International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2016, 6(3), 611-616.

Assessment of the Required Changes of Russian Ecological Taxes

Tatiana Olegovna Tagaeva[1]*, Alexander Olegovich Baranov[2], Vadim Manavirovich Gilmundinov[3]

[1]Novosibirsk State University, Institute of Economics and Industrial Engineering SB RAS, 17 Lavrentev Avenue, 630090, Novosibirsk, Russian Federation, [2]Novosibirsk State University, Institute of Economics and Industrial Engineering SB RAS, 17 Lavrentev Avenue, 630090 Novosibirsk, Russian Federation, [3]Novosibirsk State University, Institute of Economics and Industrial Engineering SB RAS, 17 Lavrentev Avenue, 630090 Novosibirsk, Russian Federation. *Email: tagaeva@ieie.nsc.ru

ABSTRACT

Russia is one of the most polluting countries in the world and environmental problem is very important in this country. The forecast of atmospheric emissions was conducted according to various economic development scenarios in Russia using dynamic input-output model. The optimistic scenario is realized under hypothesis about oil prices increase and real ruble exchange rate strengthening beginning of the end of 2015, the revival of investment processes, the successful policy of import substitution, and the competent using of instruments of monetary and fiscal policy. The pessimistic scenario is implemented under assumption of negative economic tendency prolongation of the 2014. Future increase of environmental pressure will be expected in optimistic scenario. The improvement of pollution taxes mechanism as a way of government ecological policy is discussed in the article.

Keywords: Input-output Model, Environmental Pollution, Forecast of Emission, Pollution Taxes
JEL Classifications: E62, H23, Q32, Q38, Q42, Q5

1. INTRODUCTION

The environmental issues are very important for Russia as it is one of the most polluting countries in the world. Russia accounts for 13% of total world emissions of major hazardous substances (solid substances, sulphurous oxide, nitrous oxide and carbonic gas). The country takes fourth place in the world for CO_2 emission after Chine, USA and India. Sadly, the number of polluted cities is increasing. In 2012 the number of cities with high pollution level (maximum concentration level of harmful substances is 5-10 times higher than permitted level) was 138 (compared to 98 in 2000). According to the Russian State Committee of Statistics, only 15% of urban population lives on the territories where air pollution does not exceed hygienic regulations, with 1/5 of urban population living in environmentally harmful conditions.

Nonetheless, the Russian economy spends intolerably little on these goals. The proportion of environmental protection investment in total national investments is about 1.2-2.6% per year, in comparison with developed countries where this figure ranges from 6% to 25%. The growth rate of Russian EP investment in 2013 constituted 76.2% of the 1995 level. The growth rate of the current environmental costs in 2013 constituted only 38.5% of the 1995 level. This situation in the field of environment protection costs has determined the dynamics of employing the production facilities for sewage treatment, trapping and liquidation of hazardous substances in waste gases. For example the amount of environment equipment put into operation is being reduced. For instance, if in 1980 the capacity of installations for trapping and liquidation of hazardous substances in waste gases accounted for 18.4 million m^3/h, in 2013 it was only 11.1 million cubic meters. So, there is obviously a necessity of increasing ecological expenditures.

An assessment of ecological expenditures and environmental pressure is impossible without using economic modeling methods. There are many types of models describing economic and ecological connections: For example dynamic stochastic general. equilibrium (DSGE) models as further development of neoclassic real business cycle models (Fischer and Springborn, 2011; Heutel, 2012; Dissou and Karnizova, 2012), subsequent neokeynesian DSGE models (Annicchiarico and di Dio, 2013), computable general equilibrium (CGE) models. But traditional economic Input-output (I-O) modeling and analysis are more conveniently adopted in emission studies. Environmentally extended (EE) I-O analysis is the prevailing method for assessments of environmental pressures. This method as an analytical framework describing the interdependencies between the sectors of an economy has been developed in the 1939s by Leontief, 1936. It allows the calculation of estimates of the total production output by each sector of the economy required as a result of a final demand of one unit of any sector's output. The economic transactions tables of a standard I-O system were extended by accounts of emissions and other environmental indicators (Isard et al. 1968; Ayres and Kneese, 1969; Leontief, 1970; Leontief and Ford, 1972; Duchin, 1988).

I-O approach with environmental application proceeds from the assumption that the responsibility for emissions lies not only with the producer but also with the end users of goods. In recent years there has been an increasing interest in the use of I-O methods to calculate carbon footprint (Wiedmann, 2009). This interest was preceded by a growing concern over debate on how to allocate the responsibility for emissions between producers and consumers (Munksgaard and Pedersen, 2001; Peters, 2008). Studies regarding the environmental effects related to final demand focus on household consumption (Hertwich, 2011; Lenzen et al., 2008; Druckman and Jackso, 2009; Wiedenhofer et al., 2011; Zhang, 2013; Duarte et al., 2014). The authors indicate that affluence is the major determinant of the environmental effects of household consumption, asserting that it generates more than 70% global greenhouse gas emissions (Hertwich and Peters, 2009).

Except footprint effect there is a lot of other application environmental I-O analysis. Some examples are - to study energy consumption (Lenzen et al., 2004), CO_2 emissions (Liu et al., 2012), water consumption and pollution (Zhang et al. 2011), direct and embodied carbon emissions, city-specific environmental analysis, life-cycle analysis and so on. There are examples of combination of I-O approach and CGE modeling (Duarte et al., 2014).

The impressive development in global multi-region input-output (MRIO) databases is accompanied by an increase in application published in the scientific literature. The past years have seen the emergence of EE-MRIO models (Peters et al., 2011; Wiedmann et al., 2010). As outlined in the editorial (Tukker and Dietzenbacher, 2013) this special issue of economic systems research introduces the EE-MRIO models. But often it is not obvious whether the insights gained from these models have indeed been used in political decision-making. However, several papers exist that indicate that EE-MRIO models are the appropriate tool for research related to EP policy. For example in Wiedmann and Barrett (2013) the authors ask whether and to what extent there is policy uptake of results from EE-MRIO models and how it may be improved. The recent economic literature stresses the importance of technical change for curbing emissions and proposes policies that can achieve it (Nordhaus, 2007; Stern, 2007; Acemoglu et al. 2012; Raa and Shestalova, 2015). However there are infrequent cases of papers about environmental policy using I-O analyses in developing countries. Current article reflects the conducted studies.

2. METHODS

So, we can see Russia has very serious ecological problems. The fundamental question is where we should find additional financial sources to improve the environmental situation in the country. First, it is necessary both to increase centralized investments and create incentives for enterprises to construct EP facilities. The main task is to improve the economic mechanism of environmental management. Our ecological legislation is not perfect. Enterprises find it more profitable to emit harmful substances rather than invest in pollution abatements. According to the opinions of the leading economists and ecologists, ecologization of the tax system is necessary. The current level of pollution taxes does not provide for the necessary amount of investment or cover current expenditures for the purpose of pollution abatement. To make it worse, pollution taxes are declining quickly in real terms because of inflation. For instance, in 2014 average prices stage increased from the level of 2003 by 3.41 times, whereas the index of pollution taxes was only 2.33 times.

The current system of pollution taxes needs to be refined and improved to develop standards for environmental charges. Modern economic science has developed several approaches.

The first approach suggests that payments for pollution should be based on an economic assessment of the damage due to contamination. Damage assessments should provide an evaluation of direct and indirect economic and environmental losses in monetary terms as a result of negative environmental impacts. However, the implementation of this approach entails certain difficulties due to the lack of agreed methods to assess damages. In a number of studies an attempt was made to provide such an evaluation which showed that at present enterprises in the Russian economy cause environmental damage to such an extent that they are not able to compensate for it. According to the results of research conducted at the Institute of Economic Forecasting of the Russian Academy of Sciences, the overall damage to Russia's environment is over 10%.

The second approach is based on assessing the ability of society to allocate resources for activities to protect the environment. The total amount of environmental charges is determined by the amount of environmental costs in the previous years and the forecast of their possible and appropriate growth. All estimated payments are distributed among the polluting industries in accordance with the amount of damage, taking into account the harmfulness of pollutants and the local environmental situation. In practice it is the second approach which is applied in Russia now.

The third approach is based on the estimation of costs needed to avoid EP expenditures. This approach currently has no obvious practical application because of the difficulties in the assessment of such expenditures.

The fourth approach allows for calculating the size of pollution taxes based on the value of net resources required to clean up polluted resources, making it possible to bring the contents of the resource pollutants to the level of a maximum permissible concentration. This method is almost out of use due to its complexity (for example, it cannot be applied for air).

The third approach has been used by researchers of the Institute of Economics and Industrial Engineering of the Siberian Branch of the Russian Academy of Sciences (Institute of Economics and IE SB RAS) to estimate the necessary size of pollution taxes.

The method considered in this paper makes it possible to avoid the main difficulties in the implementation of the third approach, i.e., it enables estimation of the costs of preventing pollution of water and air resources. The assessment of the EP costs was carried out according to the results of predictive calculations using the dynamic input-output model (DIOM) of the Russian economy with an EP block. This model complex has been developed in the institute of economics and IE SB RAS. Figure 1 presents a brief scheme of this model complex.

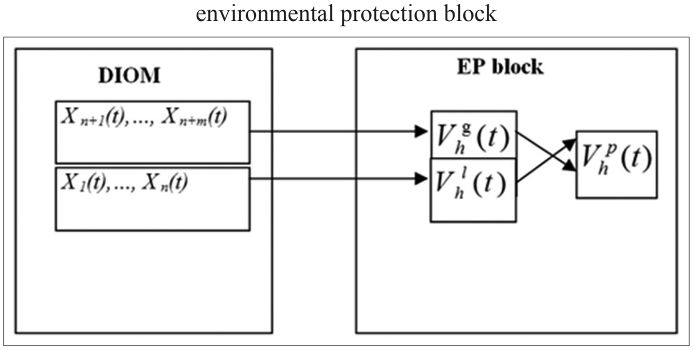
In addition to n elements which denote the traditional sectors of the economy, m elements which represent natural resources, are allocated here. A one-to-one correspondence is expected between each of these elements and the areas of EP (air protection, water conservation, etc.). At this stage of our research, one natural resource is studied - atmospheric air. For environmental activity, reproduction processes of the main environmental funds and the formation of environmental costs are modeled into the DIOM. The EP block describes the tangible indicators of ecological processes. The pollutants generated during the production process, is determined by the amount of manufactured goods in the traditional sectors of economy (x_i). Thus, this model system allows us to forecast the level of pollution formation in industrial production depending on the economic development of Russia with the help of coefficients of pollution generation per unit of gross production output. Estimates of expenditures for reducing air pollution help determine volumes of pollution trapping. The difference between formation and pollution trapping gives us the amount of emissions.

This is a description of the EP block:

$x(t) = (x_1(t),\dots, x_n(t), x_{n+1}(t),\dots,x_{n+m}(t))$ - Vector of gross outputs, where,

$x_i(t)$, $i = 1,\dots, n$ - Gross output of industry i in the year t,

Figure 1: A brief diagram of the dynamic input-output model with an environmental protection block



$x_{n+h}(t)$, $h = 1,\dots, m$ - Current EP cost for natural resource h.

The level of pollutants generated in the production process is described by the formula:

$$V_h^g(t) = \sum_{i=1}^{n} w_{ih}(t)x_i(t) + D_h(t)$$

Where,

w_{ih} - Coefficient of pollutant h generation (amount of polluted natural resource h, referring to the manufacturing of a unit of production of industry i);

$D_h(t)$ - Output of pollutant h (volume of pollution or destruction of a natural resource) in a household;

The amount of current EP costs for natural resource h or product of EP industry h is determined by the equation:

$$x_{n+h}(t) = \sum_{i=1}^{n} v_{ih}(t)V_{ih}^l(t), \quad V_h^l(t) = \sum_{i=1}^{n} V_{ih}^l(t),$$

Where,

$v_{ih}(t)$ - Current cost to recover a unit of natural resource h (to destroy or to trap a unit of pollutant h) in industry i;

$V_h^l(t)$ - The amount of a recovered natural resource (liquidated or trapped pollutant) of type h.

The amount of pollutant h (a polluted natural resource), which gets into the natural environment without purification (or by volume of destroyed but not reproduced natural resource), is described by the formula:

$$V_h^p(t) = V_h^g(t) - V_h^l(t)$$

A more detailed description of the economic and ecological units of the model complex is given in the (Baranov et al. 1997; Tagaeva, 2011).

3. RESULTS

The model calculation was based on several scenarios of Russia's economic development in the period of overcoming the global economic crisis in 2015-2020: Pessimistic scenario with slowdown of economic growth and optimistic scenario with acceleration of economic growth. The optimistic scenario is realized under hypothesis about oil prices increase and real ruble exchange rate strengthening beginning of the end of 2015, the revival of investment processes, the successful policy of import substitution, and the competent using of instruments of monetary and fiscal policy. The pessimistic scenario is implemented under assumption of negative economic tendency prolongation of the 2014. The Table 1 shows key macroeconomic indexes according to these scenarios. The forecast calculations were carried out using 64-sectoral DIOM.

Based on the results of the calculations you can see the future increase of environmental pressure, which will be expected in optimistic scenario (Figure 2).

The next step of forecast calculation considers increase of expenditures for trapping air pollutants. This scenario assumes meeting Russian government goal to reduce greenhouse emissions to 75% of the 1990 level by 2020. In 1990 Russian greenhouse gases (GHG) emissions were estimated at 3314 million tons in CO_2 -equivalent, and in accordance with the government requirements they have to be reduced to 2,486 million tons in CO_2 -equivalent by 2020, that corresponds with 2,1262.8 thousand tons of total emissions from stationary sources for 2020. You can see that this level is obviously achieved in accordance with pessimistic scenario (Figure 2). So the only optimistic scenario will be discussed now.

The estimate received as a result of predictive calculations of the amount of air pollutants produced by different industries and in the national economy as a whole in the optimistic scenario, makes it possible to determine the dynamics of trapping air pollutants in the forecast period in accordance with the objective of Russian government. Calculations based on the model complex allow for estimating the total amounts of current and investment expenditures in 2016-2020 (at 2013 prices) to ensure compliance with the specified environmental objectives, i.e., 566.2 billion rubles for the capture of atmospheric pollutants according to the forecast scenario.

Let us estimate the average regional rate of pollution tax and compare these results with those of similar existing rates. We shall proceed from the principle of cost recovery for the destruction of atmospheric pollution based on charges collected. Since records are maintained for a fairly large number of ingredients which enter the atmosphere, let us consider the problem of assessing environmental charges on the example of air-polluting nitrogen oxide, the reduction of emissions of which, along with other GHG, is assumed by government. Since the proportion of this substance among all pollutants in the atmosphere is 10.3%, we will proceed from the corresponding share in the total costs of its capture, i.e., 566.2 billion rubles × 0.103 = 58.3 billion rubles at 2013 prices. These costs were distributed by the federal districts in proportion to the current regional cost structure for the protection of air resources (Table 2, Column 1).

Column 2 in Table 2 shows the projected total volumes of regional emissions of nitrogen oxide in 2016-2020 (for all of Russia it is 10.3% out of 102,330 thou tons of emissions of air pollutants, that is, 10,540 thousand tons). We compare the pollution taxes which are estimated based on predictive calculations (Column 3 in Table 2) and obtained by dividing the data from Column 1 by the data in Column 2, with real payment rates at 2013 prices given in Column 5. According to the Government Decree of the Russian Federation No. 344 of June 12, 2003, the average standard payment for emitting nitrogen oxide is 218 rubles. We used the inflation

Table 1: Forecast of the key indexes of national economy development in Russia in 2014-2020

Scenarios' characteristics	2014	2015	2016	2017	2018	2019	2020
The pessimistic scenario							
GDP growth rate, %	100.0	96.6	94.5	92.1	100.0	100.0	100.0
Investment growth rate, %	97.5	92.0	86.5	79.2	100.0	100.0	100.0
Growth rate of dollar real exchange rate, %	102.7	105.0	105.0	105.0	105.0	105.0	105.0
Average current dollar exchange rate, rubles per dollar	35.57	41.09	47.45	54.81	58.65	62.17	65.90
Change of Urals price (in dollars per barrel)	−7.67	−10.37	−3.24	−1.47	0.0	0.0	0.0
The optimistic scenario							
GDP growth rate, %	100.0	99.1	102.4	106.6	106.6	106.6	106.6
Investment growth rate, %	97.5	97.8	104.8	113.9	113.9	113.9	113.9
Growth rate of dollar real exchange rate, %	102.7	105.0	95.5	90.9	95.0	95.0	95.0
Average current dollar exchange rate, rubles per dollar	35.57	41.09	43.14	43.14	43.14	43.14	43.14
Change of Urals price (in dollars per barrel)	−7.67	−4.41	9.60	10.56	10.56	10.56	10.56

Source: Results of forecast using DIOM. DIOM: Dynamic input-output model, GDP: Gross domestic product

Table 2: Real and model-calculated regional norms of payment for NO_x in 2016-2020 (price of 2013)

Federal districts	Total environmental cost in 2016-2020 (million Rbl)	Total emission in 2016-2020 (thousands tons)	Forecast payment norms (Rbl per ton)	Lower and upper boundaries of the regional coefficients of the environmental situation	Real payment norms (Rbl per ton)
	[1]	[2]	[3]=[1]:[2]	[4]	[5]=[4]×479.6
Central FO	5259.4	1594.3	3299	1.12-1.21	537-580
North-West FO	8947.3	1006.6	8889	1.06-1.33	508-638
South FO	4658.1	480.3	9698	1.23-1.46	590-700
North-Caucasian FO	337.6	149.6	2257	1.23-1.46	590-700
Privolzhskiy FO	11341.8	1671.4	6786	1.14-1.21	547-580
Ural FO	14647.5	2726.4	5373	1.07-1.18	513-566
Siberian FO	10628.7	2285.5	4651	1.02-1.13	489-542
Far East FO	2494.3	625.9	3985	1.00-1.20	480-576
Russia	58314.6	10540	-		-

Source: Results of forecast using DIOM. DIOM: Dynamic input-output model index of ecological payment (2.2 in 2013 to the level of 2003) and obtained the average standard payment for emitting nitrogen oxide at 2013 prices - 479.6 rubles per ton. Given the lower and upper boundaries of the regional coefficients of the environmental situation and environmental significance (Column 4 in Table 2), this base rate of payments was differentiated by the federal district (Column 5 = Column 4 × 479.6 rubles). It is obvious from Table 2 that in all federal districts, even the upper limits of the existing rates do not coincide with those in the forecast of the required size of payments for air pollution with nitrogen oxides. In addition, forecasts of payments are more differentiated depending on the environmental situation in each district compared to the actual standards.

4. DISCUSSION

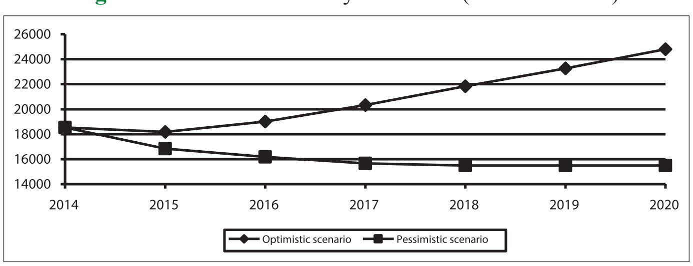
Thus, the results of the calculations make it possible to assess the extent of increases in payments for environmental pollution in Russia, which correspond to world practice.

In developed countries there is currently an increase in the rates of environmental taxes with the collected amount being 1% of gross domestic product (GDP) (in Russia it is 0.03-0.04% of GDP), despite the fact that the standards of pollution charges are 10-100 times higher for various ingredients (Table 3).

5. CONCLUSIONS

Although most Russian economists and ecologists recognize the need to increase pollution taxes, many oppose this measure, citing the inability of enterprises to pay higher fees for pollution. Of course, the improvement of environmental legislation should occur in a complex interactive way along with improving of the entire tax system. In particular, it is proposed to aim fiscal policy at solving environmental problems with a general decline in direct taxes. In addition, in order to reduce the tax burden, a practice of granting tax reliefs and other financial incentives should be more widely used (offsets of environmental payments in the amount of the environmental costs incurred, provision of favorable loans, state guarantees for environmental loans, schemes of accelerated depreciation of environmental capital stock) to stimulate the implementation of advanced technologies, unconventional energy types, the use of recycled resources and waste management, as well as the implementation of other effective measures to protect the environment. All these measures are obviously an effective means of economic and environmental procedures.

Figure 2: Forecast stationary emissions (thousands tons)



Source: Results of forecast using dynamic input-output model

Table 3: Pollution taxes for SO_2 and NO_x (euro per ton) in 2005

Country	Pollution taxes	
	SO_2	NO_x
Czech Republic	28	22
Estonia	3.52	8.5
Poland	85	85
Slovakia	22.7	18.2
Slovenia	14	-
Finland	17.1	-
France	27.4	38.1
Italy	53.2	105
Russia	2.6	5.5

6. ACKNOWLEDGMENTS

We would especially like to thank Professor Victor Pavlov for his software development of model complex DIOM with an EP block. The authors thank also anonymous referees for their very valuable comments.

REFERENCES

Acemoglu, D., Aghion, P., Bursztyn, L., Hemous, D. (2012), The environment and directed technical change. American Economic Review, 102, 131-166.

Annicchiarico, B., di Dio, F. (2013), Environmental Policy and Macroeconomic Dynamics in a New Keynesian Model. CEIS Research Paper 286, Tor Vergata University, CEIS, Revised 30 Sep. 2013.

Ayres, U., Kneese, A. (1969), Production, consumption and externalities. American Economic Review, 59, 282-297.

Baranov, A., Pavlov, V., Tagaeva, T. (1997), Analysis and forecast of the state of environment and environmental protection in Russia with use of a dynamic input-output model. Environmental and Resource Economics, 9, 21-42.

Dissou, Y., Karnizova, L. (2012), Emissions Cap or Emissions Tax? A Multi-sector Business Cycle Analysis. Working Paper, Department of Economics, University. Ottawa.

Druckman, A., Jackson, T. (2009), The carbon footprint of UK households 1990-2004: A socio-economically disaggregated, quasi-multi-regional input-output model. Ecological Economics, 68, 2066-2077.

Duarte, R., Rebahi, S., Sanchez-Choliz, J., Sarasa, C. (2014), Households' behaviour and environmental emissions in a regional economy. Economic Systems Research, 26, 410-430.

Duchin, F. (1988), Framework for the Evaluation of Scenarios for the Conversion of Biological Materials and Wastes to Useful Products: An Input-Output Approach. The American Economic Association Conference: Prospects and Strategies for the American Economy in New York, USA.

Fischer, C., Springborn, M. (2011), Emissions targets and the real business cycle: Intensity targets versus caps or taxes. Journal of Environmental Economics and Management, 62, 352-366.

Hertwich, E.G. (2011), The life cycle environmental impacts of consumption. Economic Systems Recearch, 23, 27-47.

Hertwich, E.G., Peters, G.P. (2009), Carbon footprint of nations: A global, trade-linked analysis. Environmental Science and Technology, 43, 6414-6420.

Heutel, G. (2012), How should environmental policy respond to business cycles? Optimal policy under persistent productivity shocks. Review of Economic Dynamics, 15, 244-264.

Isard, W., Bassett, K., Choguill, C., Furtado, J., Izumita, R., Kissin, J., Romanoff, E., Seyfarth, R., Tatlock, R. (1968), On the linkage of socio-economic and ecologic systems. Papers in Regional Science, 21, 79-99.

Lenzen, M., Dey, C., Foran, B. (2004), Energy requirements of sydney household. Ecological Economics, 49, 375-399.

Lenzen, M., Wood, R., Foran, B. (2008), Direct versus embodied energy – The need for urban lifestyle transitions. In: Droege, P., editor. Urban Energy Transition. Amsterdam: Elsevier. p91-120.

Leontief, W. (1936), Quantitative input-output relations in the economic systems of the United States. Review of Economics and Statistics, 18, 105-125.

Leontief, W. (1970), Environmental repercussions and the economic structure – An input-output approach. Review of Economics and Statistics, 52, 262-271.

Leontief, W., Ford, D. (1972), Air pollution and the economic structure: Empirical results of input-output computations. In: Brody, A., Carter, A., editors. Input-Output Techniques. Amsterdam: North-Holland. p9-30.

Liu, Z., Geng, Y., Lindner, S., Zhao, H., Fujita, T., Guan, D. (2012), Embodied energy use in China's industrial sectors. Energy Policy, 49, 751-758.

Munksgaard, J., Pedersen, K.A. (2001), CO_2 accounts for open economies: Producer or consumer responsibility? Energy Policy, 29, 327-334.

Nordhaus, W.D. (2007), A review of the stern review on the economics of global warming. Journal of Economic Literature, 45, 686-702.

Peters, G.P. (2008), From production-based to consumption based national emission inventories. Ecological Economics, 65, 13-23.

Peters, G.P., Andrew, R., Lennox, J. (2011), Constructing an environmentally-extended multi-regional input-output table using the GTAP database. Economic Systems Research, 23, 131-152.

Raa, T.T., Shestalova, V. (2015), Supply-use framework for international environmental policy analysis. Economic Systems Research, 27, 77-94.

Stern, N. (2007), The Stern Review on the Economics of Climate Change. New York: Cambridge University Press.

Tagaeva, T. (2011), Improving environmental charges using results of the forecast of the environmental and economic development of the Russian Federation. Studies on Russian Economic Development, 22, 331-338.

Tukker, A. Dietzenbacher, E. (2013), Global multiregional Input-Output Frameworks: An introduction and outlook. Economic Systems Research, 25, 1-19

Wiedenhofer, D., Lenzen, M., Steinberger, J.K. (2011), Spatial and socioeconomic drivers of direct and indirect household energy consumption in Australia. In: Newton, P.W., editor. Urban Consumption. Collingwood, Australia: CSIRO Publishing. p251-266.

Wiedmann, T. (2009), Editorial: Carbon footprint and input-output analysis – An introduction. Economic Systems Research, 21, 175-186.

Zhang, Z., Yang, H., Shi, M. (2011), Analyses of water footprint of Beijing in an interregional input - Output framework. Ecological Economics, 70, 2494-2502.

Zhang, Y. (2013), Impact of urban and rural household consumption on carbon emissions in China. Economic Systems Research, 25, 287-299.

Wiedmann, T., Wood, R., Minx, J., Lenzen, M., Guan, D., Harris, R. (2010), A carbon footprint time series of the UK – Results from a multi-region input-output model. Economic Systems Research, 22, 19-42.

Wiedmann, T., Barrett, J. (2013), Policy-relevant applications of environmentally extended MRIO databases - Experiences from the UK. Economic Systems Research, 25, 143-156.