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Indirect Estimation of Citizens' Willingness to Pay for Past Environmental Damage Elimination: Case Study of Kemerovo City

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The paper describes the results of the first attempt in Russia to indirectly estimate Kemerovo city residents' willingness to pay for the implementation of projects aimed at past environmental damage elimination and health risk reduction. The study employs choice experiment format incorporated into originally designed questionnaires which were used during the household survey. The analysis of interview results revealed that the majority of population in Kemerovo is concerned about past environmental damage issues; however, aggregated numbers for willingness to pay for the city level appeared to be much lower of those estimated by local authorities as required for project implementation.

Keywords: past environmental damage, willingness to pay, health risk assessment, choice experiment format, Russia

Introduction

Old industrial areas in any country including Russia have current environment with a considerable anthropogenic load. Accumulated environmental damage is a risk factor for economic actors as well as for the inhabitants' health.

In most cases, this results in impossibility of the area to be used for agricultural and urban development purposes. This also leads to inhabitants' shorter lifetime and higher sickness rate caused by negative environmental impact. Past environmental damage assessment (PEDA) for the purpose of this research can be generally defined as residual costs that finally must be covered to rehabilitate, diminish and/or localize environmental, health or property damages resulting from present or past economic activities. In most cases it is valid for industrial sites and municipal utilities used by both businesses and residents. However, responsibility goes to the government, too.

Most frequently, it appears as land, subsoil and surface water, atmosphere pollution and in

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some cases as solid or liquid industrial waste. From the geographic point of view PEDA is limited within a specific site which is the source of pollution and where the pollution is spread. So, in most cases of initiatives regarding to PEDAs the principal attention is paid to so-called *polluted spots*. However, the limits of *polluted spots* often go beyond the sites and properties being sources of pollution and spread over adjacent sites and properties and other more general ecological resources in particular over subsoil and surface water.

Matters of past ecological damages are not sufficiently studied in the Russian scientific literature, the practical experience of assessing the past ecological damages is rendered to a fewer extent within the context of contemporary Russian situation of a transition to a market economy (privatization, bankruptcy, etc.) especially as a part of real estate appraisal. Matters of reparation of ecological damages in general and past ecological damages in particular are represented in the fullest way in pilot project reports of the Institute of the World Bank in Russia (Altai Territory, Rostov, Tomsk, Kemerovo regions etc.). The research of approaches to defining structure of damages, assessment methods and compensation tools is an important aspect of PEDA practical experience.

Analysis of international and Russian PEDA experience showed the similarity of principal assessment parameters and tools. During the process of industrialization, the same processes and technologies were applied in Russia and other countries, so this legacy (present damages – PD) is comparable to ones in many other countries.

However, as for any country in the world there are a range of national particularities to be taken into consideration when resolving the PEDA problem and they will have an effect on applicability of international experience to this process. In Russia, these particularities include:

- A high concentration of industrial businesses and a high urbanization level in these areas;
- An industrial exploration of a considerable part of the territory including areas with extreme natural conditions (permafrost, climate aridity, boggy ground etc.);
- All known branches are represented in the structure of economy that extremely diversifies types of impact. In particular, they include almost all harmful types of pollutants such as persistent organic and toxic compounds, other types of chemical pollutants, inherited from technologies and industries of military-industrial complex;
- A large territory and long frontiers make this problem more significant in the global context and having a big potential in relation to transboundary transfer of polluting substances, including persistent toxic compounds capable for the large spreading in global ecosystems;
- A large-scale privatization in Russia during the transition to a market economy was done without taking into account PEDA matters and moreover without precise legal basis in regard to PEDA. As opposed to other countries where industrial businesses are private or privatization was performed taking into account specific matters of PEDA, this problem was solved in Russia much later.

The analysis of accessible research reports enable to draw a conclusion and name the principal reasons of growing attention to PEDA matters:

- Public and governmental interest in solving the PEDA problem is explained by growing attention to environmental

issues at the level of individual businesses, regions and the whole country;

- Determining the responsibility and financial obligations within the bounds of PEDA and transfer of ownership. Russian situation is totally different from examples of international experience because the privatization has been done without precise basis for solving the PEDA problem;
- Strengthening the role of the government in determining PEDA because in a range of cases the government has inevitably to assume PEDA. It is almost typical when the matter is about abandon sites which are, however, sources of substantial risk for environment or inhabitants' health. During the process of privatization, the government can include elimination of past ecological damages into government aid to save them from bankruptcy or to modernize them for promoting social and economic development.
- Need to create a system of PEDA filing and priority evaluation at least a data base or inventory of polluted sites where there are past ecological damages;
- Scarcity of legal basis for assessing and eliminating past ecological damages;
- Making public opinion aware of PEDA and struggling for creation of compensation tools;
- Need to create financial schemes for eliminating past ecological damages etc.

In spite of urgency of PEDA development, the Russian government does not manifest special activity but in our opinion this process is catalyzed by making up of a real estate market, land turnover and rise in the standard of living. So we are expecting this type of assessing work to grow faster.

The accumulated environmental damage in the Kemerovo Region can be characterized as a risk for current economy in terms of disturbed and polluted lands, large volumes of toxic wastes, morbidity and mortality rates, degradation of ecosystems, etc. Judging by all parameters the major portion of its territory has been for a long time a zone of emergency ecological situation. PEDA is becoming very important in creating compensation tools. At present, it is impossible to estimate even a number of sites affected by past ecological damages as information about them is broken up through different agencies and there was no complex inventory of such sites. Inquiry of managers and experts from different agencies shows that there are a lot of such sites on the Kemerovo Region territory in each economy branch.

The need to create compensation tools and division of responsibility for past ecological damages is important for carrying out its economic evaluation. Economic evaluation of damage of the natural resources, economy of the region, the inhabitants' health caused by past environmental damage was made several years ago using the data of inspection of some closed chemical and defense businesses sites in Kemerovo city that's to say former Aniline and Dye Plant and Communard Kemerovo Plant.

A direct evaluation of damage of past ecological damages was performed within the frame of a pilot project. In particular, its structure was identified, the criteria were determined and there was an attempt to assess in value terms the actual damage. Taking into account the fact that there are several actors (the government, economic actors and public opinion) having interest in eliminating accumulated damage, the principal task of this research was to assess the inhabitants' attitude towards the study problems in relation to the past environmental damages.

Former Aniline and Dye Plant Case Study

Former Aniline and Dye Plant (ADP) is located in Kirovsky district of Kemerovo city and has been chosen as a case PEL site for the current study due to several reasons main of which are geographical location (within city boarders) and vast negative impact from the site to environment and humans.

ADP occupies 20 ha of land in immediate proximity to the Tom River, which is the main source of drinking water in Kemerovo. The operation of the plant was stopped in 2004 after more than 60 years of functioning. According to the Statement on the Environmental Audit of OAO Aniline and Dye Plant (2004), the ADP site today is characterized by large amounts of wastes being stored on the territory of the closed plant. The total amount of sodium phosphate, boric anhydride, bromine, broken glass in wooden containers, flexible containers, scrap iron, steel barrels that had lost their use properties, construction wastes, unsorted waste from welfare spaces accumulated in ADP equals to 6,603.5 tons.

It is defined that potential environmental damage from ADP might be sludge collector's accident. The wastewater from the "emergency" section will be directly discharged to the Tom River causing its contamination in case of the collapse of collector's protective dam. Since Tom River is the main source of drinking water in Kemerovo, the accident will deteriorate its quality. The World Bank experts have calculated the potential environmental/economic damage from the Tom River pollution as a result of a probable ADP sludge collector accident. These findings are presented in Table 1.

The land in the vicinity of enterprise is highly contaminated with lead, zinc, cadmium, manganese, arsenic and organic compounds. This is an evidence of current health risks associated with past operation of ADP. The contamination happened during the 47 years of operation of the plant when various noxious substances had been emitted and this created diffuse chemical pollution within radius up to 4.5 km. As a result, vegetables grown on such lands are also contaminated with above-mentioned pollutants and pose hazards for residents' health (World Bank 2007).

The program of area decontamination, pollution utilization and rehabilitation of disturbed and polluted land has been developed by Kemerovo City Administration. It is supposed that the program will be implemented in three main stages:

1) decontamination and utilization of pollutants and hazardous substances;
2) area rehabilitation; and
3) returning of the land to the economic turnover.

The required amount of financing (50 million rubles) has been estimated for the initial stage only. This is a sufficient amount for the city and the implementation of the program has faced serious difficulties due to the budget constraints. One of the objectives of this study is, in fact, to estimate Kemerovo residents willingness to bear some of the financial burden associated with program implementation.

Table 1. Potential environmental/economic damage from the Tom River pollution as a result of a probable ADP sludge collector accident

RUB thousand/ thousand m3	Outflow volume, thousand m3	RUB thousand	Degree of hazard
1,228.02	132	162,098.51	Very high

Source: World Bank (2007)

Methods

Analysis of respondents' willingness to pay for the implementation of the program aimed at ADP land decontamination and rehabilitation underlay in the evaluation of the environmental quality improvements in Kemerovo city. We designed the household survey based on the choice experiment techniques and derived data for the analysis.

Louviere (1988) mentions that choice-based approaches originated from the economics discipline and have been widely used for valuing a diverse range of goods and services. Individual's preferences are frequently elicited by means of a choice experiment technique. Usually it is used when a researcher faces some difficulties or finds it impossible to infer preferences from actual behavior. Respondents are asked to choose their most preferred option from a series of presented alternatives when choice experiment method is employed. Each choice set usually contains so-called baseline alternative, corresponding to the status quo. The composing characteristics of the utilities (which in their turn, are constituents of a good or service associated with the utility) make an influence on individual valuation (Lancaster, 1966)

There are at least four reasons for this technique to be successfully used for consistent welfare estimations. Firstly, changes in attribute levels against the cost of making these changes provide a respondent with an incentive to trade-off. Secondly, there is always an option for the respondent to vote for current situation ("no changes") by choosing the status quo. Thirdly, the method rests on the theory of rational and probabilistic choice and represents the econometric technique used in a way, which is exactly parallel to it. Fourthly, estimates of compensating and equivalent surplus can be easily derived by using the method.

For our study we described each environmental situation by a bundle of various attributes and asked respondents to state their preference over hypothetical environmental quality improvement situations since this was a choice experiment format we designed.

Design of the discrete choice experiment

In the beginning, we used open-ended question format in order to interview 15 respondents having different socio-economic characteristics and living in different districts of Kemerovo city. The data from this in-depth interview as well as factual data on pollution and health risks allowed us to establish attributes and attribute levels for the main interview of the survey. At the initial stage of our research we aimed at encouraging respondents to share their opinions on current environmental situation in the city in respect of past environmental liability issues, preference for various environmental quality improvement programs, and priority areas for these changes. Kemerovo State University Center for Sociological studies took part in this study by providing professionally trained interviewers to work in the field survey.

Table 2 represents attributes as well as attribute levels that have been defined for the choice experiment questions. Environmental quality improvement programs have different importance to respondents and policy relevance, that's why we chose four attributes and included them in the experiment format based on it. Concentration of iron in drinking water, implementation of regular health checks and cancer development reduction, ADP site soil decontamination and mortality risk reduction, and additional tax appeared to be attributes used in current study. The selection was based on the analysis of responses to the questions at the pilot stage when several descriptive themes, which include number of monetary and non-monetary

Table 2. Attributes and levels used in the discrete choice experiment

Attribute	Levels
Concentration of iron in drinking water (mg/l)	0.96
	0.6
	0.3
Mortality risk due to consumption of vegetables cultivated on the soil contaminated by ADP (number of people)	340,000
	140,000
	40,000
Cancer development due to consumption of polluted drinking water (number of people)	28
	14
	7
Additional tax (Rub)	100
	300
	500

benefits, respondents' health condition, and their attitude towards selected quality characteristics of the environment were identified and described.

Past environmental degradation as well as deteriorated quality of drinking water, both cause various risks by having great negative impact on human's health. At the same time, Kemerovo city government often face the problem of efficient allocation of scarce budget resources and, thus, to develop and implicate necessary programs and projects that could improve the quality of environment in the region since these two issues are highly interconnected. By choosing these particular environmental attribute for drinking water quality and past environmental contamination issues we followed the idea of their seriousness and topicality for the region.

At the pretest stage of our study we interviewed 30 respondents located in all city's districts. The results allowed us to make minor modifications to attribute definition levels. The orthogonal main effect design (which is one of the advantages of conjoint analysis compared with the revealed preference methods that often suffer from multicolinearity issues) enables elimination of the multicolinearity of the attributes and was used for developing the attributes and levels of the profiles. Finally, the questionnaire took the form of a series of choices between two hypothetical plans of environmental quality improvement, with one representing current situation (status quo). The total sample of 300 respondents was divided into three sub samples each of which contained 100 survey participants. Kemerovo residents were asked to state whether they would choose 'Plan 1', 'Plan 2', or 'Current Situation' after being presented with three questions. Mention should be made that hypothetical scenarios, named as "Plan 1" and "Plan 2," indicate the improvement scenarios from the status quo, but required additional financial burden for citizens. The questionnaire ended up with the section containing questions on respondents' socio-economic characteristics and respondents were randomly allocated to one of its three versions. Table 3 provides an example of choice set.

Estimation Procedures

Random Parameter Logit (RPL) model which, according to Revelt and Train (1998), can relax the assumptions of conditional logit (CL), the preference homogeneity and the independence

Table 3. Structure of choice experiment question

	Plan 1	Plan 2	Current Situation
Concentration of iron in drinking water (mg/l)	0.30 (RF standard)	0.6 (reduction by 0.36)	0.96
ADP site soil decontamination, land rehabilitation and reduction of mortality risk (number of people)	170000 (reduction by 170,000)	340000 (no changes)	340,000
Regular health check carrying aimed at reduction of cancer development (number of people)	14 (reduction by 14)	21 (reduction by 7)	28
Additional tax (Rub per household yearly)	100	300	0
Check the most desirable plan			

of irrelevant alternatives (IIA) was applied for the estimation.

The estimation procedures of the RPL model can be described as follows. We assume a random utility theory whereby utilities involve created components, "representative utility" V_i, and "random components" (unobservable components), ε_i. Thus, the utilities when a respondent selects choice *i* as the first choice, we obtain:

$$U_i = V_i + \varepsilon_i \tag{1}$$

In addition, we assume linear-in-parameters utility functions that originate from an additively separable linear utility model; that is:

$$V_i = \sum_{j=1}^{J} \beta_{ij} x_{ij} \tag{2}$$

where x_{ij} are the vectors of attributes and β_{ij} is the marginal utility (j=1,2,...J). β_{ij} is estimated confound with the scale parameter λ (λ is a scale parameter that is inversely proportional to the standard deviation of the unobserved components ε_i). The real marginal utility is $\beta_{ij}^{'}$:

$$\beta_{ij} = \beta_{ij}^{'} \lambda \tag{3}$$

Assuming ε_i conforms to the extreme value type 1 (EV1) distribution, then the choice probability of selecting *i*, $P(i)$ becomes the following conditional logit model (McFadden 1974):

$$P(i) = \frac{\exp(V_i)}{\sum_{m \in C} \exp(V_m)} \tag{4}$$

The choice probability of respondent *n* in the case of RPL is as follows:

$$P_{ni} = \int \Pi_{t=1}^{3} \frac{\exp(V_{ni})}{\sum_{j=1}^{J} \exp(V_{nj})} f(\beta \mid \Omega) d\beta \tag{5}$$

where t(t=1,...,3) denotes the number of answers from the respondent, as the number of repeated scenarios for the respondents equals to 3. $f(\cdot)$is the probability distribution function of β, Ω and is the parameter matrix of the mean and variance of β. Since the integral calculus of equation 5 need to be estimated by the simulation using Halton Draw sequence (refer Train (2003) for details).

Marginal willingness to pay (MWTP) was estimated by the ratio of the price parameter (i.e., the parameter of the additional tax) and the parameters of other profile attributes. The scale parameters are cancelled out in estimating MWTP. The MWTP is represented by equation 6.

$$MWTP = -\frac{\beta_x}{\beta_p} \tag{6}$$

Results

In order to make sample representative we randomly selected 300 respondents from each

Table 4. General characteristics of Kemerovo household survey respondents

Variable	Description	Value
Age	Respondent's age in years	46.68
Gender	1 if male; 2 if female	1.77
Family size	Number of people in household	2.73
Number of children	Number of children under 10 years old	0.28
Income	Mean monthly household income (Rub)	17,981
Present health condition	From 1 to 5: if 1 'very good'; if 5 'very bad'	1.90
Health care expenditure	Mean personal health care expenditures in 2009 (Rub)	10,354
Answering confidence	From 1 to 4: 1 if 'absolutely confident', 4 if "not confident at all"	1.90

Note: 1 USD = 30.04 Rub (The Central Bank of the Russian Federation, 2010)

city's district. The number of respondents in districts was based on the total population living in them. The overall impression from the survey is that residents in Kemerovo enthusiastically participated in the survey. Indeed, only 2.3 percent of initially defined sample declined to take part in it. Table 4 summarizes some general results of the study.

As one can see, respondents were predominately female, married and had children. Personal health care expenditures (purchasing medicine, visiting doctors, staying in hospitals, etc.) in 2009 appeared to be relatively high (5 percent of mean monthly household income), however, the majority of the survey participants defined their present health condition as "good". Following recommendations from previous studies we included so-called debriefing questions in the final part of the questionnaire. The analysis of responses to these questions revealed that most of respondents found themselves confident while answering questions. Indeed, 85 percent were absolutely and rather confident while 88 percent found questions absolutely and rather understandable.

One of the objectives of this study was to figure out residents' perception towards PED and PEL issues in Kemerovo city since both of them appear to be new for the study area and not much has been yet done to solve them. We designed the question "Have you ever heard about PED and PEL and how, in your opinion, it affects your health?" and respondents faced it before moving further to main part of the questionnaire. Thus, citizens' perception of environmental problems in focus has been elicited. The analysis of responses revealed that 60.7 percent somehow heard about these issues and the majority of the respondents believe that environmental degradation in the region associated with the past negatively affect their health condition. 85.7 percent of participants stated this (33.7 percent of which have not heard about PED or PEL before, however, consider it to be possible to cause health problems).

We based our estimations on the responses of 167 respondents after removing protest zero bids. The results of econometric analysis are presented in Table 5.

The analysis of data from Table 5 shows that most of coefficients are significant; however, *Bmedi* associated with regular medical check-ups conduction and aimed at the reduction of cancer development cannot be explained due to its insignificance. We also concluded that our model fits well since the Adjusted R-squared equaled to 0.279. The main conclusion from the study can be the fact that respondents' overall level of utility

Table 5. Random parameters logit model results

Variable	Coefficient	Standard Error	P[|Z| > z]
Random parameters in utility functions			
Btax	-0.033	0.005	0.000 ***
Nonrandom parameters in utility functions			
ASC1	5.028	0.816	0.000 ***
Biron	-0.799	0.349	0.022 **
Bsoil	-3.128E-06	6.377E-07	0.000 ***
Bmedi	0.001	0.014	0.939
ASC2	4.997	0.828	0.000 ***
Derived standard deviations of parameter distribuitions			
NsBtax	0.036	0.006	0.000 ***

*Note: The symbols ** and *** indicate significance level at 5% and 1%, respectively*

will be increased with the implementation of suggested plans since both of alternative specific constants (ASC1 and ASC2) are significant and greater than zero.

Coefficients *Btax*, *Biron*, and *Bsoil* have negative signs. We explain this by the fact that individual level of utility will be decreasing in the situation of increase in these parameters. Naturally, the raise in tax level, increase of iron concentration in drinking water as well as increase of the mortality rate associated with consumption of vegetables cultivated in contaminated soils will be resulted in the decrease of the level of respondents' utility.

The main objective of the paper is paper is to figure out how much Kemerovo residents are willing to pay for the implementation of program aimed at ADP site soil decontamination and land rehabilitation and, thus, to decrease mortality risk associated with the consumption of vegetables cultivated on the contaminated soils by calculating their WTP based on the analysis results. Marginal WTP for the reduction in mortality risk by one case (person) for single household can be calculated using estimated coefficients *Btax* and *Bsoil* from Table 5 as follows:

$$MWTP_{household} = \frac{Bsoil}{Btax} = \frac{-0{,}312 * 10^{-5}}{-0{,}033} =$$

$$= 9{,}45 * 10^{-5}\ Rub\ per\ year$$

According to the Kemerovo Regional Statistical Bureau (2009), the total number of households in Kemerovo equals to 206,040. Based on this data, marginal WTP for the city level can be calculated as follows:

$$MWTP_{city} = MWTP_{household} * \left(H - H^{*}\right),$$

where H* stands for the number of households that showed "protest behavior" and must be excluded from the analysis. We defined "protest respondents" as those who chose current situation in all three questions and explained such choice by disbelief in the fact that the studied problem can be solved. 43.3 percent of respondents were eliminated from the analyses due to above-mentioned reason. Thus,

$$MWTP_{city} = 9{,}45 * 10^{-5}\left(206{,}040 * 0{,}567\right) =$$

$$= 11{,}03\ Rub\ per\ year$$

WTP for the expected elimination of mortality risk associated with ADP site

contamination from 340,000 to 0 cases as a result of the program implementation for the city as a whole will equal to:

$$WTP_{city} = 11{,}03(340{,}000 - 0) =$$
$$= 3{,}75 \; mln \; Rub \; per \; year$$

Conclusions and Discussion

Our study appeared to be the first attempt to address PEL issues from an individual point of view. The result of analysis revealed preferences of Kemerovo residents towards environmental quality improvements. We have found that this study's numbers for WTP are significantly smaller than those have been announced as a required amount of financing for the initial stage of ADP site rehabilitation and decontamination. In other words, value of WTP for the city level calculated for a period of one year hardly to be comparable with estimated cost of City Administration program implementation. Thus, one can conclude that Kemerovo citizens are unlikely to financially support the implementation of the environmental quality improvement program in focus.

In order to explain unwillingness to pay several reasons must be mentioned. The main reason to understanding relates to the Soviet times of modern Russia with its command type of economy and state ownership. Now people believe that the government must be responsible for solving problem of past environmental liability though the majority of respondents are very much concerned about studied issues.

In current research WTP estimation was based on indirect techniques which, accompanied by the relatively small sample size (although it was representative), can be defined as some of the study limitations. For future analysis it can be recommended to undertake supplementary analysis in order to obtain a deeper understanding of residents' perception towards PEL issues by estimating their WTP through direct techniques (i.e. contingent valuation).

To conclude, it can be said that this study makes it possible to obtain a deeper understanding of the expected impact of the programs and strategies as well as their implementation cost using its findings based on monetary assessment of individual perception towards past environmental liability issues in transitional economy context.

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Непрямая оценка готовности населения платить за ликвидацию прошлого экологического ущерба на примере города Кемерово

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Данная статья представляет результаты первой в России попытки непрямой оценки готовности населения города Кемерово платить за осуществление мероприятий, направленных на ликвидацию прошлого экологического ущерба (ПЭУ) и снижение риска здоровью. В исследовании применен метод выборных экспериментов, на основе которого были разработаны анкеты и проведен опрос домохозяйств в городе. Анализ результатов выявил существенную обеспокоенность населения вопросами прошлого экологического ущерба, однако значения готовности платить для города в целом оказались существенно ниже сумм, определенных местными властями как необходимые для осуществления проекта по ликвидации ПЭУ.

Ключевые слова: прошлый экологический ущерб, готовность платить, оценка рисков здоровью, метод выборных экспериментов, Россия.