income does not have any noticeable influence on the short-term fluctuations of electricity consumption of households. The coefficient of the relative price variable B, which equals -0.256 can be interpreted as the "instant" elasticity, reflecting changes in power consumption in the same month as the changes in prices. The short-run elasticity E_h = B/(1+A) takes into consideration the change in consumption, which occurs for some months after the change in tariffs, where A is the coefficient of the lagged-dependent variable. Based on our estimation, the short-term elasticity for households E_h = -0.256/(1+0.461) = -0.17

The "normal" level of consumption can be interpreted as the level, to which consumption tends to return after it has changed due to changes in tariffs. The effect of price changes on energy consumption is most significant in the same month. During the following 3-4 months, the effect of a price change on energy consumption is almost dampened, but the final effect on consumption during this time period is lower than the initial one. A plausible explanation could be that the desire to save more expensive energy partially vanishes with time because changes in the relative price explain only about 5-8 % of consumption changes (excluding seasonality). Changes in real income do not affect changes in energy use in the short-run. Real income may play a role in defining the "normal" level of consumption, but it is difficult to quantify. For the period under consideration, it appears that the “normal level” is determined largely by other factors (e.g., quantity and quality of home appliances).

4.3 Estimation of elasticity of demand for industrial users

The electricity demand for industrial users is estimated in a similar fashion. In this case, electricity prices for industry are deflated by the index of industrial prices P_N in Novosibirsk region. Thus $P = P_i / P_N$. The most desirable approach to estimate industrial energy demand should include the prices of other resources and output prices in the regression equation. Unfortunately such detailed data are not available. Therefore, we use a general index P_N that serves as a proxy for all relevant prices. All other definitions remain the same as in (1). Table 6 contains the results of estimation. The short-run elasticity of demand for industrial enterprises $E_i = -0.596/(1+1.495) = -0.40$. From the estimated values of elasticities, we can conclude that industry demand is more price-sensitive (more elastic) than households. This conclusion is consistent with estimates of elasticities in mature market economies.

Table 6. Estimation of elasticity of demand for industrial users

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4.4 Test for the equality of two elasticities

All coefficients of demand elasticity are statistically significant and less than one. We test the null hypothesis $Ei = B_i/(1+A_i) = B_h/(1+A_h) = E_h$, where B_i , A_i B_h and A_h are the coefficients from the demand equations of industry and households. Using the Wald test, the null hypothesis is rejected at a significance level of 95%. The χ^2 value equals 4.1957 with probability equal to 0.04.

4.5 Cost function

With regard to the cost function of electrical utilities we make the following assumptions. We assume that the variable costs are represented only by the costs of fuel and additional power purchased from other firms. All other costs, including salaries of workers, are treated as fixed costs as they are not directly related to the volume of output, at least in the short-term. Although Novosibirskenergo supplies electricity along with heat, a special method is used to separate costs of electricity production. In our analysis we used the cost data for electricity only.

For costs we have only quarterly data, which is insufficient because the seasonal effects cannot be adjusted. Hence a cost function cannot be estimated. The unavailability of detailed data on costs is a usual problem in studies similar to ours. Therefore, in order to have meaningful estimates of costs, it is necessary to make certain assumptions and then investigate how the results might change by relaxing the assumptions.

We do have information about the total variable costs. Therefore, it is possible to calculate average variable costs based on the total output, regardless of the consumer type. However, there is some evidence showing that distribution costs of energy are different for different types of consumers. For example, for the more dispersed networks, energy losses are greater. According to existing estimates, the variable costs of providing energy to households are approximately 1.5 times higher than for other consumers.

Simple comparison of the available data reveals that the cost of fuel per unit of energy rises with the increase in energy output. However, some part of this increase is due to the fact that the percentage of energy loss is higher during the cold winter quarters when output is also higher. At the same time, if we compare average variable costs in the same season (e.g., winter) for different years, it is possible to see that these costs are somewhat higher when energy output is higher. This is due to the fact that a higher level of production and distribution of energy results in a relatively higher percentage loss. Therefore, it is reasonable to expect that average variable and marginal costs will be rise slightly with the increase in output and the marginal cost will be somewhat higher than the average variable cost.

5. The Ramsey model

Now we can compare existing prices using the Ramsey model. Initially, we assume that the marginal costs of production are equal to the average variable costs and are also equal for all types of consumers. That is $MC = MC_i = MC_h = AVC$. We relax this assumption later to investigate how the conclusions change. It is reasonable to assume that because the demands of household and industrial users are independent, the cross-price elasticities are zero.

Because, all estimated values of demand elasticities are less than unity, the prices charged cannot be profit-maximizing prices under monopoly. Thus the monopoly is restricted by the regulatory agencies from charging profit-maximizing prices. If we assume that the goal of the regulatory bodies is to maximize the social welfare, allowing the monopoly to fully recover the total costs, then under the Ramsey rule, the prices and marginal costs must satisfy the following inverse-elasticity relationship.

$$R = \frac{(P_i - MC)/P_i}{(P_h - MC)/P_h} = \frac{E_h}{E_i} \tag{2}$$

E_h and E_i are the demand elasticity coefficients for households and industry, respectively, P_h and P_i are the (real) prices charged and MC is the marginal cost. In our case, household price must exceed marginal cost to a greater degree than the industrial price for the Ramsey ratio to be optimal. If prices were to be optimal, the ratio R must equal $E_h/E_i = -0.17/-0.40 = 0.425$. The actual values of R are shown in Figure 2. Our estimates show that for the observed period, R is greater than 1 (see Figure 2). Not shown are the situations where household prices were lower than the marginal cost.

Figure 2. Estimated Ramsey ratio.

About here

Now consider the case when $MC = MC_i = MC_h > AVC$. For this case, the left side of the equation (2) would be even higher and the Ramsey ratios would be even farther from the optimal value 0.425. For the opposite situation when $MC = MC_i = MC_h < AVC$, (or even significantly lower than the average variable costs), the left side of the equation (2) will be lower but still greater than one because the household price is consistently lower than the industrial price. As in the previous case, the Ramsey ratios would not correspond to the optimal value. Finally, suppose that the marginal costs for different groups of consumers are not equal. Because they are higher for households ($MC_i < MC_h$), it is evident that the left side of equation (2) would again be higher than one, and the Ramsey ratios would not equal the optimal value 0.425.

5.1 Robustness of the Ramsey Ratio

To test the robustness of the optimal Ramsey ratio obtained from our estimation one can use the following approach. The elasticities values are calculated based on the four coefficients in the estimated demand functions. Instead of using the point estimates, one can construct a 95% confidence interval and see how the Ramsey ratios would fluctuate with the varying coefficient values within that interval. Table 7 below presents the results.

Table 7 shows that although variations in elasticities estimates provide for a considerable variation in R, the latter always remains below one. Therefore, we can conclude that even allowing for a wide difference in the magnitude of marginal cost and for imprecision in estimates of elasticities, the current prices for electric power are not optimal. A substantial increase in the prices for households (69-192%) and a decrease in prices for industrial users (23-56%) are necessary to correct the situation.

Table 7: Sensitivity analysis of estimated Ramsey ratio

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6. Conclusion

From our investigation, the policy implication from an efficiency standpoint is rather straightforward. In the Novosibirsk region, based on the social welfare criteria, prices for industrial users must be lowered and those for households increased. However, this goal might be difficult to achieve politically because price increase for households must take into consideration the affordability of those households living at or below subsistence level. Thus, the level of poverty in the population and the share of energy expenditure in households' budgets become significant factors in a trade-off between price reforms aimed at efficiency, on the one hand and affordability, on the other. If the household tariff were to be increased and industry tariff lowered, there would be a redistribution of consumer surplus from households to industrial users, resulting in a reduction in the deadweight loss. However, the magnitude of overall welfare gain that would result from these price changes cannot be estimated based just on these two groups of electricity users (households and industry) because together they represent about 50% of consumption in the region. It is also important to note that at present, a large part of welfare distribution in favor of households goes to families with higher income levels, which does not correspond to the declared goals of redistribution policies. Thus, for policy purposes, the relevant issue is the choice between an increase in overall social welfare through a change in pricing, or preservation of a sub-optimal pricing structure, which retains freedom of redistribution of consumer surplus by regulatory agencies.

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Table 1
Electricity generating capacity in Russia by source of energy, 1980-2001, in millions of kW

	1980	1985	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Total	165.4	195.8	213.3	213.0	212.0	213.4	214.9	215	214.5	214.2	214.1	214.3	212.8	214.8
Thermal	121.1	137.3	149.7	149.5	148.4	148.8	149.7	149.7	149.2	149	148.7	148.3	146.8	147.4
Hydro	35.1	41.5	43.4	43.3	43.4	43.4	44	44	44	43.9	44.1	44.3	44.3	44.7
Nuclear	9.2	17.0	20.2	20.2	20.2	21.2	21.2	21.3	21.3	21.3	21.3	21.7	21.7	22.7

Source: Russian Statistical Yearbook, 2000, p. 320; 2002, p. 358.

Table 2
Production of electricity in Russia by source of energy, 1980-2001, in billions of kWh

	1980	1985	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Total	805	962	1082	1068	1008	957	876	860	847	834	827	846	878	891
Thermal	622	703	797	780	715	663	601	583	582	567	564	563	582	578
Hydro	129	160	167	168	173	175	177	177	155	158	159	161	165	176
Nuclear	54	100	118	120	120	119	98	99	109	109	104	122	131	137

Source: Russian Statistical Yearbook, 2000, p. 320; 2002, p. 358.

Table 3

Some indicators of electricity sector of the Russian economy, 1980-2001

	1980	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Number of enterprises.	1006	849	887	943	895	1096	1165	1130	1242	1289	1528	1431	1464
Number of employed, 000	467	545	563	626	666	710	750	790	810	852	891	913	942
Number of production workers, 000	358	404	416	465	494	530	560	588	597	629	657	672	692

Source: Russian Statistical Yearbook, 2000, p. 318; 2002, p. 358.

Table 4
Electricity consumption and prices in Novosibirsk region: 1995:03-2000:06

Variable	Mean	Maximum	Minimum	Std. Dev.
Household electricity consumption, 1000 kWh's.	147401.1	253597	105033	25691.92
Household electricity prices, rubles.	0.102735	0.268046	0.016572	0.054219
Relative household electricity prices (deflator - inflation index)	0.812505	1.367831	0.321237	0.261652
Industry electricity consumption, 1000 kWh's.	245152	357277	161577	44502.34
Industry electricity prices, rubles.	0.25933	0.3878813	0.101422	0.064984
Relative industry electricity prices (deflator - index of industrial prices)	0.893351	1.159971	0.575943	0.169776

Table 5
Dependent variable: $dlogE_t$
Period: 1995:03 - 2000:06
64 observations

Variable	Coefficient	Standard Error	t-statistic	Probability
$dlogE_{t-1}$	-0.461851	0.106812	-4.323957	0.0001
$dlog(P = P_e/P_c)$	-0.256443	0.097834	-2.621216	0.0111
C	0.021444	0.020323	1.055133	0.2956
C1	-0.031357	0.029488	-1.063397	0.2919
R^2	0.315684	F-statistic		9.226281
Adj. R^2	0.281469	Probablity (F-statistic)		0.000042

Model is tested for heteroscedasticity, autocorrelation, functional form, and normal distribution of residuals.

Table 6
Dependent variable: $dlogE_t$
Period: 1995:03 - 2000:06
64 observations

Variable	Coefficient	Standard Error	t-statistic	Probability
$dlogE_{t-1}$	-0.494957	0.096289	-5.140303	0.0000
DlogP	-0.596473	0.122615	-4.864606	0.0000
C	-0.002143	0.009543	-0.224616	0.8230
R^2	0.437941	F-statistic		23.76479
Adj. R^2	0.419513	Probability (F-stat.)		0.000000

Model is tested for heteroscedasticity, autocorrelation, functional form and normal distribution of residuals.

Table 7
Sensitivity analysis of estimated Ramsey ratio

Variable coefficients:	Average	Standard deviation	Top border of the interval +2 s.e.	Bottom border of the interval - 2 s.e.	$R = E_h/E_i$ for top border	$R = E_h/E_i$ for bottom border
Demand function for the households						
$DlogE_{t-1}$	-0.461	0.106	-0.249	-0.673	0.513	0.383
DlogP	-0.256	0.097	-0.062	-0.45	0.106	0.772
Demand function for the industry						
$dlogE_{t-1}$	-0.494	0.096	-0.302	-0.686	0.382	0.495
dlogP	-0.596	0.122	-0.352	-0.84	0.743	0.311

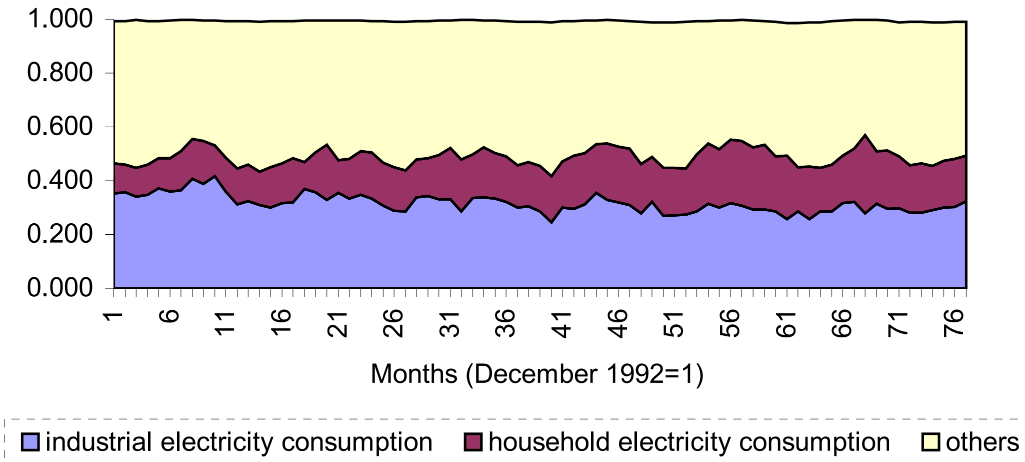

Figure 1. Shares of different users in total electricity consumption in Novosibirsk Region, 1992-99 (total consumption=1).

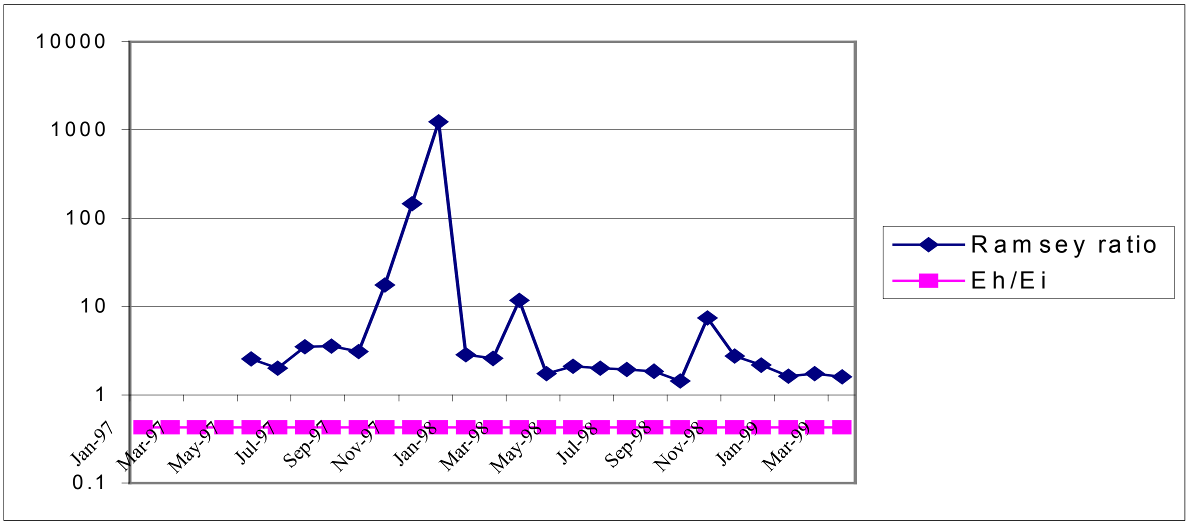

Figure 2. Estimated Ramsey ratios. Baseline 0.425 corresponds to the optimal ratio of Eh/Ei= 0.425