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EFFECTIVENESS OF ECOLOGICAL EDUCATION AND AWARENESS IN PUBLIC POLICY: MICROECONOMIC ANALYSIS OF REGULATION EFFECTS AT REGIONAL ENERGY MARKET

Abstract

Ecological safety is one of the most important challenges for the people all over the world. Remedies applied are often a part of public policy ad, as a rule, undermine losses of public welfare in a short-run to achieve environmental goals. These losses may be considered as a fee paid by society for cleaner environment. The aim of the state as a regulator in this context (or even a kind of its social responsibility) is to choose the way to better environment which guarantees a minimum public welfare loss. Welfare effects are construed here in microeconomic perspective – as welfare changes measured at the markets under regulation. Ecological education and awareness represent a rare case of regulation which could result in gain of public welfare. The arguments come from theoretical analysis of situation when the information first unavailable is transmitted to consumers, and they change their preferences.

Public welfare gain as a result of consumers' awareness on NOx emission, measured at Novosibirsk regional energy market, could run up to 25 mln of rubles per month (regional market is based on energy consumption and production data). This gain of welfare could occur if consumers show rational reaction, which undermines a decrease of energy demand as a response on information of energy production externalities; or if they react at all. The second remark is crucial for regulation effect. It means that consumers have to consider ecological information as meaningful. These values and behavior are next to ecological education. As some researches show the cleaner environment is out of the priorities for people in Russia. Therefore Russian government has to promote ecological education. Sufficiency of current efforts is considered in the paper as well.

Keywords

ecologic awareness, ecological education, environmental policy, microeconomic analysis

1. Introduction

Being a part of public policy environmental regulation is very sensible to efficiency matter. Its benefits sometimes are hardly to be measured and are hardly to be expected soon enough to be transmitted to political benefits for the authorities today. As for the costs, environment-friendly behavior is rather expensive thing both for the state and for the society. For the State it means considerable efforts (and the budget is always limited). For the society it results in rather restrictive changes of production and consumption patterns. Being painful enough to change polluters' behavior environmental regulation affects domestic producers' competitiveness which is a crucial point for the state.

So if the regulator is wise enough to follow long-run benefits of cleaner environment, it is anxious for environmental regulation costs efficiency. Regulation costs here mean losses in

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public welfare which can be considered as a price of better environment for the society. The aim of the state as a regulator in this context (or even a kind of its social responsibility) is to choose the way to achieve environmental goals which guarantees a minimum public welfare loss.

Public welfare is considered usually as a sum of consumers' and producers' net incomes (incomes after expenses incurred). It is measured, as a rule, in a macroeconomic way (for national economy). In the meantime microeconomic analysis allows to measure welfare of the market actor's as a sum of consumer and producer surpluses. The last approach seems to be convenient for regulation effects analysis, since the regulation often affects some of the markets, not all of them. Still, in most cases of environmental regulation we face the losses of surpluses sum. If the society cares of the environment, it can accept these losses. But the most interesting thing is that if the people care, they can change their preferences so the environmental goal can be achieved without negative welfare changes. Going further with the concept of consumer sovereignty it can result in eco-friendly behavior of producers without any substantial efforts from the state.

To observe this idea more precisely we start from conventional microeconomic analysis of market welfare change resulting from consumer preferences alteration. We apply then this analysis to the case of Novosibirsk regional energy market and see how and when environmental regulation can bring welfare gain. Finally, we conclude whether or not regional or federal authorities in Russia are doing enough to take advantage of social awareness as an instrument of environmental policy.

2. Social awareness as an instrument of environmental policy: microeconomic analysis

The most common environmental regulators considered in the textbooks are taxes and standards – as a kind of generalization for direct (administrative) and indirect (economic) policy instruments. Both of them, as well as many other, affect producer (polluter), which results to supply decrease. Conventional microeconomic analysis demonstrates then market welfare loss as for the case of environmental tax (Figure 1). Transfer to the state is S_{p1DFB}, and the welfare loss is S_{DEF}. Compare it with the case, where consumers are informed about negative effect of good's consumption or production. If they care of, they change their preferences, which results in demand decrease (Figure 2). We can reach the idea of welfare gain if we imagine the situation as following: curve D_1 reflect false preferences (consumption under externalities ignorance), while curve D_2 reflects consumers' real preferences. Therefore the figure between two curves cannot be interpreted as surplus loss. It seems like they don't want to buy amount Q_1-Q_2, but they do. So their excess expenditures are equal the figure ACQ_1Q_2FB, and they will gain this amount while adjusting preferences.

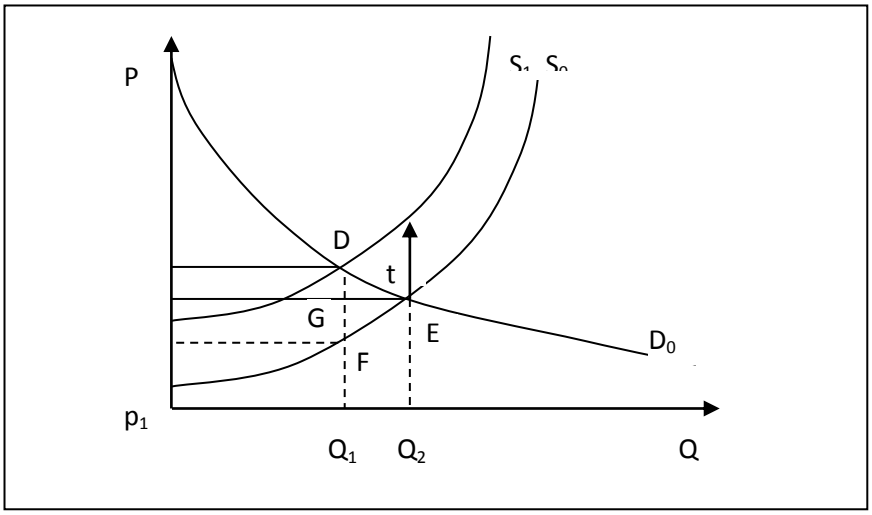

Figure 1: *Market under regulation: environmental tax*

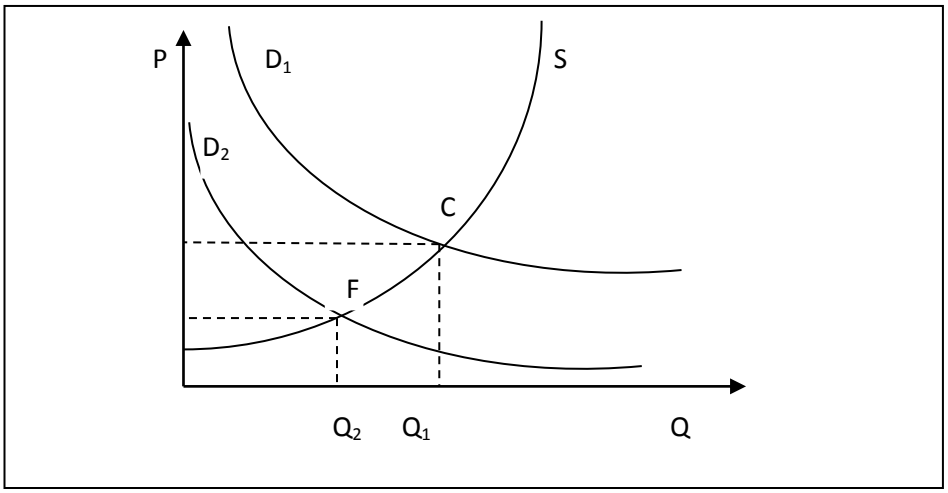

Figure 2: *Market under regulation: information campaign (as in Arnold, 1994)*

As for the producer's side, his surplus loss is equal to the figure *ACBD*. All in all we have net gain of market welfare measured as the figure CQ_1Q_2F. Arnold (1994) provides more detailed analysis of the case.

To apply this analysis to the case of Novosibirsk regional energy market, the market itself was modelled, environmental goal was chosen and responses of regional energy company were estimated.

3. Modeling of regional energy market

Modeling of demand and supply at regional energy market started with research by N. Suslov, A. Mishura (2003). Empirical basis for their modelling consists of monthly data on energy consumpltion and prices for different groups of energy consumers within the period 1995-2000. For the purpose of current research regression analysis of demand functions was

made on monthly data of energy consumption, prices and accumulated price indexes for the period 1998-2003 with further adjustment to the changing structure of energy consumption.

Energy prices were considered as exogenious variable, because tariffs are first fixed by regiobal regulator and then affect consumers decisions. As data series derived were nonstationary, we turned to logarithm difference. Dummy variable was introduced to meet seasonal changes of energy consumption. ADL model was considered for demand modeling:

$$x_t = \mu + \varphi_1 x_{t-1} + \alpha_0 z_t + \alpha_1 z_{t-1} + \varepsilon_t .$$

Suppose factor z_t and error ε_t are stationary, then if $|\varphi_1| < 1$ the target variable is stationary as well. For expectation of the equation we've got the following:

$$\bar{x} = \mu + \varphi_1 \bar{x} + \alpha_0 \bar{z} + \alpha_1 \bar{z} .$$

Or:

$$\bar{x} = \frac{\mu}{1-\varphi_1} + \frac{\alpha_0 + \alpha_1}{1-\varphi_1} \bar{z} = \mu' + \lambda \bar{z} .$$

This equation describes long-run stationary condition of the process.

Table 1 shows estimates of demand functions for different group of consumers. Price and consumption lags coefficients were calculated on data of energy prices and production in 2005 weighted according structure of energy consumption for year 2002.

Consumers	Demand function formalization	Demand function estimate
Industry	$E_t = 10^{-0.0098} \left(\frac{P_t}{P_{t-1}}\right)^{-0.4807} \frac{E_{t-1}^{0.719}}{E_{t-2}^{-0.281}}$	$E_t = 320259.6 * P_t^{-0.4807}$
Agriculture	$E_t = 10^{0.000925} \frac{P_t^{-0.2403}}{P_{t-1}^{-0.372} P_{t-2}^{0.1317}} \frac{E_{t-1}^{0.6162}}{E_{t-2}^{-0.3832}}$	$E_t = 59444.73 * P_t^{-0.2403}$
Forestry	$E_t = const$	727
Transport and communications	$E_t = 10^{0.0247} \left(\frac{P_t}{P_{t-1}}\right)^{-0.1777} \frac{E_{t-1}^{0.8796}}{E_{t-2}^{-0.1204}}$	$E_t = 217187.6 * P_t^{-0.1777}$
Construction	$E_t = 10^{0.0523} \left(\frac{P_t}{P_{t-1}}\right)^{-0.2831} \frac{E_{t-1}^{0.7205}}{E_{t-2}^{-0.2795}}$	$E_t = 17245.53 * P_t^{-0.2831}$
Communal services	$E_t = 10^{0.1602} \frac{P_t^{-0.4412}}{P_{t-1}^{-0.1409} P_{t-2}^{-0.3003}} \frac{E_{t-1}^{0.7048}}{E_{t-2}^{-0.2952}}$	$E_t = 13124 * P_t^{-0.4412}$
Final consumption (population)	$E_t = 10^{0.0812} \left(\frac{P_t}{P_{t-1}}\right)^{-0.7814} \frac{E_{t-1}^{0.5245}}{E_{t-2}^{-0.3755}}$	$E_t = 60454.01 * P_t^{-0.7814}$
Other	$E_t = 10^{0.0423} \left(\frac{P_t}{P_{t-1}}\right)^{-0.4621} \frac{E_{t-1}^{0.592}}{E_{t-2}^{-0.408}}$	$E_t = 149882.6 * P_t^{-0.4621}$

Table 1: *Estimates of energy demand functions adjusted to energy consumption structure in 2005 (Limanova, 2011, p.148)*

Regional demand function is calculated by the aggregation of individual demand functions:

$$E_{рын_e} = 727 + 320259.6 * P_t^{-0.4807} + 59444.73 * P_t^{-0.2403} + 217187.6 * P_t^{-0.1777} + 17245.53 * P_t^{-0.2831} + \\ + 13124 * P_t^{-0.4412} + 60454.01 * P_t^{-0.7814} + 149882.6 * P_t^{-0.4621}.$$

This function allows estimating energy demand per month for Novosibirsk region.

Starting point for supply modeling is the idea that regional energy company is an example of natural monopoly. As the average cost of the company are falling while energy production increases, the only producer at the market operates more effectively than several companies. It means that regional energy operator is regulated by the state. Price policy for the energy is based on the level of average costs plus normal profitability. Prices vary for different kind of consumers, which allows realizing cross-funding for some groups of energy consumers.

This consideration is important, because it brings us to the idea of supply function as a horizontal line at the level of average costs of energy production. Analysis of market welfare changes resulting environmental regulation comes then to consumer surpluses difference before and after regulation.

4. Environmental regulation modeling

Environmental goal setting is based on the information about heat and power plants emissions of air pollutants and their contribution to pollution of the environment in the region.

Heat and power plants are the main air polluters in Novosibirsk region among stationary sources of pollution. They generate over 20 % of air pollutant emission (see at Обзор состояния окружающей среды в г. Новосибирске за 2005 г. Новосибирск: мэрия г. Новосибирска, Городской комитет по охране окружающей среды и природным ресурсам). Two pollutant – NO_x and benzapirene – are the most problematic for energy sector. Their emission causes regular violation of maximum permitted concentration (MPC). So hypothetical environmental goal here is 10 % reduction of NOx emission (real concentration of NO_x near heat and power plants in Novosibirsk is about 1.1 of NO_x MPC (Limanova, 2011, p. 153)), which means 153.5 tons of NO_x reduction per month.

We're going to consider consumers' preferences changes after information campaign. They are expected to reduce energy consumption as much as needed for heat and power station to abate 153 tons NO_x per month. That's why we need to convert NO_x remission into energy production. The combustion of 1 kg of coal generates 4 kilowatts of power and 4 grams of NO_x. It's not difficult to calculate desirable decrease of energy consumption - 153 mln of kilowatt-hours.

Now we can imagine perfect world, where regulator knows precisely desirable parameters of regulation and sounds reasonable enough to convince people to act; and the people are eco-friendly to be convinced, they do act and they act predictable. That's what we need to estimate effects of regulation.

5. Ecologocal awareness effect for market measured welfare

As we arrived to the situation of absolute elastic supply for energy market (energy company provides any amount of heat and power at the price fixed by the regional authorities), let's first adjust our theoretic model.

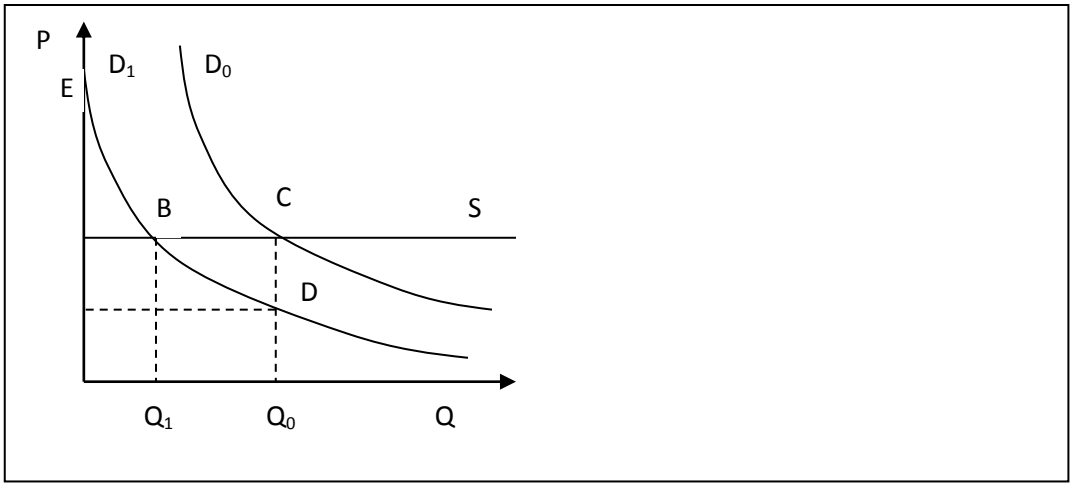

Figure 3: *Ecological awareness effect at the market with absolute elastic supply*

We analyze the situation when previously unavailable information about energy consumption externalities is delivered to consumers. If they react, and react rationally, we can observe changes of their preferences, for instance, energy saving. For the case of absolutely elastic supply of energy at regulated price, as we see at figure 3, there is no producer's surplus. For the consumers we can imagine as they buy amount Q_0 at price p_0 while willing to buy amount Q_1. They pay for this extra amount Q_0-Q_1 p_0*(Q_0-Q_1) though they value it as area under D_1 curve within the interval [Q_1;Q_0]. If the consumers adjust the amount to buy, they win area BCD. That's welfare gain for this kind of market.

Let's estimate this gain if consumption decrease is 153 mln of kilowatt-hours, p_0 is equal 0.91 roubles/kilowatt-hour, Q_0 is 870,5 kilowatt-hours (as it was in 2005). Net change of welfare measured at the market is equal area BCD, i.e.:

$$\Delta W = Q_0(p_0 - p_1) - \int_{p_1}^{p_0} D_1 dp \ .$$

Or:

$$\Delta W = 260288.5896 - \int_{0.611}^{0.91} D_1 dp = 260288.5896 - (616714\,p^{0.5193} + 78247.64\,p^{0.7597} + 264122.1p^{0.8223} +$$

$$+ 24055.7\,p^{0.7169} + 23486.4\,p^{0.5588} + 276550.8\,p^{0.2186} + 278664\,p^{0.5379} - 152273p + C)\Big|_{0.611}^{0.91} =$$

$$= 25085.1896$$

As we see, estimated welfare gain is near 25 mln. roubles monthly. This estimate is to be considered as upper edge for a number of reasons. First, regional demand aggregates different consumers' demands, not only population, whereas information campaign is aimed to the people. Second, people in Russia in general do not share ecological values to get desirable feedback (see, for example, Blam (2005)). Third, the other (institutional)

consumers are not interested to save energy as their clients (people) do not put eco-friendly behavior in claims.

6. Concluding remark on political appropriateness

Well, the truth is that ecological information as theoretically very attractive instrument for environmental policy, hardly to be effective for real life in Russia. To make it acting it is to rely on ecological values people share. Is it possible then to grow these values? Yes, it is. As any other values, they can be produced by education and training. That's why ecological education is crucial to the point. It is a part of public policy as well. The problem is that new values as a base for a new ideology are forming for a long time. It is a matter of generation, frankly speaking, which takes for politicians to make hard decision: to launch costly programs and keep going without any hope to get feedback for decade(s).

How realistic is this in Russia? The legislative base favors to ecological education. It's mentioned both in federal law on environmental protection and in Ministry of natural resources and the environment plans. Ministry report on achievements and plans for 2014-2016 (http://www.mnr.gov.ru/regulatory/detail.php?ID=131696) is arguing that ecological culture and education corresponds to the Concept of long-run development for Russian Federation up to year 2020 adopted by Russian government in 2008. However we often face a gap between normative and positive sides of reality in Russia, so let's see to the other side. To start with, the share of environmental protection does not exceed 0,15% of federal budget expenditures for last 3 years (see the structure of federal budget expenditures http://www.protown.ru/information/hide/6395.html), there are no ecological education or ecological culture mentioned within. There were no educational expenditures planned in the budget of the Ministry of natural resources and the environment for year 2012. For the year 2013 the Ministry planned to spend about 4.9 mln roubles for ecological education which is about 0.004 % of Ministry budget. The same share is planned for year 2014. Every year I ask my students whether or not they had some experience in this field studying in the school. The answers are negative. Without exceptions.

So we have to conclude that the government doesn't spend enough efforts for ecological education. No wonder. If the society is not interested for something, politicians prefer to ignore it. Somehow it reminds a vicious circle.

The positive thing is that the government really becomes more transparent. I've got response for every question addressed to governmental bodies for the last couple of years. In this sense the one who wish to be aware will be aware. If either society or the state would try, the vicious circle could change direction.

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