Introducing Environmental Taxes in Russia: Relevance of Tax-Interaction Effects

Anton Orlov and Harald Grethe

Abstract

The theoretical literature on the double dividend concept is mainly focused in pre-existing distortionary taxes in the labour and capital market; however, the relevance of interactions with other taxes and tariffs is often neglected. Using an analytical model and a numerical general equilibrium model, we analyze the incidence of carbon taxes as well as tax interactions in Russia. The main findings are the following: substituting carbon taxes for labour taxes can lead to increases in revenues from export taxes, import tariffs, value added taxes, and some excise taxes because of the expansion of tax bases. Increases in revenues from taxes and tariffs decrease the cost of environmental tax reform. On the other hand, revenues from taxes on labour and capital income, mineral resource extraction taxes, excise taxes on petroleum products, and social security contribution decrease.

JEL classification code: Q50, H20, C30, C68

Key words: carbon taxes; Russia; tax-interaction effect.

Anton Orlov,
Department of Agriculture and Food Policy (420a),
University of Hohenheim,
Schloß, Osthof-Süd.
70599 Stuttgart.
Email: orlov@uni-hohenheim.de
Tel: 0711 459-22522
Fax: 0711 459-23752

Harald Grethe,
Department of Agriculture and Food Policy (420a),
University of Hohenheim,
Schloß, Osthof-Süd.
70599 Stuttgart.
Email: grethe@uni-hohenheim.de
Tel: 0711 459-22631
Fax: 0711 459-23752

Contents

1 Introduction

Russia is not only one of the world's major sources of carbon energy – coal, oil and gas – but is also one the most intensive users of energy. Large energy saving potential can be realized through technological modernization. Introducing carbon taxes would, potentially, address concerns on several fronts simultaneously. In the short to medium term, they would reduce the emission of CO2 and other emissions which are stemming from the use of energy commodities. In the longer term, the increased costs of primary energy products should both accelerate the rate of technological replacement and induce technological progress (Ruttan, 1997; Newell et al., 1999; Popp, 2002). Furthermore, according to the environmental taxation literature, an introduction of environmental taxes is often related to the concept of double dividend, where substituting environmental taxes for other distortionary taxes not only benefits the environment, but also reduces efficiency costs of the tax system (Goulder, 1994). The theoretical literature on environmental taxation is mainly focused on pre-existing distortionary taxes in the labour and capital market (Goulder et al. 1997; de Mooij and Bovenberg, 1998), whereas interactions with other taxes and tariffs such as imports tariffs, export taxes, valued added taxes, excise taxes, and mineral resource extraction taxes are often neglected. Introducing environmental taxes, however, can indirectly affect the efficiency of the tax system through changes in the tax bases. As a result, carbon taxes can either alleviate or exacerbate pre-existing distortions. Moreover, taxes other than labour and capital taxes can be a large source of government revenues. For instance, revenues from import tariffs and export taxes, especially export taxes on crude oil, petroleum products, and natural gas, amount to approximately 21% of total government revenues in Russia (FSSS, 2010; Roskazna, 2010).

The objectives of this analysis are the following: (1) to verify the hypothesis of a double dividend of carbon taxes in Russia, (2) to analyse the incidence of carbon taxes, (3) to investigate interactions of carbon taxes with other taxes and tariffs. This analysis is based on an analytical model developed by Parry (2001) as well as a computable comparative static general equilibrium model – an energy/environment adaptation of the STAGE model (McDonald, 2007). To our knowledge this is the first such study for Russia. Moreover, this is the first paper which explicitly treats the interaction between environmental and other taxes by using a computable general equilibrium model. The paper is organised as follows. The next section gives a brief overview on the Russian tax system, especially tax regimes applied with respect to production, consumption and trade of energy commodities. Section three provides a theoretical background of welfare effects resulting from an introduction of environmental taxes. Section four gives a short description of the numerical model, database, and experiment – an informal description of the model can be found in the appendix B. The results of simulations are presented in section five. The final section summarises the main results and discussions. The main findings are the following: substituting carbon taxes for labour taxes can lead to increases in revenues from export and import taxes, value added taxes, and some excise taxes because of expanding tax bases. Increases in revenues from taxes decrease the cost of environmental tax reform. On the other hand, revenues from taxes on labour and capital income, mineral resource extraction taxes, excise taxes on petroleum products, and social security contribution decrease.

2 Tax System in Russia

Overview of the Russian Tax System. The Russian economy as well as other economies is distorted by different taxes. In this section, we give a short overview of the Russian tax system, especially the tax regime which is applied to production, consumption and trade of energy commodities. Data on the tax system are taken from different legislative documents[1], which are summarized in Table 2.1. The documents were reviewed at March 2012.

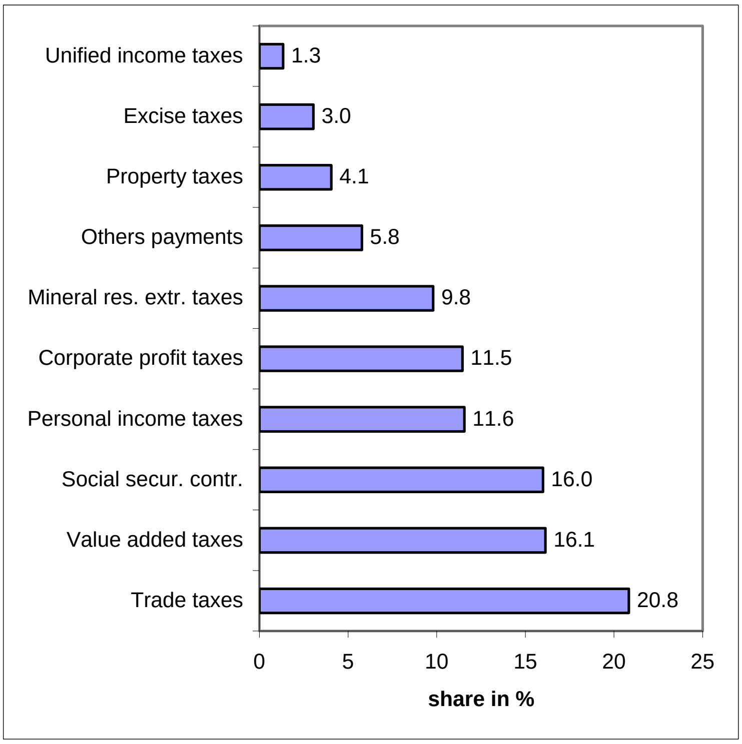
Table 2.1 Legislative documents of the Russian tax system.

Taxes and Tariffs	Corresponding Legislative Documents
Value added tax, excise tax, corporate income tax, personal income tax, mineral resource extraction tax, and others	Russian Tax Code (second part) No.117-FZ from 5.Aug. 2000 (further Russian Tax Code)
Export taxes on crude oil and oil products	Government Decree No.695 from 16.Nov 2006
Export taxes on other commodities	Government Decree from 6. Feb. 2012 No. 88
Import tariffs	Enactment No. 850 from 18. Nov. 2011
Calculation of export taxes on crude oil	Law of Trade Tariffs No.5003-1 from 21.May 1993
Calculation of export taxes on oil products	Government Decree No.1155 from 27.Dec. 2010

Fig. 2.1 illustrates the structure of government revenues in Russia in 2010. The largest source of government revenues is trade taxes such as import and export taxes with a share of 20.8% in total government revenues, following by value added taxes (16.1%), social security contributions (16%), personal income taxes (11.6%), corporate income taxes (11.5%), and mineral resource extraction taxes (9.8%). The magnitude of tax revenues depends on tax bases and tax rates.

[1] All documents are available (in Russian) at http://www.consultant.ru/.

Fig. 2.1 Structure of government revenues in 2010 (%).



Unified income taxes are taxes imposed according to the simplified tax system in Russia; **Others payments** are payments for the use of public property, free payments and others; **Mineral res.extr.taxes** states for mineral resource extraction taxes; **Social secur.contr.** states social security contributions;
Source: FSSS (2010)

Trade taxes. In April 2010 the *Customs Code of the Customs Union* (further Customs Code) came into force. The Customs Code is a legislative document, which regulates trade within the Customs Union as well as trade with non-members of the Customs Union. The Customs Union consists of the Republic of Belarus, the Republic of Kazakhstan and the Russian Federation, and this allows for free trade between the members of the Union, whereas import tariffs are imposed on Union's imports. According to the *Enactment No. 850 from 18.Nov. 2011*, there are high import tariffs on some food products, textile products, machineries, electronic equipment, and transports. For example in 2012, the import tariff rate on beef and pork was at 15%, and on sheep meat and poultry it was at 25%. Import tariffs on textile products, machineries, electronic equipment, and transports differ from product to product, where tariff rates were between 5% and 30%. Import tariff rates on energy commodities excluding electricity were at 5% in 2012.

High export taxes are imposed on commodities such as seeds, animal hide, timber, scrap metals, and energy resources. For example according to *Government Decree No.88 from 6.Feb. 2012*, the rates of export taxes on seeds in 2012 were between 10% and 20%, 500 €/ton for raw animal hides, between 10% and 25%, or 100 Euro/m^3 for timber, and between 6.5%

and 50% for scrap metals. Revenues from trade taxes consist mainly of export taxes on energy resources such as crude oil, oil products, and natural gas. For instance, the revenue share of export taxes on crude oil was at 52% in the total revenues from trade taxes in 2010, for petroleum products it was at 19% and for gas it was at 6% (Roskazna, 2012). There are no export taxes on electricity and coal; however, an export tax on coke with a tax rate of 6.5% was introduced in 2007. Export taxes on crude oil and oil products are specific. The rate of export tax on crude oil is recalculated by the Russian Government each month in accordance with changes in the price of Urals[2] oil (*Law of Trade Tariffs No.5003-1 from 21.May 1993*). The tax rate is calculated according to the formula, which is shown in Table 2.2.

Table 2.2 Formula for calculation of export taxes on crude oil.

Tax Regimes	Formula
if PW_{oil} < 109.5 $/ton	then TE_{oil} = 0%
if 109.5 $/ton < PW_{oil} < 146 $/ton	then TE_{oil} = 0.35*(PW_{oil} – 109.5 $/ton)
if 146 $/ton < PW_{oil}< 182.5 $/ton	then TE_{oil} = 12.77 $/ton + 0.45*($PW_{oil}$ – 146 $/ton)
if PW_{oil} > 182.5 $/ton	then TE_{oil} = 29.2 $/ton + 0.65*($PW_{oil}$ –182.5 $/ton)
where PW_{oil} is the world price of Urals oil and TE_{oil} is the rate of export tax on crude oil.	

Source: Law of Trade Tariffs from 21.May 1993 No.5003-1

The formula for calculation of the export tax rate on crude oil includes four regimes, depending on the price of Urals oil. For instance, the export price of Urals oil was at 774 $/ton since 1.Jan. until 1. May 2011 (Ministry of Economics, 2011). Since the export price (PW_{oil}) was higher than 182.5$/ton, the specific export tax rate on crude oil (TE_{oil}) is calculated as follows:

$$29.2 \text{ \$/ton} + 0.65*(774 \text{ \$/ton} – 182.5 \text{ \$/ton}) = 413 \text{ \$/ton} \quad (2.1)$$

Therefore, the rate of export tax on crude oil was at approximately 413 $/ton from January to May in 2011, which amounts to approximately 53% of the export price of Urals oil. Rates of export taxes on oil products depend on the export tax rate on crude oil. According to the *Government Decree from 27.Dec. 2010 No.1155*, the rates of export taxes on oil products are calculated as follows:

$$TE_{petl} = K_{petl} * TE_{oil}, \quad (2.2)$$

where TE_{petl} are specific tax rates on oil products in $/ton, K_{petl} are multiplier coefficients, and TE_{oil} is the specific export tax rate on crude oil in $/ton. From 2003 to 2010 the multiplier coefficient was at 0.9 for all oil products. Since 2010 coefficients differ among oil products

[2] Urals is an oil brand, whose prices are used to calculate export taxes on crude oil.

(*Government Decree No.1155 from 27.Dec. 2010*). Until 2015 the multiplier coefficients should equal 0.66 for most oil products. The calculated rates of export taxes on crude oil and oil products can be found in *Government Decree No.695 from 16.Nov 2006*.

The export tax rate on natural gas is at 30%, while the export tax rate on liquefied petroleum gas (LPG) is specific and this is calculated according to the formula in Table 2.3. For example, if the price of LPG is higher than 740 $/ton, then the specific tax rate on LPG equals 135 $/ton plus the difference between the observed average price and 740 $/ton, multiplied by a coefficient is 0.7.

Table 2.3 Formula for calculation of export taxes on LPG.

Tax Regimes	Formula
if PW_{gas} < 490 $/ton	then $TE_{LPG} = K_1*490$
if 490 $/ton <$PW_{gas}$ < 640 $/ton	then $TE_{LPG} = K_2*(PW_{gas} – 490)$
if 640 $/ton <$PW_{gas}$ < 740 $/ton	then $TE_{LPG} = 75 + K_3*(PW_{gas} – 640)$
if PW_{gas} > 740 $/ton	then $TE_{LPG} = 135 + K_4*(PW_{gas} – 740)$
where PW_{gas} is the average price of LPG observed on the border of Poland, TE_{LPG} is the specific rate of export tax on LPG, $K_1 = 0$, $K_2 = 0.5$, $K_3 = 0.6$, $K_4 = 0.7$.	

Source: Government Decree No.1155 from 27.Dec.2010

Domestic Taxes. As shown in Table 2.4, the rate of corporate income tax was at 20%, the rate of value added tax was at 18%, the flat tax rate on labour earnings was at 13%, and the rate of social security contributions was at 34% in 2012. In February 2012, the rate of mineral tax on extraction of crude oil was at approximately 411.2 $/ton, condensate gas (18.5 $/ton), and natural gas (8 $/1000m$_3$). The rate of excise tax on petrol (Euro-5) was at approximately 227 $/ton and for diesel (Euro-5) it was at approximately 119 $/ton in 2012.

Table 2.4 Tax system of the Russian Federation.

Name of Taxes	Tax Rates
Federal Taxes[3]:	
Corporate Income Tax	According to the *Federal Law No.223-FZ from 26.Nov. 2008*, the rate of corporate income tax was reduced from 24% to 20% in 2008.
Value Added Tax	According to the *Federal Law No.117-FZ from 7.Jul. 2003,* the rate of value added tax was reduced from 20% to 18% in 2003. Moreover, a tax rate of 10% is applied on some products such as food products, children's clothing, books, education, and medical services. The tax rate on exported commodities equals 0%.
Personal Income Tax	The flat tax rate on labour income was at 13%, the tax rate on dividends was at 35%, tax rates on other personal income were at 9% or 30% in 2012.
Social Security Contributions	According to the *Federal Law No. 212-FZ from 24.Jul. 2009*, the unified social tax with a rate of 26% was replaced by social security contributions (SSC) with a rate of 34%. SSC are distributed between different funds: pension fund (26%), social insurance fund (2.9%), obligatory health insurance (5.1%).
Mineral Resource Extraction Tax	Mineral resources extraction taxes, *inter alia*, are imposed on condensate and natural gas, coal, and crude oil with different specific tax rates. For example, in February 2012 the rate of mineral tax on the extraction of crude oil was at approximately 411.2 $/ton, condensate gas (18.5 $/ton), and natural gas (8 $/1000m$_3$). For more details see text below.
Excise Tax	Excise taxes are imposed on commodities such as alcohol, cigarettes, cars, and petroleum products with different specific tax rates. Rates of excise taxes on petroleum products differ among products according to their environmental impact. For example in 2012, the rate of excise tax on petrol (Euro-5) was at approximately 227 $/ton and for diesel (Euro-5) it was at approximately 119 $/ton. For more detail see text below.
Other taxes	In addition, federal taxes include (1) water taxes, (2) state fees, and (3) fees for the use of biological resources. These taxes are specific with different tax rates.
Regional and Local Taxes:	
Transport Tax	There are different specific tax rates.
Gambling Tax	
Property Tax	Regions may set own tax rates, yet tax rates may not exceed 2.2%.
Land Tax	The tax rate can be either 0.3% or 1.5%.

Source: Russian Tax Code

Mineral Resource Extraction Tax. Table 2.5 shows tax rates on the extraction of condensate and natural gas. The rate of mineral tax on the extraction of natural gas was at approximately 8 $/1000m$_3$ in 2012, which is about 10% of the average price[4] of natural gas for households.

[3] The differentiation between federal, regional and local taxes is in accordance with the three-level budget system.

[4] Prices of natural gas for households are regulated by the Federal Tariff Service. According to the *Regulation of Federal Tariff Service No. 333-e/2 from 9.Dec. 2011*, the average price of natural gas for household was at approximately 86$/1000m$_3$ since July 2012. The price was recalculated by authors using an exchange rate is 30

The multiplier coefficient (K_{ng}) should be reduced from 0.493 to 0.447 until 2014. In 2012 the tax rate on condensate gas was at approximately18.5 $/ton. Associated gas is not subject for taxation.

Table 2.5 Rates of mineral tax on gas extraction from 2012 to 2014[5].

	Condensate gas	Natural gas
1.Jan. - 31.Dec. 2012	TM_{cgas} =18.5 $[6]/ton	$TM_{natlgas} = K_{ng}$*17 $/1000m3, where K_{ng}=0.493
1.Jan. – 31.Dec. 2013	TM_{cgas}= 19.7 $/ton	$TM_{natlgas} = K_{ng}$*19 $/1000m3, where K_{ng}=0.455
1.Jan. 2014	TM_{cgas}= 21.6 $/ton	$TM_{natlgas} = K_{ng}$*21 $/1000m3, where K_{ng}=0.447
where TM_{cgas} is the specific mineral tax rate on extraction of condensate gas, $TM_{natlgas}$ is the specific mineral tax rate on extraction of natural gas, K_{ng} are multiplier coefficients.		

Source: Russian Tax Code

The rate of mineral tax on the extraction of coking coal was at approximately 1.9 $/ton in 2012, which equals 2.3% of the producer price[7] (82 $/ton). The tax rate for brown coal was at approximately 0.4 $/ton in 2012, which equals 2.6% of the producer price (15 $/ton). According to the *Russian Tax Code*, the rate of mineral tax on the extraction of crude oil is calculated as follows:

$$TM_{oil} = BTM_{oil} * K_P * K_D * K_S \quad (2.3)$$

$$K_P = (PW_{oil} - 15) * \frac{ER}{261} \quad (2.4)$$

$$K_D = 3.8 - 3.5 * \frac{N}{V} \qquad if\ 0.8 < \frac{N}{V} < 1 \quad (2.5)$$

$$K_D = 0.3 \qquad if\ \frac{N}{V} > 1 \quad (2.6)$$

$$K_D = 1 \qquad others \quad (2.7)$$

$$K_S = 0.125 * V_S + 0.375 \qquad if\ V_S < 5\ Mio.\ ton\ and\ \frac{N}{V_S} \le 0.5 \quad (2.8)$$

$$K_S = 1 \qquad if\ V_S \ge 5\ Mio.\ ton\ and\ \frac{N}{V_S} > 0.5 \quad (2.9)$$

$$K_S = 1 \qquad for\ the\ difference\ (N-V_S)\ if\ V_S > N \quad (2.10)$$

Ruble/$. The document is available on the official web-side of the Federal Tariff Service at http://www.fstrf.ru/tariffs/info_tarif/gas

[5] Tax rates for 2013 and 2014 are calculated by indexing the current tax rate with the expected inflation rate.

[6] The tax rates are recalculated from Ruble into USD using an exchange rate of 30Ruble/$ with an accuracy of one decimal point.

[7] Producer prices of coal are taken from Federal State Statistic Service at http://www.gks.ru/wps/wcm/connect/rosstat/rosstatsite/main/price/#

where TM_{oil} is the company specific mineral tax rate on crude oil in Ruble/ton, BTM_{oil} is the base mineral tax rate on crude oil in Ruble/ton, K_P is a coefficient which characterizes changes of the world price of crude oil, K_D is a coefficient which characterizes the depletion of resources, K_S is a stock coefficient, PW_{oil} is the average price of Urals oil in $/barrel, *ER* is the exchange rate, *N* is the volume of extracted oil, *V* are oil reserves registered on 1.Jan. 2006, $\frac{N}{V}$ is the depletion rate with respect *V*, and V_S are oil reserves registered in the previous year, $\frac{N}{V_S}$ is the ration of reserves. The base mineral tax rate on crude oil (BTM_{oil}) was at approximately 14 $/ton in 2011, 15 $/ton in 2012, and 16 $/ton in 2013. The tax rates for 2012 and 2013 are calculated by indexing the current tax rate with the expected inflation rate.

Excise Taxes. Among energy commodities excise taxes are applied only on oil products such as petrol and diesel with specific tax rates. Furthermore, according to the *Federal Law No.282-FZ from 28.Nov. 2009*, since January 2011 rates of excise tax on oil products differ according to their environmental adverse effects[8], where a high tax rate corresponds to oil products with worse quality, as shown in Table 2.6. For example, from January until June 2012 the excise tax rate on petrol (Euro-3) was at approximately 246 $/ton, whereas on petrol (Euro-5) it was at 227 $/ton.

Table 2.6 Excise taxes on oil products from 2012 to 2014 ($/ton[9]).

	1.Jan.-30.Jun. 2012	**1.Jul.-31.Dec. 2012**	**1.Jan.-31.Dec. 2013**	**1.Jan.-31.Dec. 2014**
Petrol (others)	258	274	337	370
Petrol (Euro-3)	246	263	325	258
Petrol (Euro-4)	227	227	285	314
Petrol (Euro-5)	227	171	171	189
Diesel (others)	137	143	195	215
Diesel (Euro-3)	127	143	195	215
Diesel (Euro-4)	119	119	164	181
Diesel (Euro-5)	119	99	144	159
Motor oil	202	202	250	275
SRG	261	261	321	353

SRG is the straight-run gasoline.

Source: Russian Tax Code

[8] According to European environmental standards for fuels, which were introduced in Russian according to the *Government Degree No. 118 from 27.Feb. 2008*.

[9] The rates of excise taxes are recalculated from Ruble into US dollars by using an exchange rate of 30 Ruble/USD with an accuracy of zero decimal point.

3 Theoretical Background

According to the environmental taxation literature, an introduction of environmental taxes is often related to the concept of double dividend, where substituting environmental taxes for other distortionary taxes benefits not only the environment, but also reduces efficiency costs of the tax system. A "weak" and "strong" double dividend hypothesizes are distinguished. The relatively uncontroversial "weak" double dividend hypothesis argues that using revenues from environmental taxes to reduce other distortionary taxes, one can achieve cost savings (reductions in welfare costs of taxation) compared to the case where revenues are returned to households in lump-sum form. The more ambiguous "strong" double dividend hypothesis argues that not only can environmental welfare be increased but net welfare gains can be achieved by alleviating pre-existing distortions (Goulder, 1994). The theoretical literature on environmental taxation is mainly focused on pre-existing distortionary taxes in the labour and capital market (Goulder et al. 1997; de Mooij and Bovenberg, 1998), whereas interactions with other taxes such as imports and export taxes, valued added taxes, excise taxes, and mineral resource extraction taxes are often neglected.

Using the analytical model developed by Goulder et al. (1997), and further modified to an open economy model[10] by Parry (2001), we analyze the welfare effect of pollution taxes. Since the Russian economy strongly depends on revenues from export taxes on energy resources, we extend the model framework by introducing an export tax on polluting commodities. Household utility is given by the following equation:

$$U = u(C_1, C_2, H) - v(E_H), \tag{3.1}$$

where $u(*)$ is a utility function, which is quasi-concave and $v(*)$ is a disutility function, which is concave. Both functions are continuous. C_1 is the domestic demand for the non-polluting good 1, which is a composite of the domestically produced good (Q_1) and the imported good (M). The domestically produced and imported good 1 are treated as perfect substitutes (3.2). C_2 is the domestic demand for the polluting good 2, which is produced domestically only. The domestic supply of good 2 (C_2) is defined as the difference between the total supply (Q_2) and export (X), as given in equation (3.3). We consider the situation, where the country is an exporter of the polluting good. H is leisure.

$$C_1 = Q_1 + M, \tag{3.2}$$

$$C_2 = Q_2 - X. \tag{3.3}$$

[10] To make it comparable, we keep the notation which is applied by Parry (2001).

We assume a small open economy, where the world price of the exported good (*X*) and the world price of the imported good (*M*) are normalized at unity. Therefore, the trade account balance is simply given by the following equation:

$$M = X \ , \qquad (3.4)$$

Consumption of good 2 induces emissions. The environmental quality at home country (E_H) and abroad (E_A) is defined by the following functions:

$$E_H = e_H(C_2) \ , \qquad (3.5)$$

$$E_A = e_A(X) \ . \qquad (3.6)$$

The marginal environmental damage (*D*) from consumption of good 2 (C_2) in the home country is measured in value terms. This can be derived using the disutility function in (3.1) and (3.5):

$$D = \frac{1}{\lambda}\frac{\partial v}{\partial e_H}\frac{\partial e_H}{\partial C_2} \ , \qquad (3.7)$$

where λ is the marginal utility of income. We assume perfect competition and constant returns to scale in the production of both goods, where labour is the only input. Therefore, the marginal product of labour is constant, implying a perfectly elastic demand for labour. Normalizing the wage rate and prices at unity, the economy resource constraint can be written as follows:

$$T = Q_1 + Q_2 + H \ , \qquad (3.8)$$

where *T* is the household time endowment. The total labour supply is the difference between the time endowment and leisure: (*T* – *H*). Households are assumed to maximise the utility (2.1) subject to the following household budget constraint:

$$C_1 + (1+\tau_{C2})C_2 = (1-\tau_L)(T-H) + TR \ , \qquad (3.9)$$

where τ_{C2} is the pollution tax on the good 2 (C_2), τ_L is the tax on labour income, and *TR* is the total government revenue, which is returned to households as lump-sum transfers. The total government revenue consists of revenues from pollution tax, labour tax, and export tax:

$$TR = \tau_{C2}C_2 + \tau_L(T-H) + \tau_X X \ , \qquad (3.10)$$

where τ_X is the export tax. *TR* is exogenous in the model. This is because we analyse a revenue neutral experiment, where the revenue from the pollution tax is recycled through a reduction in the labour tax. Using this analytical framework, we can derive the following propositions.

Proposition 1. *The tax-interaction effect dominates the revenue-recycling effect, if* τ_{C2} *>0,* τ_X *=0, and* C_1 *and* C_2 *are equal substitutes for leisure.*

Proof. Totally differentiating equation (3.1) with respect to τ_{C2}, we obtain the following expression for the welfare effect:

$$\frac{dU}{d\tau_{C2}} = \left(\frac{\partial U}{\partial C_2} - \frac{\partial v}{\partial e_H}\frac{\partial e_H}{\partial C_2}\right)\frac{dC_2}{d\tau_{C2}} + \frac{\partial U}{\partial C_1}\frac{dC_1}{d\tau_{C2}} + \frac{\partial U}{\partial H}\frac{dH}{d\tau_{C2}}. \tag{3.11}$$

Maximising the utility function (3.1) with respect to the household income balance (3.9), we obtain the following first-order conditions:

$$\frac{\partial U}{\partial C_1} = \lambda; \qquad \frac{\partial U}{\partial C_2} = \lambda(1+\tau_{C2}); \qquad \frac{\partial U}{\partial H} = \lambda(1-\tau_L). \tag{3.12}$$

The implicit demand functions are the following:

$$C_1(\tau_{C2},\tau_L); \qquad C_2(\tau_{C2},\tau_L); \qquad H(\tau_{C2},\tau_L). \tag{3.13}$$

Substituting (3.12) and (3.7) into (3.11) to obtain:

$$\frac{1}{\lambda}\frac{dU}{d\tau_{C2}} = (1+\tau_{C2}-D)\frac{dC_2}{d\tau_{C2}} + \frac{dC_1}{d\tau_{C2}} + (1-\tau_L)\frac{dH}{d\tau_{C2}}. \tag{3.14}$$

Differentiating (3.8) with respect to τ_{C2} and making use of (3.2), (3.3) and (3.4), we obtain:

$$\frac{dC_2}{d\tau_{C2}} = -\frac{dC_2}{d\tau_{C2}} - \frac{dH}{d\tau_{C2}}. \tag{3.15}$$

Substituting (3.15) into (3.14), we obtain:

$$\frac{1}{\lambda}\frac{dU}{d\tau_{C2}} = (\tau_{C2}-D)\frac{dC_2}{d\tau_{C2}} - \tau_L\frac{dH}{d\tau_{C2}}. \tag{3.16}$$

Totally differentiating the implicit demand function for leisure (3.13) with respect to τ_{C2}, we obtain:

$$\frac{dH}{d\tau_{C2}} = \frac{\partial H}{\partial \tau_{C2}} + \frac{\partial H}{\partial \tau_L}\frac{d\tau_L}{d\tau_{C2}}. \tag{3.17}$$

Totally differentiating the government revenue equation (3.10) with respect to τ_{C2}, after some simple algebraic manipulation, gives

$$\frac{d\tau_L}{d\tau_{C2}} = -\frac{C_2 + \tau_{C2}\dfrac{dC_2}{d\tau_{C2}} - \tau_L \dfrac{\partial H}{\partial \tau_{C2}} + \tau_X \dfrac{dX}{d\tau_{C2}}}{T - H - \tau_L \dfrac{\partial H}{\partial \tau_L}}. \tag{3.18}$$

Substituting (3.18) and (3.17) into (3.16), we can obtain:

$$\frac{1}{\lambda}\frac{dU}{d\tau_{C2}} = \underbrace{(\tau_{C2} - D)\frac{dC_2}{d\tau_{C2}}}_{dW^P} + \underbrace{M\left(C_2 + \tau_{C2}\frac{dC_2}{d\tau_{C2}} + \tau_X \frac{dX}{d\tau_{C2}}\right)}_{\partial W^R} - \underbrace{(1+M)\tau_L \frac{\partial H}{\partial \tau_{C2}}}_{\partial W^I}, \tag{3.19}$$

where $M = \dfrac{\tau_L \dfrac{\partial H}{\partial \tau_L}}{T - H - \tau_L \dfrac{\partial H}{\partial \tau_L}}$. (3.20)

According to Goulder et al. (1997), the numerator in equation (3.20) defines the partial equilibrium net welfare from a marginal change in the labour tax. This is the change in leisure multiplied by τ_L. The denominator defines the partial equilibrium change in government revenues from a marginal change in the labour tax. Therefore, M is the partial equilibrium efficiency costs[11] resulting from an increase of labour tax to receive an additional dollar. The first term in the RHS of the equation (3.19) is the Pigouvian effect, dW^P, which is defined as a reduction of C_2, multiplied by the difference between the marginal social benefit and the marginal social cost. The revenue recycling effect is labeled by ∂W^R. The revenue-recycling effect defines efficiency gains from a reduction of labour tax and gains from pollution tax revenues. The tax interaction effect which is labeled by ∂W^I defines the welfare loss, resulting from decreasing labour supply and revenues from labour taxes. The tax interaction effect (∂W^I) can be shown by the following approximation, which is derived following Goulder et al. (1997) (see appendix A):

$\partial W^I = \phi_C M C_2$, where $$\phi_C = \frac{n_{C_2H}{}^C + n_{LI}}{n_{C_1H}{}^C \dfrac{C_1}{C_1 + C_2} + n_{C_2H}{}^C \dfrac{C_2}{C_1 + C_2} + n_{LI}}, \tag{3.21}$$

[11] According to Goulder et al. (1997), M is also defined as marginal excess burden of labour taxation, where one plus the marginal excess burden of taxation equals the marginal cost of public funds.

where $n_{C_1H}{}^{C}$ and $n_{C_2H}{}^{C}$ are the compensated elasticities of demand for C_1, and C_2 with respect to the price of leisure, and n_{LI} is the income elasticity of labour supply. The degree of substitution between C_2 and leisure compared to that between total consumption and leisure is measured by the term, ϕ_C. For example, if C_1 and C_2 have equal elasticities of substitution for leisure ($n_{C_1H}{}^{C}$ equals $n_{C_2H}{}^{C}$), then ϕ_X equals unity. Therefore, the difference between the revenue-recycling effect (∂W^R), and the tax-interaction effect (∂W^I) equals:

$$M\left(\tau_{C2}\frac{dC_2}{d\tau_{C2}}+\tau_X\frac{dX}{d\tau_{C2}}\right). \tag{3.22}$$

If $\tau_{C2}>0$, $\tau_X=0$, then $\partial W^I>\partial W^R$ by the term $M\left(\tau_{C2}\frac{dC_2}{d\tau_{C2}}\right)$. **Q.E.D.**

This confirms the conclusion made by Parry (1995) and Goulder et al. (1997) and implies a failure of the strong double dividend hypothesis. The intuitive explanation for this is that narrow-based taxes (pollution taxes) induce a larger marginal excess burden compared to broad-based taxes (income taxes). Nevertheless, if pollution goods and leisure are complements, the tax-interaction effect is an efficiency gain (Goulder et al. 1997). In addition, Bovenberg and de Mooij (1994) show that the optimal pollution tax typically falls short of the Pigouvian tax in the presence of tax distortions in the labour market. This means that substituting pollution taxes for labour taxes exacerbate pre-existing distortions rather than alleviate this.

Proposition 2. *The tax-interaction effect is less than the revenue-recycling effect, if* $0<\tau_{C2}<\tau_X$ *and* C_1 *and* C_2 *are equal substitutes for leisure.*

Proof. Under the assumption of a small open economy and homogeneity of C_2 and X in supply, $\frac{dC_2}{d\tau_{C2}}=\frac{dX}{d\tau_{C2}}$ where $\frac{dC_2}{d\tau_{C2}}<0$ and $\frac{dX}{d\tau_{C2}}>0$. Therefore from (3.22), if $\tau_{C2}<\tau_X$, then $\partial W^I<\partial W^R$. **Q.E.D.**

Expanding base of the export tax results in additional revenues, which allows for a larger reduction in labour taxes. Such a *positive tax-interaction effect* decreases the cost of environmental tax reform, raising the possibility of a strong double dividend.

Proposition 3. *The tax-interaction effect equals the revenue-recycling effect, if* $\tau_{C2} = \tau_X$, τ_X >0, *and* C_1 *and* C_2 *are equal substitutes for leisure.*

Proof follows from the proof of the **Proposition 2,** see equation (3.22). **Q.E.D.**

Using this analytical framework, we can also see that introducing (increasing) pollution taxes harms the environmental quality abroad: $\frac{de_A}{d\tau_{C2}} = \frac{\partial e_A}{\partial X}\frac{dX}{d\tau_{C2}}$<0 because $\frac{\partial e_A}{\partial X}$<0 and $\frac{dX}{d\tau_{C2}}$>0. This indicates the emission leakage effect.

In addition, other important aspects of the double dividend hypothesis can be summarized as follows:

(1) Williams[12] (2002) analyses the link between pollution, human health, and labour productivity. By using a modified version of the model developed by Parry et al. (1999), he shows that introducing pollution taxes can improve health, resulting in increases of labour productivity. This creates additional benefits from the environmental tax reform, *benefit-side tax-interaction effect*, which can offset the negative tax-interaction effect under certain conditions.

(2) Parry and Bento (2000)[13] show that welfare gains from substituting environmental taxes for labour taxes can be substantially larger, when tax-favoured consumption is introduced in the model. This is because labour taxes distort also the choice among consumption goods.

(3) In the presence of capital in the short and medium term, an environmental tax reform can induce the so-called *tax-shifting effect* between factors. For example, if capital is internationally mobile, substituting environmental taxes for capital taxes can yield a double dividend, or if capital is internationally immobile, substituting environmental taxes for labour taxes can reduce the efficiency costs of the tax system. Nevertheless, in the long-run, capital is rather perfectly mobile. Therefore, under the assumption of international capital mobility, an environmental tax reform can exacerbate rather than alleviate initial inefficiencies in the tax system (de Mooij and Bovenberg, 1998).

(4) Apart from capital, natural resources can also be considered as a fixed factor. For instance, Bento and Jacobsen (2007) show that in the presence of a fixed factor and untaxable Ricardian rents, an environmental tax reform can induce a double dividend

[12] In comparison, Williams (2003) considers the relationship between pollution and the health effect only.
[13] For another special case see Parry and Bento (2001).

since the burden of environmental taxes is shared by labour and natural resources in terms of lower prices of natural resources (Ricardian rents).

(5) According to Bovenberg and Ploeg (1998), important conditions under which an environmental tax reform can increase employment are the following: low initial tax rates on resources, a large production share of fixed factors, and high substitution between labour and resources. The use of exhaustible resources, however, is often subject for high taxes.

(6) Furthermore, there are other types of tax-shifting effects that can lead to a double dividend such as tax-shifting across countries (terms of trade effect) and tax-shifting among household incomes. For example, Killinger (1995) and de Mooij (1996) show that the burden of environmental taxation can be partially shifted to foreign supplier trough a terms-of-trade effect. This, however, is feasible only for large economies, which can affect the world market price, exercising some market power.

A strong tax-shifting effect is the crucial condition for the occurrence of a strong double dividend (de Mooij, 1996). In general, the occurrence of double-dividend effects is ambiguous. The outcome, *inter alia*, depends on the tax and economic structure, household preferences, factor mobility, factor substitution, and revenue recycling strategies. Hence general equilibrium analysis is an appropriate analytical method (Goulder, 2002).

4 Numerical Model

4.1 Model and Database

The model is a modified version of the comparative static “STAGE” model (McDonald, 2007). The STAGE model is a member of the class of computable-general equilibrium (CGE) models descended from the model described by Dervis et al. (1984) and more specifically the USDA ERS model (Robinson et al., 1990; and Kilkenny, 1991). The model is a Social Accounting Matrix (SAM) based single-country CGE model, which is implemented in General Algebraic Modeling System (GAMS) software. For informal descriptions of the model see appendix B.

This analysis is based on version 7 of the Global Trade Analysis Project (GTAP) database, which represents the global economy in 2004. The GTAP database describes bilateral trade, production, and consumption of 57 commodities and 113 regions (GTAP, 2007). The GTAP database does not, however, include any enterprise accounts, and only one aggregated private household is represented in the database. For our analysis we extract a Social Accounting

Matrix (SAM) for Russia using the GAMS version of the SAM extraction program developed by McDonald and Thierfelder (2004). For this analysis, we aggregate 57 activities to 25 activities, where the SAM for Russia represents single product activities. The database provides information on the main policy instruments such as import and export taxes, consumption taxes, taxes on factor income, and taxes on factor use. According to the model framework, commodity taxes are imposed on the final consumption as well as the intermediate consumption. This, however, does not reflect the real system of value added taxation in Russia. Under a value added tax system, which is applied in Russia as well as many European countries, only the final consumption is taxed so that industries receive rebates to avoid the cascading effect. Therefore, we can not draw any explicit conclusion with respect to value added taxes; however, we can form plausible expectations based on changes in final consumption. Furthermore, corporate income taxes are not explicitly depicted in the database so that taxes on capital income include corporate income taxes, taxes on interest from bank deposits and dividends.

CO2 coefficients are calculated based on the Energy Information Administration (EIA) database (2011), by dividing the total CO2 emission of a certain energy product (measured in million metric tons) by the total amount of energy used (measured in quadrillion Btu). Coal and petroleum products contain the largest emission contents: for example, the CO2 coefficient for coal is 93 million metric tons per quadrillion Btu, petroleum products and crude oil (67), natural gas, and gas manufacture (54). Moreover, following the GTAP emission database (Lee, 2008), CO2 coefficients of coal, crude oil, and petroleum products used by the petroleum sector equal zero. The same assumption is made for natural gas used by gas manufacturing.

4.2 Experiments and Model Closures

In this analysis we simulate an introduction of carbon taxes on energy commodities such as coal, natural gas, petroleum products, and gas manufacture used by households and industries. Carbon taxation is not applicable for crude oil since crude oil is consumed mainly by the petroleum sector. For instance, the share of crude oil consumption by the petroleum sector is 98% of domestic consumption (GTAP, 2007). The magnitude of carbon taxation aims at a targeted reduction of carbon emissions by 10% through a proportional increase in tax rates on carbon emissions. This means that carbon taxes differ between energy commodities according to the CO2 coefficients, yet are the same among sectors and households. Revenues from carbon taxes are recycled through a reduction in taxes on income from unskilled and skilled labour. In the model we assume the following closure rules:

Foreign Exchange Closure. The external trade balance is fixed and the exchange rate is flexible so that changes in the exchange rate clear the foreign exchange market;

Investment-Savings Closure. Volumes of investment are fixed and household savings rates are variable so that the capital accounts are cleared by changes in the household savings rate. The assumption of fixed investment is consistent with the long-run experiment;

Government Account Closure. Government savings rates and government consumptions are fixed so that the government account is cleared by a reduction of labour taxes;

Numeraire. The consumer price index (CPI) is set as numeraire;

International Factor Mobility Closure. All factors are assumed to be internationally immobile;

Factor Market Closure. Capital is assumed to be perfectly mobile among sectors; however, we assume immobility of natural resources. Land is used by the agricultural sector only, and hence it is a *de facto* immobile resource. Furthermore, we assume a perfectly elastic supply of land. This is because Russia has a large potential for land resources – a lot of land remains fallow. The supply of skilled and unskilled labour is assumed to be inelastic. We incorporate supply functions for skilled and unskilled labour:

$$FS_f = shfs_f * (WF_f * (1 - TYF_f))^{efs_f} , \qquad (4.1)$$

where FS_f is the supply of skilled and unskilled labour, $shfs_f$ is the shift parameter for the supply function, WF_f is the wage level, efs_f is the labour supply elasticity which is assumed to equal 0.30, following Böhringer et al. (2008)[14], TYF_f is the tax on factor income.

5 Results

Introducing carbon taxes results in welfare gains measured by equivalent variation[15] (EV) of 2575 million USD or 0.9% of initial household expenditures. Household income increases by 1.3% because of higher income from land via an increase in supply of land as well as higher income from increased skilled and unskilled labour via lower labour taxes and higher labour supply. Moreover, the real GDP increases by 0.5%, accompanied by a depreciation of the

[14] Evers et al. (2008) confirms this order of magnitude found that the mean labour supply elasticity for men equals 0.07, whereas for women it is 0.43.

[15] Equivalent variation measures how much a consumer would pay before a price increase to avoid the price increase so that the income change is equivalent the price change regarding the utility change (Varian, 1999).

currency by 0.5%. Household expenditure – household income net of savings plus lump-sum transfers – increases by 1.8%, which is stronger than the increase in household income because of a lower savings rate, which falls by 1%. According to the model closures, government savings, government consumption, and investment are fixed, which implies an investment driven closure. Due to increasing household income, the savings rate decreases to match fixed investment. Alternatively, if we fix the savings rate, investment in real terms would increase because of higher household income; however, the increase in final consumption would be less pronounced than it is under the investment driven closure. Introducing carbon taxes compensated by a reduction in taxes on labour income leads to a decrease of total government expenditures by 2.1% because of a decreasing price of public services, whereas government consumption and savings are fixed. Government consumption consists mainly of public services. As shown in Table 5.1, substituting carbon taxes for labour taxes leads to increases in revenues from export, import and land taxes. In addition, expenditures on production subsidies and transfers to households increase. In contrast, revenues from taxes on factor income and consumption taxes decrease. The reasons for this are explained further below.

Table 5.1 Changes of government revenues and expenditures from trade and domestic taxes (million USD and %).

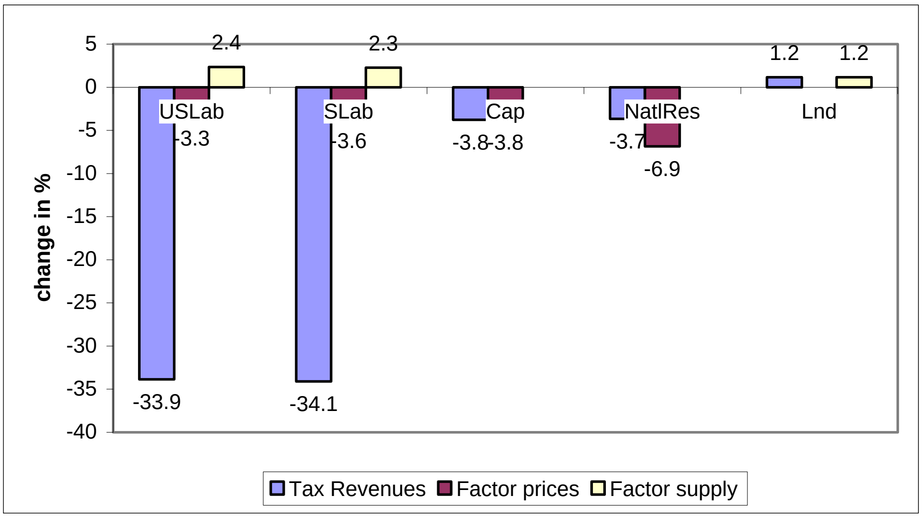
	Absolute changes in million USD	**Relative changes in %**
Import taxes	54.89	0.56
Export taxes	1037.30	4.05
Consumption taxes	-1624.12	-3.25
Capital income taxes	-706.94	-3.73
Labour income taxes (unskilled labour)	-10207.60	-33.86
Labour income taxes (skilled labour)	-4797.92	-34.09
Land taxes	4.96	1.15
SSC (unskilled labour)	-153.74	-1.06
SSC (skilled labour)	-94.96	-1.41
Mineral resource extraction taxes	-86.65	-3.66
Production subsidies	4.57	0.66
Lump-sum transfers	1131.38	1.27
Carbon taxes	15936.51	no

Source: model simulation results

Domestic Taxes. Substituting carbon taxes for taxes on labour earnings leads to increases in supply of unskilled and skilled labour by 2.4% and 2.3%, respectively (Fig. 5.1). Increases in labour supply indicate the so-called employment double dividend (Bovenberg and Ploeg, 1998). Due to tax incidence, gross wages for unskilled and skilled labour decreases by 3.3% and 3.6%, respectively. Tax rates on earnings from unskilled and skilled labour decrease by

33.15% each. Both a reduction in labour tax rates and decreasing gross wages lead to decreases in tax revenues from labour income: for example, revenues from taxes on unskilled and skilled labour decrease by 33.9% and 34.1%, respectively. On the other hand, a reduction in labour taxes as well as increasing labour supply alleviates distortions in the labour market. Furthermore, even though supply of labour increases, the amount of social security contributions from unskilled and skilled decreases by 1.1% and 1.4%, respectively, because of decreasing gross wages.

Fig. 5.1 Changes of factor supply, factor prices, and revenues from factor taxes (%).



USLab is unskilled labour; **SLab** is skilled labour; **Cap** is capital; **NatlRes** is natural resources; **Lnd** is land.
Source: model simulation results

Introducing carbon taxes leads to decreases in demand for capital and natural resources, resulting in decreases of returns to these factors. Decreasing prices of capital and natural resources indicate a so-called tax-shifting effect (de Mooij and Bovenberg, 1998; Bento and Jacobsen, 2007; Fraser and Waschik, 2010). This means that the burden of carbon taxes does not fully pass on to final consumers, yet it is partially absorbed by lower factor prices. According to the environmental taxation literature, the tax-shifting effect is an important condition for the occurrence of a strong double dividend (de Mooij, 1996). Under the assumption of a stock of capital and natural resources, changes of return to capital and resources determine changing tax revenues. Due to decreasing returns to capital and natural resources, revenues from taxes on capital income and mineral resource extraction taxes decrease by about 3.7% each. In contrast, revenues from land taxes increase by 1.1% because of increasing supply of land (Table 5.1).

Revenues from value added taxes and excise taxes are a significant part of the Russian government budget. As discussed in section 4.1, we can not draw any explicit conclusion with respect to changes of revenues from value added taxes; however, we can form plausible expectations based on changes of final consumption. Table 5.2 reveals changes of household demand resulting from the environmental tax reform.

Table 5.2 Changes of final consumption (%).

	Changes of values in %	Changes of volumes in %
Agriculture	0.56	1.18
Coal	-14.16	-5.03
Crude oil	-1.59	2.18
Natural gas	-4.17	-0.47
Minerals	-1.27	2.03
Food products	0.58	1.17
Textiles	1.06	0.96
Wood products	3.61	-0.13
Paper and publishing	0.21	1.34
Petroleum products	-7.65	-3.59
Chemical products	3.96	-0.27
Mineral products	1.80	0.64
Metals	2.56	0.31
Metal products	1.42	0.80
Transport equipment	0.93	1.02
Electronic equipment	1.49	0.77
Machinery equipment	1.00	0.99
Electricity	9.24	0.05
Gas manufacturing	-4.94	-3.37
Water	0.63	1.15
Construction	0.09	1.39
Trade	-0.63	1.72
Transports	2.44	0.36
Privet services	-0.16	1.51
Public services	-0.35	1.59

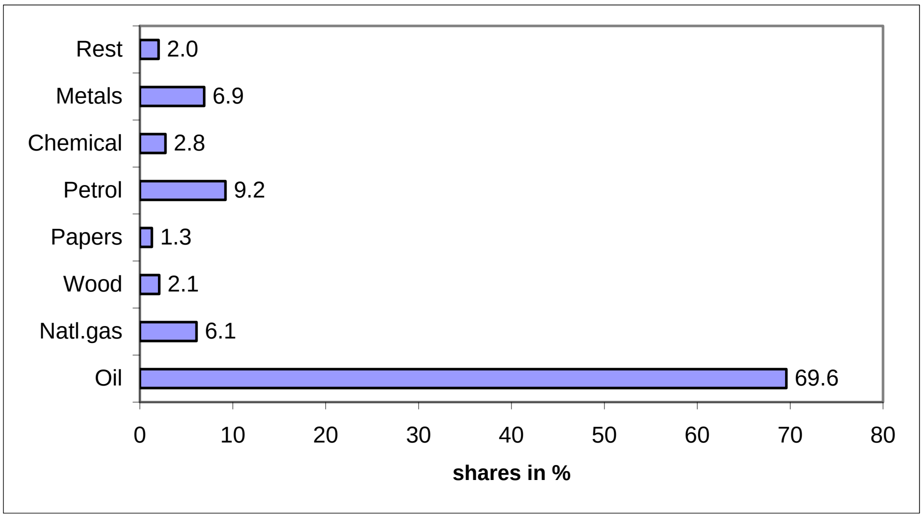
Source: model simulation results

Substitution carbon taxes for labour taxes decreases the final consumption of energy and energy-intensive commodities such as coal by 5%, petroleum products (3.6%), gas manufacture (3.4%), natural gas (0.5%), chemical products (0.3%), and wood products (0.1%). Since the base of value added taxes is the value of commodities, not only changes of final consumption determine changes of revenues from value added taxes, but also the price effect is matter. Table 5.2 reveals that the value of final consumption of coal decreases by 141%, petroleum products (7.7%), gas manufacturing (4.9%), natural gas (4.1%), crude oil (1.6%), minerals (1.3%), trade (0.6%), and public and private services (0.3% and 0.2%). In contrast, the value of final consumption of other commodities increases: for example, the value of electricity increases by 9.2%, chemical products (3.9%), and wood products (3.6%). The total value of final consumption increases by 1.6%. Therefore, it is expected that revenues from value added taxes should increase because of increasing value of final consumption. Excise taxes are imposed on commodities such as alcohol, cigarettes, cars, and petroleum products. Introducing carbon taxes leads to increases in values of final consumption of transport equipment by 0.9% and for food products[16] it increases by 0.6%. Therefore, we expect that revenues from excise taxes on alcohol, cigarettes, and transport equipment should also increase. On the other hand, revenues from excise taxes on petroleum products decrease, since the values of final consumption of petroleum products decreases by 7.6%.

Furthermore, the environmental tax reform leads to an increase in lump-sum transfers to households by 1.3% because of increasing household income[17]. Expenditures on production subsidies increase by 0.7%. The reason for this is an increase in agricultural production, since only the agricultural sector receives production subsidies.

Trade Taxes. As shown in Fig. 5.2, the majority of revenues from export taxes come from export taxes on crude oil, petroleum products, natural gas, and metals because of high tax rates and high export supply. For example, the largest source of export revenues is export taxes on crude oil, which amount to 69.6% of the total revenues from export taxes, followed by petroleum products (9.2%), metals (6.9%), and natural gas (6.1%).

Fig. 5.2 Shares of several commodities in the total revenues from export taxes (%).



Source: version 7 of the GTAP database

Introducing carbon taxes leads to increasing exports of energy resources such as crude oil, petroleum products, and natural gas. For example as shown in Table 5.3, export supply of

[16] The demand category “food products” includes, *inter alia*, alcohol and cigarettes.
[17] Household income is the base of lump-sum transfers.

crude oil increases by 5.6%, natural gas (14.3%), and petroleum products (3.5%). As a result, revenues from export taxes on energy resources increase because of the expanding tax bases. Moreover, the environmental tax reform leads to a depreciation of the currency by 0.5%, which implies increasing export prices. Thus, both increasing export supply and a depreciation of the currency leads to increasing revenues from export taxes.

Table 5.3 Changes of export tax revenues and export supply (million USD and %).

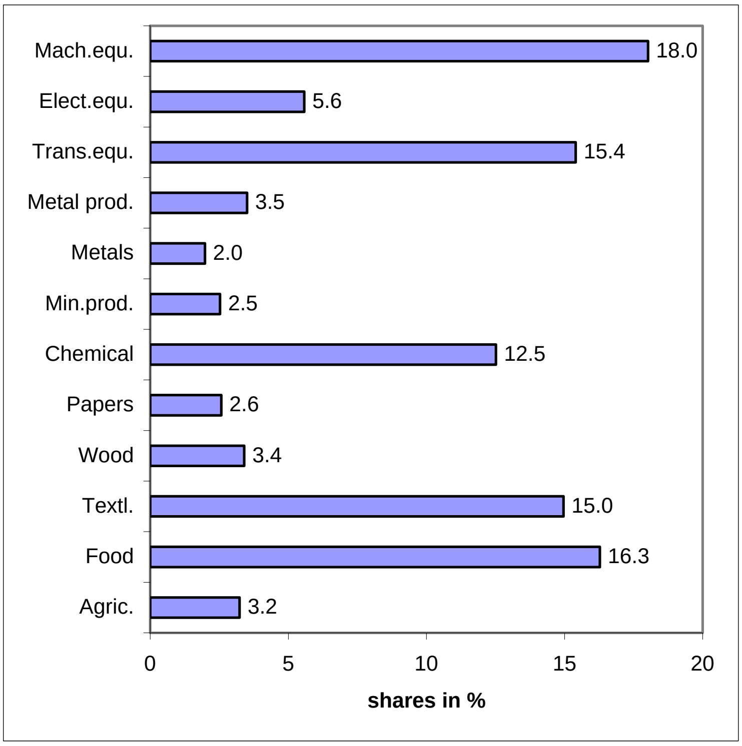
	Absolute changes of export tax revenues in million USD	Relative changes of export tax revenues in %	Changes of export supply in %
Agriculture	0.06	3.72	3.13
Coal	-1.19	-4.36	-4.90
Oil	1103.59	6.20	5.60
Natural gas	155.19	9.95	14.32
Minerals	6.52	3.94	3.35
Textile product	5.22	4.69	4.10
Wood products	-99.75	-18.65	-19.11
Paper and publishing	20.61	6.21	5.61
Petroleum products	95.30	4.05	3.46
Chemical products	-110.17	-15.67	-16.14
Mineral products	-1.11	-2.61	-3.16
Metals	-141.58	-7.99	-8.52
Metal products	-0.16	-0.70	-1.26
Transport equipment	3.79	6.23	5.63
Electronic equipment	-0.06	-1.04	-1.60
Machinery equipment	1.04	1.40	0.83

Source: model simulation results

On the other hand, revenues from export taxes on metals, metal products, chemical products, wood products, mineral products, coal, and electronic equipment decrease because of decreasing export supply of these commodities. For example, export supply of metals decreases by 8.5%, chemical products (16.1%), and wood products (19.1%). Because of a deprecation of the currency, decreases in revenues from decreasing export supply are diminished. Increases in revenues from export taxes on energy resources dominate decreases in revenues from export taxes on other commodities. As a result, the total revenues from export taxes increase by 4.1% (Table 5.1).

As shown in Fig. 5.3, the majority of revenues from imports tariffs come from import tariffs on machinery equipment, food products, transport equipment, textiles, and chemical products, because of high tariff rates and high import demand for these commodities. For example, imports of machinery equipment is the largest source of revenues from import tariffs with a share of 18% in the total revenue from import tariffs, followed by food products with a share of 16.3%, transport equipment (15.4%), textiles (15%), and chemical products (12.5%).

Fig. 5.3 Shares of several commodities in the total revenues from import tariffs (%).



Source: version 7 of the GTAP database

As shown in Table 5.4, introducing carbon taxes leads to increases in import demand for electricity by 6.6%, wood products by 4.9%, chemical products (3.4%), electronic equipment (0.4%), and metals (0.3%). This leads to increases in revenues from import tariffs on these commodities. Similar to export taxes, increases (decreases) in revenues from imports tariffs are increased (diminished) by a depreciation of the currency by 0.5%. Therefore, revenues from import tariffs on textile and mineral products increase in spite of decreasing import demand. On the other hand, revenues from import tariffs on other commodities decreases because of decreasing import demand. Nevertheless, the bottom line is that the total revenues from import tariffs increase by 0.6% (Table 5.1).

Table 5.4 Changes of import tax revenues and import demand (million USD and %).

	Absolute changes of import tax revenues in million USD	Relative changes of import tax revenues in %	Changes of import demand in %
Agriculture	-0.69	-0.22	-0.78
Coal	-0.22	-26.04	-26.45
Oil	-0.00	-16.86	-17.33
Natural gas	-0.00	-35.48	-35.84
Minerals	-0.76	-5.00	-5.54
Food products	-2.18	-0.14	-0.70
Textile products	5.43	0.38	-0.19
Wood products	18.10	5.51	4.92
Paper and publishing	-4.62	-1.86	-2.41
Petroleum products	-0.52	-14.65	-15.13
Chemical products	48.05	3.98	3.40
Mineral products	1.25	0.51	-0.05
Metals	1.66	0.87	0.30
Metal products	-1.09	-0.32	-0.88
Transport equipment	-0.12	-0.01	-0.57
Electronic equipment	5.25	0.97	0.41
Machinery equipment	-15.42	-0.89	-1.45
Electricity	0.78	7.18	6.57

Source: model simulation results

6 Conclusions

Russia is not only a large source of carbon emissions, but is also one the most intensive users of energy. Introducing carbon taxes would, potentially, address concerns on several fronts simultaneously. In the short to medium term, they would reduce the emission of CO2 and other emissions which are stemming from the use of energy commodities. In the longer term, the increased costs of primary energy products should both accelerate the rate of technological replacement and induce technological progress (Ruttan, 1997; Newell et al., 1999; Popp, 2002). In this paper, we analyze the incidence of carbon taxes as well as interactions of carbon taxes with other taxes which are applied in Russia. Based on analytical and numerical results, we can draw the following conclusions:

(1) Substituting carbon taxes for taxes on labour earnings in Russia leads an increase in supply of unskilled and skilled labour by 2.4% and 2.3%, respectively, i.e. the so-called employment dividend (Bovenberg and Ploeg, 1998);

(2) Under the assumption of international capital immobility, the burden of carbon taxes is partially borne by capital in terms of decreasing capital income. In other words, increasing energy costs do not fully pass on to final consumers. This indicates the so-called tax-shifting effect (de Mooij and Bovenberg, 1998);

(3) Moreover, natural resources such as coal and natural gas also share the burden of carbon taxation in terms of decreasing income from natural resources, which also indicates the tax-shifting effect. This confirms to the conclusion made by Bento and Jacobsen (2007) and Bovenberg and Ploeg (1998);

(4) The environmental tax reform leads to an increase in revenues from taxes on land income because of expanding land supply by 1.2%;

(5) Revenues from export taxes increase by 1037.3 million USD or 4.1% because of increases in export supply of natural gas, crude oil, petroleum products, minerals, textiles, paper products, and transport and machinery equipment as well as a depreciation of the currency;

(6) Revenues from import tariffs increase by 54.9 million USD or 0.6% because of increases in revenues from import tariffs on wood products, textiles, chemical products, metals, mineral products, metals, electronic equipment, and electricity because of increasing import demand and currency depreciation;

(7) In addition, revenues from value added taxes as well as excise taxes on alcohol, cigarettes, and transport equipment are expected to increase because of an increasing value of final consumption;

However,

(8) Introducing carbon taxes leads to declining revenues from taxes on unskilled and skilled labour by 10208 and 4798 million USD or about 34% each because of a reduction of tax rates on labour income;

(9) Social security contributions from unskilled and skilled labour decline by 154 and 95 million USD or 1.0% and 1.4%, respectively, because of decreasing gross wages, even though the employment increases;

(10) The environmental tax reform induces a reduction of revenues from taxes on capital income by 707 million USD or 3.7% because of a decreasing return to capital. Taxes on capital income include corporate income taxes, taxes on interest from bank deposits and dividends;

(11) Revenues from taxes on mineral resource extraction decrease by 87 million USD or 3.7% because of a decreasing return to natural resources;

(12) Revenues from excise taxes on petroleum products decrease because of a decreasing value of final consumption of petroleum products;

First of all, the model simulation results should be taken with caution since they are quite sensitive to different parameters and assumptions. We find that substitution of carbon taxes for labour taxes leads to welfare gains, yet this strongly depends on the labour supply elasticity and elasticities of substitution between capital, energy and labour (Capros et al., 1996; Sancho, 2010). This paper is aimed to show the relevance of interactions of carbon taxes with other taxes. The main consideration behind this analysis is that increases (decreases) in revenues from other taxes decrease (increase) the cost of environmental tax reform. The analysis has some limitations. Other important issues that are behind the scope of this analysis are carbon leakage effects and income inequality. Environmental tax reform can induce large carbon leakages in countries that import Russian energy resources. Income inequality is of high relevance in Russia. Carbon taxes are typically regressive; however, substituting carbon taxes for labour taxes can redistribute income in favour of low and middle income households, since the burden of taxation shifts from labour towards capital and natural resources.

References

Bento, A., Jacobsen, M., 2007. Ricardian Rents, Environmental Policy and the 'Double-Dividend' Hypothesis. Journal of Environmental Economics and Management, 53 (2007), 17-31.

Böhringer, C., Löschel, A., Welsch, H., 2008. Environmental Taxation and Induced Structural Change in an Open Economy: The Role of Market Structure. German Economic Review, 9(1), 17-40.

Bovenberg, L., Goulder L., 1996. Optimal Environmental Taxation in the Presence of Other Taxes: General-Equilibrium Analyses. The American Economic Review, 86(4), 985-1000.

Bovenberg, A., and de Mooij, R., 1994. Environmental Levies and Distortionary Taxation. The American Economic Review, vol. 84. No. 4, 1085-1089.

Bovenberg, A., Ploeg., F., 1998. Environmental Policy, Public Finance and the Labour Market in a Second-Best World. Journal of Public Economics, 55 (1994), 349-390.

Burniaux, J-M., Truong, T., 2002. GTAP-E: An Energy-Environmental Version of the GTAP Model. GTAP Technical Paper No.16.

Burniaux, J-M., Martin, J.P., Nicolette, G., Martins, J.O., 1992. GREEN: A Multi-Sector, Multi-Region General Equilibrium Model for Quantifying the Costs of Curbing CO2 Emissions: A Technical Manual, OECD Department of Economics Working Papers No. 116. Paris: OECD

Capros, P., Georgakopulos, P., Zografakis, S., Proost, S., van Regemorter, D., Conrad, K., Schmidt, T., Smeers, Y., Michiels, E., 1996. Double Dividend Analysis: First Results of a General Equilibrium Model (GEM-E3) Linking the EU-12 Countries. Environmental Fiscal Reform and Unemployment. Kluwe Academic, 1996. pp. 193-227.

de Mooij, R., 1996. Environmental Taxation and the Double Dividend. Kluwe Academic, 1996. pp. 121-152.

de Mooij, R., Bovenberg, A., 1998. Environmental Taxes, International Capital Mobility and Inefficient Tax Systems: Tax Burden vs. Tax Shifting. International Tax and Public Finance, 5(1), 7-39.

EFA (Energy Forecasting Agency) 2009. Report: Operation and development of the Russian electric power industry. Available at: http://www.e-apbe.ru/analytical/

Evers, M., de Mooij, R., van Vuuren, D., 2008. The Wage Elasticity of Labour Supply: A Synthesis of Empirical Estimates. De Economist, 56, 25-43.

Fraser, I., Waschik, R. 2010. The Double Dividend Hypothesis in a CGE Model: Specific Factors and Variable Labour Supply. Working Paper No.2.

FSSS (Federal State Statistics Services) 2010. Financial Statistics 2004-2010. Available at: http://www.gks.ru/wps/wcm/connect/rosstat/rosstatsite/main/finance/

Goulder, L., 1994. Environmental Taxation and the "Double-Dividend": A Reader's Guide. International Tax and Public Finance, 2(2), 157-183.

Goulder, L., Parry, I., Burtraw, D., 1997. Revenue-Raising versus Other Approaches to Environmental Protection: The Critical Significance of Preexisting Tax Distortions. The RAND Journal of Economics, vol. 28 No. 4. pp. 708-731.

Goulder, L., 2002. Environmental Policy Making in Economies with Prior Tax Distortion. Cheltenham; Northampton, Mass.: Elgar: 2002: XXIII.

GTAP, 2007. Version 7 of the GTAP database.

Kilkenny, M., 1991. Computable General Equilibrium Modelling of Agricultural Policies: Documentation of the 30-Sector FPGE GAMS Model of the United States, USDA ERS Staff Report AGES 9125.

Killinger, S., 1995. Indirect Internalization of International Environmental Externalities. Discussion paper Nr.264. University of Konstanz.

Lee, H-L., 2008. An Emissions Data Base fro Integrated Assessment of Climate Change Policy Using GTAP. https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=1143

Malcolm, G., 1998. Adjusting Tax Rates in the GTAP Data Base. GTAP Technical Paper No. 12.

McDonald, S., Thierfelder, K., 2004. Deriving a Global Social Accounting Matrix from GTAP Versions 5 and 6 Data. GTAP Technical Paper No. 22.

McDonald, S., 2007. A Static Applied General Equilibrium Model: Technical Documentation. STAGE Version 1: July 2007. Course documentation.

Newell, R., Jaffe, A., Stavins, R., 1999. The Induced Innovation Hypothesis and Energy-Saving Technological Change. Working Paper No. 6437.

Orlov, A., Grethe, H., McDonald, S. 2011. Energy Policy and Carbon Emission in Russia: A Short Run CGE Analysis. GTAP Conference Paper 2011.

Parry, I., 1995. Pollution Taxes and Revenue Recycling. Journal of Environmental Economics and Management 29, 64-77.

Parry, I., Williams, R., Goulder, L., 1999. When Can Carbon Abatement Policies Increase Welfare? The Fundamental Role of Distorted Factor Markets. Journal of Environmental Economics and Management, 37, 52-84.

Parry, I., 2001. The Costs of Restrictive Trade Policies in the Presence of Factor Tax Distortions. International Tax and Public Finance, 8, 147-170.

Parry, I., Bento, A., 2000. Tax Deductions, Environmental Policy, and the Double Dividend Hypothesis. Journal of Environmental Economics and Management, 39(1), 67-96.

Parry, I., Bento, A., 2001. Revenue Recycling and the Welfare Effects of Road Pricing. Scandinavian Journal of Economics, 103(4), 645-671.

Popp, D., 2002. Induced Innovation and Energy Prices. The American Economic Review, 92(1), 160-180.

Robinson, S., Kilkenny, M., Hanson, K., 1990. USDA/ERS Computable General Equilibrium Model of the United States, Economic Research Service, USDA, Staff Report AGES 9049.

Ruttan, V., 1997. Induced Innovation, Evolutionary Theory and Path Dependence: Sources of Technical Change. Economic Journal, 107(1997), 1520-1529.

Sancho, F., 2010. Double Dividend Effectiveness of Energy Tax Policies and the Elasticity of Substitution: A CGE Appraisal. Energy Policy, 38(6), 2927-2933.

Varian, H.R., 1999. Grundzüge der Mikroökonomik. 4. Auflage. Oldenbourg, 1999.

Williams III, R., 2002. Environmental Tax Interactions When Pollution Affects Health or Productivity. Journal of Environmental Economics and Management, 44, 261-270.

Williams III, R., 2003. Health Effects and Optimal Environmental Taxes. Journal of Public Economics, 87, 323-335.

Appendices

Appendix A: Derivation of Equation (3.21)

The tax-interaction effect (∂W^I) is defined as following:

$$\partial W^I = (1+M)\tau_L \frac{\partial H}{\partial \tau_{C2}}, \tag{a1}$$

where $M = \dfrac{\tau_L \frac{\partial H}{\partial \tau_L}}{T - H - \tau_L \frac{\partial H}{\partial \tau_L}}$. (a2)

Substituting (a2) into (a1), we obtain:

$$\partial W^I = \left(\frac{T-H}{T-H-\tau_L \frac{\partial H}{\partial \tau_L}} \right) \tau_L \frac{\partial H}{\partial \tau_{C2}}. \tag{a3}$$

Multiplying by $\dfrac{\frac{\partial H}{\partial \tau_L}}{\frac{\partial H}{\partial \tau_L}}$ yields:

$$\partial W^I = \frac{M(T-H)\frac{\partial H}{\partial \tau_{C2}}}{\frac{\partial H}{\partial \tau_L}}, \tag{a4}$$

Making use of the Slutsky equation: $\frac{\partial H}{\partial \tau_{C2}} = \frac{\partial H^C}{\partial \tau_{C2}} - C_2 \frac{\partial H}{\partial I}$ and the Slutsky symmetry property: $\frac{\partial H^C}{\partial \tau_{C2}} = -\frac{\partial C_2{}^C}{\partial \tau_L}$, the term $\frac{\partial H}{\partial \tau_{C2}}$ in the numerator of (a4) can be defined as following:

$$\frac{\partial H}{\partial \tau_{C2}} = -\frac{\partial C_2{}^C}{\partial \tau_L} - C_2 \frac{\partial H}{\partial I}, \tag{a5}$$

where c states for compensated and I is the disposable household income.

Making use of the Slutsky equation, the term $\frac{\partial H}{\partial \tau_L}$ can be defined as following:

$$\frac{\partial H}{\partial \tau_L} = \frac{\partial H^C}{\partial \tau_L} - (T-H)\frac{\partial H}{\partial I}. \tag{a6}$$

Differentiating time endowment constraint (3.8) with respect to τ_L, we obtain:

$$\frac{\partial H^C}{\partial \tau_L} = -\frac{\partial Q_1{}^C}{\partial \tau_L} - \frac{\partial Q_2{}^C}{\partial \tau_L}. \tag{a7}$$

Substituting (a7) into (a6) gives:

$$\frac{\partial H}{\partial \tau_L} = -\frac{\partial Q_1{}^C}{\partial \tau_L} - \frac{\partial Q_2{}^C}{\partial \tau_L} - (T-H)\frac{\partial H}{\partial I}. \tag{a8}$$

Differentiating (3.2) and (3.3) with respect to τ_L, we obtain:

$$\frac{\partial Q_1{}^C}{\partial \tau_L} = \frac{\partial C_1{}^C}{\partial \tau_L} - \frac{\partial M^C}{\partial \tau_L}, \tag{a9}$$

$$\frac{\partial Q_2{}^C}{\partial \tau_L} = \frac{\partial C_2{}^C}{\partial \tau_L} + \frac{\partial X^C}{\partial \tau_L}. \tag{a10}$$

Substituting (a9) and (a10) into (a8) to obtain:

$$\frac{\partial H}{\partial \tau_L} = -\frac{\partial C_1{}^C}{\partial \tau_L} - \frac{\partial C_2{}^C}{\partial \tau_L} - (T-H)\frac{\partial H}{\partial I}. \tag{a11}$$

Substituting (a5) and (a11) into (a4) gives:

$$\partial W^I = \frac{M(T-H)\left(-\frac{\partial C_2{}^C}{\partial \tau_L} - C_2\frac{\partial H}{\partial I}\right)}{-\frac{\partial C_1{}^C}{\partial \tau_L} - \frac{\partial C_2{}^C}{\partial \tau_L} - (T-H)\frac{\partial H}{\partial I}}. \tag{a12}$$

Equation (a12) can be rewritten as following:

$$\partial W^I = \frac{M(T-H)\left(-\frac{\partial C_2{}^C}{\partial \tau_L}\frac{(1-\tau_L)}{C_2}\frac{C_2}{(1-\tau_L)} - C_2\frac{\partial H}{\partial I}\frac{(1-\tau_L)(T-H)}{(T-H)}\frac{(T-H)}{(1-\tau_L)(T-H)}\right)}{-\frac{\partial C_1{}^C}{\partial \tau_L}\frac{(1-\tau_L)}{C_1}\frac{C_1}{(1-\tau_L)} - \frac{\partial C_2{}^C}{\partial \tau_L}\frac{(1-\tau_L)}{C_2}\frac{C_2}{(1-\tau_L)} - (T-H)\frac{\partial H}{\partial I}\frac{(1-\tau_L)(T-H)}{(T-H)}\frac{(T-H)}{(1-\tau_L)(T-H)}} \tag{a13}$$

Multiplying equation (a13) by $(1-\tau_L)$ gives:

$$\partial W^I = \frac{MC_2(C_1+C_2)(n_{C2H}{}^C + n_{LI})}{n_{C1H}{}^C C_1 + n_{C2H}C_2 + n_{LI}(C_1+C_2)}, \tag{a14}$$

where

$$n_{C2H}{}^{C} = \frac{\partial C_2{}^{C}}{\partial \tau_L}\frac{(1-\tau_L)}{C_2};\; n_{C1H}{}^{C} = \frac{\partial C_1{}^{C}}{\partial \tau_L}\frac{(1-\tau_L)}{C_1};\; n_{LI} = \frac{\partial H}{\partial I}\frac{(1-\tau_L)(T-H)}{(T-H)}. \quad \text{(a15)}$$

Dividing by $(C_1 + C_2)$ to obtain:

$$\partial W^{I} = \frac{MC_2(n_{C2H}{}^{C} + n_{LI})}{n_{C1H}{}^{C}\dfrac{C_1}{C_1+C_2} + n_{C2H}\dfrac{C_2}{C_1+C_2} + n_{LI}}, \quad \text{(a16)}$$

or

$$\partial W^{I} = \phi_C MC_2, \quad \text{(a17)}$$

where

$$\phi_C = \frac{(n_{C2H}{}^{C} + n_{LI})}{n_{C1H}{}^{C}\dfrac{C_1}{C_1+C_2} + n_{C2H}{}^{C}\dfrac{C_2}{C_1+C_2} + n_{LI}}. \quad \text{(a18)}$$

Appendix B: Numerical Model

The standard “STAGE” model is extended by:

(1) Incorporating factor-fuel as well as inter-fuel substitution[18] for non-energy producing sectors;

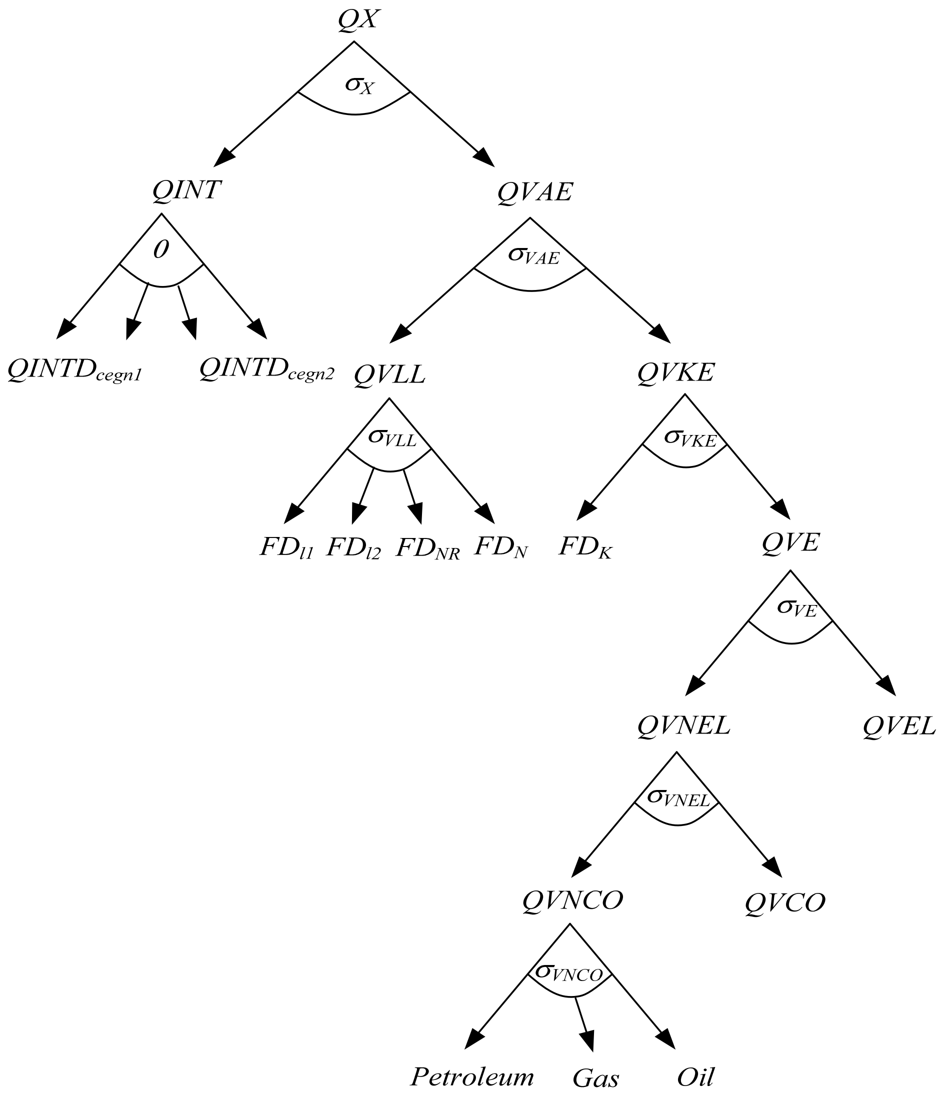
(2) Incorporating a nested linear expenditure system for households, this distinguishes between energy and non-energy composites;

(3) Disaggregating the electricity sector into four technologies: coal-fired, gas-fired, nuclear, and hydro, using a technology bundle approach.

The main modifications[19] relate to the production structure of the model follow a precedent set by the GREEN model (Burniaux et al., 1992), and followed by other models, e.g., GTAP-E (Burniaux and Truong, 2002), whereby energy inputs are nested with primary inputs to form an energy-capital aggregate (*QVKE*). The production structure for non energy producing sectors is illustrated in Fig. B1. Aggregate energy (*QVE*) is formed from electricity (*QVEL*) and non electricity (*QVNEL*) with the latter being a two level aggregate from coal (*QVCO*) and non-coal (*QVNCO*) where non coal energy sources are gas and oil based. Energy producing sectors do not incorporate inter-fuel and factor-fuel substitutions. Elasticities of substitution used are reported in Table B1.

[18] A factor-fuel substitution is a substitution between energy inputs and primary factors. An inter-fuel substitution is a substitution among energy inputs (Burniaux and Truong, 2002).
[19] Only informal descriptions of the model modification are provided here; for a formal description of the model see Orlov (2011)

Fig. B1 Production structure for non-energy producing sectors.



Source: own compilation

A slightly different production structure was used for gas and coal fired electricity generation sectors. For these sectors the aggregate energy input (*QVE*) was derived as a single level aggregate across the primary energy sources, while the preceding levels were left unchanged from those reported in Figure A1; the elasticities are reported in Table B1. For the nuclear and hydro electricity generating sectors there are no recorded inputs of primary energy sources but electricity is used so the production structure effectively collapses so that the capital-energy aggregate is an aggregate of capital and electricity.

Table B1 Elasticities of Substitution.

	Non energy	**Energy**	**Alternate Non energy**
σ_X	0.5	0.5	0.5
σ_{VAE}	GTAP	GTAP	GTAP
σ_{VLL}	GTAP	GTAP	GTAP
σ_{VKE}	0.0	0.0	0.0 or 0.5
σ_{VE}	1.0	0.0	0.0 or 0.5
σ_{VNEL}	0.5	na	na
σ_{VNCO}	1.0	na	na

In addition the final demand system was modified by creating a two level demand system. At the top level the household consumes two ‘commodities’ – energy and non energy – that assumed to be aggregated with CES preferences (elasticity of substitution of 0.5). The energy composite is also a CES aggregate (elasticity if substitution of 1.5) across all energy products consumed by the household, while the non energy composite is a Cobb-Douglas aggregate across all other commodities consumed by the household.

Appendix C: Elasticities in the Model

Table C1 Armington elasticities, CET elasticities, and elasticities of substitution among primary factors.

	Armington elasticities	CET elasticities	Elasticities of substitution among primary factors
Agriculture	1.45	1.50	0.22
Coal	1.52	0.50	0.20
Crude oil	2.60	3.00	0.20
Natural gas	8.60	3.00	0.20
Minerals	0.45	1.50	0.20
Food products	1.47	0.75	1.12
Textile products	1.91	1.50	1.26
Wood products	1.70	3.00	1.26
Paper products	1.47	1.50	1.26
Petroleum products	1.05	3.00	1.26
Chemical products	1.65	1.50	1.26
Mineral products	1.45	3.00	1.26
Metals	1.78	3.00	1.26
Metal products	1.87	3.00	1.26
Transport equipment	1.77	3.00	1.26
Electronic equipment	2.20	0.50	1.26
Machinery equipment	1.95	0.50	1.26
Electricity	1.40	0.50	1.26
Gas manufacture	1.40	0.50	1.26
Water	1.40	0.50	1.26
Construction	0.95	3.00	1.26
Trade	0.95	3.00	1.40
Transports	0.95	3.00	1.68
Private services	0.95	0.75	1.26
Government services	0.95	1.50	1.26

Source: Armington elasticities and elasticities of substitution among primary factors are from version 7 of the GTAP database; CET elasticities are assumed