# THE INFLUENCE OF ECOLOGICAL TAXES ON THE EXPOSURE OF WASTE AND $CO_2$ EMISSIONS IN A SELECTED GROUP OF EU COUNTRIES

**France KRIŽANIČ, Žan OPLOTNIK, Jože MENCINGER and Boštjan BREZOVNIK**[1]

*In the continental European countries (EU Member States) an increase of the environmental taxes by 1% after one year leads to a 0.13% reduction in the amount of deposited waste per capita. Across the entire business sector and the construction industry this effect is the greatest for the tax on energy used, as well as for the taxes and charges on pollution and the use of natural resources. An increase for 1% in taxes on transport yields a 0.5% reduction in emissions of $CO_2$, and an increase in energy taxes of 1% after one year yields a 0.13% decline in emissions of $CO_2$. When a technological and economic opportunity adapt to changed environmental tax rates, as is the case for the landfill tax, increased tax rates leads to sharp pollution reduction and thus have a limited fiscal effect.*

**Key words:** Economic Welfare; Taxation; Environmental Management; Tax Law; Public finance.

## 1 INTRODUCTION

Economic growth leads to the increased pollution of nature. This effect comes from the supply side (production of goods, provision of services) as well as from the demand side (household consumption, investments, state spending and exports). The state has the possibility and duty to limit the burden on the environment by direct regulation (prohibitions, etc.), by leading a specific approach to development policy (promoting the introduction of cleaner technologies) and through tax policy. In this article we analyse the effectiveness of its environmental tax measures based on data from continental EU Member States.

The article starts with a short outline of economic theory on pollution and the role of ecological levies, followed by the presentation of the methodology, the data used and the estimated model of the impact of various factors on the

[1] **France KRIŽANIČ**, Ph.D., Asistant Professor, EIPF. **Žan Jan OPLOTNIK**, Ph.D., Professor, University of Maribor, Faculty of Economics and Business. **Jože MENCINGER**, Ph.D., Professor, EIPF. **Boštjan BREZOVNIK**, Ph.D., Associate Professor, University of Maribor, Faculty of Law.

generation of waste and $CO_2$ emissions. Below is the outline on how change in environmental taxation affects deposited waste and $CO_2$ emissions. In the last part of the article an example of the effectiveness of the landfill tax on the disposal of waste at landfills is specifically illustrated. The end of the article presents the conclusions, an indication of the literature used, data sources and the software used.

## 2 POLLUTION, EXTERNAL DISECONOMIES AND ECOLOGICAL TAXES

Economizing is a conscious human activity to reduce the required limited resources for meeting our needs. These resources are called goods. In the process of economizing, the consumers maximize their utility and the producers maximize their profits. One and all act in accordance with the prices of goods as they are established on the market in the relation between supply and demand (Kneese and Clifford 1994). In most cases the production and consumption of goods cause negative externalities or external diseconomies, which are not included in prices as established in the relation between the supply and demand of these goods.[2] This fact represents a market failure. The first economic thinker to theoretically explain it was Arthur Pigou (1920), the successor to Alfred Marshall at Cambridge University. As a solution, he proposed the introduction of an ecological tax. Of course, apart from this economic incentive to limit or even prevent pollution, the state also operates through direct regulation and subsidies. An economic analysis of the effectiveness of various measures to reduce pollution and to eliminate external diseconomies has been in constant development since the 1970s (Kneese and Bower 1979). External diseconomies or different forms of pollution are on one side increasing with the growth of the production and consumption of goods, and on the other side they decrease with state regulation, investments in clean technologies and ecological taxes. Which of the instruments the regulator (the state) elects to use depends on how producers are able to respond to the price signals of environmental taxes. If the cost of reducing pollution is low, environmental taxes are effective; otherwise, direct bans are more effective (Weitzman 1974; Stavins 1996). When the state combines ecological taxes with other measures (licenses) to reduce certain pollution, it must also take into account the interaction effect of limiting the emissions of one pollutant on the emissions of other pollutants, i.e. that the goods associated with this pollution exist in a complementary or substitute relation (Ambec and Coria 2013). In models of endogenous growth (Romer 1986; Romer 1990) environmental policy measures (including ecological taxation) influence the choice of technologies and the structure of the economy (Soretz 2007). Market power or a monopoly of polluting economic subjects increases the importance of tax regulation in relation to prohibitions (Heuson 2010). In North-South international trade, however, synchronized environmental tax policy cannot prevent distortion in the allocation of resources (Daubanes and Grimaud 2010).

Environmental taxes, environmental contributions (charges) and environmental penalties all sit among environmental levies in the Pigou sense. The basis for an environmental tax is a physical unit (or its approximation) of something that has

[2] In the case of negative externalities, it is not necessary that a precisely defined person or group of persons is damaged by pollution of the natural environment; it can also be a deterioration of the state of public goods that people need collectively and for which there is no sense in differentiating individuals from total consumption (Samuelson 1954). Air is a typical example of such a good, yet the entirety of living and non-living nature, in fact, belongs here.

a provable negative effect on the environment. Dedicated use of the resultant revenue collected with them, as with other taxes, is not well established; furthermore, the funds acquired through such taxation are not necessarily fully used to protect the environment. In the case of environmental contributions the opposite holds, where they serve to raise funds for a specific purpose. While they are mandatory, they can be paid into the budget or into a certain fund or organization to cover the costs of specific related services, such as water supply, cleaning or access to a natural resource. However, there is no strict distinction between environmental taxes and contributions; different countries use different definitions in their classifications (Križanič, Mencinger and Kolšek 2016). According to Eurostat's typology, environmental taxes are divided into energy taxes, transport taxes, pollution and resource taxes (Eurostat 2001).

Environmental taxation has two objectives or effects: the first is the protection of the environment or the elimination of that external diseconomy, while the other is the fiscal, i.e. generating revenue for the state treasury. For the environmental impact of a tax or duty, it is important to reduce environmental pollution and to use the funds collected to eliminate the damage; the "moral" effect of benefits is also important in raising awareness of environmental protection (Križanič, Mencinger and Kolšek 2016). Some analyses show that the link between environmental taxes and awareness of the importance of protecting the environment is not linear, as environmental taxes can sometimes reduce the impact of ecological awareness on environmental protection (Lanz, Wurlod, Panzone and Swanson 2018; see also Kuokštis 2017). The fiscal effect of the environmental tax allows the reduction of income tax rates, in particular tax rates on income from work (Ekins and Barker 2001). Such a reorientation of public expenditure financing is called a green reform (Fullerton and Metcalf 1997; Hettich 1998). Fiscal revenue from environmental taxation may allow the financing of transfers to the population to eliminate the negative distribution effects of this tax – connected to the fact that people with lower incomes spend relatively more on polluting goods (Klenert, Schwerhoff, Edenhofer and Mattauch 2016), as well as on financing projects for remediation of environmental damages. Analyses show that the use of these funds to reduce the damage caused by pollution increases the political acceptability of environmental taxation (Carattini, Baranzini, Thalmann, Varone and Vöhringer 2017).

## 3 METHODOLOGY

We designed a model to explain various factors that influence waste generation and $CO_2$ emissions while also assessing the link between the first differences in the amount of waste collected per capita (data vary among seventeen EU Member States) and the first differences of the variables which influence the change in the amount of waste collected (ecological taxes, investments in cleaner technologies, GDP, etc.).[3] We estimated panel equations on annual first differences of different variables across different countries:

[ws_? - ws_?(-1)] = f {[ [tax_? - tax_?(-1)] + [in_? - in_?(-1)] + … + u}

[3] Data are annual, and the first differences are calculated as the difference in the value of the given variable (quantities of collected waste in kilograms per capita, collected ecological taxes in millions of euros, etc.) in a given year and the value of this variable in the previous year. Since we have data for the analyzed countries from 2004 to 2012, we analyze data on the first differentials from 2005 to 2012.

where:

ws_? indicates the amount of collected waste in kilograms per capita in the analysed group of 17 countries; these countries are designated by "?";

ws _? (- 1) indicates the amount of collected waste in kilograms per capita (ws_?) in the previous year;

tax_? indicates the total collected ecological taxes (millions of euros) per country (?) in the analysed group;

tax _? (- 1) indicates tax_? in the previous year;

in_? indicates investments (millions of euros) into cleaner technology related to the generation or treatment of waste by country (?) in the group;

in _? (- 1) indicates in_? in the previous year;

... indicates other variables that have a statistically significant effect on the amount of waste (different types of ecological taxes and eco-investments, economic growth variables and proxy variables for the institutional framework);

u indicates the remaining unexplained factors in the regression analysis.

The equations were estimated on annual data that were tested for Unit Root, and the hypothesis that the series has a single root was rejected. In the regression the specificities of individual countries that could introduce bias in the final result (heteroskedasticity) were eliminated by the introduction of weights.

## 4 DATA

The analysis of the impact of ecological taxation (as reported by Eurostat) and other variables on the amount of collected waste per capita included EU Member States that have provided relevant data to Eurostat. Listed in alphabetical order, these countries are Austria, Belgium, Czech Republic, Finland, France, Germany, Hungary, Italy, Lithuania, the Netherlands, Poland, Portugal, Romania, Slovenia, Slovakia, Spain and Sweden. The analysed group of 17 countries has almost 400 million inhabitants (78% of the EU population before Brexit), and their national economies together generate a gross domestic product of 11 trillion euros (77% of the EU total). The analysis was carried out on Eurostat annual data for the period 2004 to 2012 with data on various ecological taxes (including those on energy consumption and transport), on waste (total and structural parts, depending on the nature of the waste or according to its source), $CO_2$ emissions, investment in cleaner technologies (including individual structural upgrades according to purpose), economic growth (GDP, wages, etc.) and institutional conditions (as an indicator of the state's readiness to intervene also in the environmental field, we assume a share of general government revenues to GDP or a share of the general government deficit to GDP). Data on waste are given in kilograms per capita and the data on $CO_2$ emissions are in thousands of tons. Data on ecological taxation are in millions of euros; these figures represent the tax rate or the rate of excise duties per unit of goods indirectly rather than directly.

Changes in the amount of ecological taxes collected can also be linked to greater or lesser intensity of enforcement, changes in the tax base, inclusion or exclusion of taxpayers, changes in tax incentives, etc. The data used in the analysis are collected exclusively from the Eurostat website.[4] The data on the deposited waste are published every two years. Each intermediate period was calculated as the average of the amount of collected waste of the two adjacent years.

## 5 FACTORS OF CHANGING THE AMOUNT OF WASTE AND $CO_2$ EMISSIONS

The equations that explain the first differences in the quantity of deposited waste per capita and the $CO_2$ emissions in the 2005–2012 period for the analysed group of EU Member States are presented in Tables 1 and 2. Table 1 shows the impact of different factors on deposited waste and $CO_2$ emissions for the group's combined, entire national economies, while Table 2 presents results separately for the group-wide economy and households. The results are presented for collected waste with or without mineral waste and just for mineral waste. The last lines of both tables present the determination coefficient ($R^2$), indicating the portion of explained variance in the amount of collected waste per capita (and $CO_2$ emissions), and the results of the Durbin-Watson statistic (DW), which assesses first-order autoregression in the equations. The explanation for changes in the amount of collected waste per inhabitant (and $CO_2$ emissions) is good: $R^2$ ranges from 36% to 98% and results of the DW statistics are near 2. In the basic equation (third column of Table 1) of our model to explain the change in total collected waste per capita $R^2$ is 95% and the DW statistic is 1.58.

In Table 1 and Table 2 the dependent variables (change in the amount of collected waste per capita and in $CO_2$ emissions) are shown in columns, and the independent variables (change of ecological taxes, etc.) that influence the dependent variables are shown in rows. Here we can see the regression coefficient that shows the influence of each independent variable on a dependent variable. Annual time lag of influence is shown in the brackets next to the regression coefficients. In the brackets under the regression coefficients are the t-values showing the statistical significance of the influence of each explanatory variable (change in ecological taxes, etc.) on the corresponding dependent variable (change in the amount of collected waste or $CO_2$ emissions).

From the equations shown in Tables 1 and 2 it can be understood that the impact of ecological taxes on the disposal of mineral waste is different than the influence of these taxes on the disposal of total waste, while the impact of economic growth and eco-investments is similar in both cases. The impact of energy taxes on waste disposal in the economy occurs faster than the impact of total ecological taxes on the disposal of waste in the economy without the inclusion of mineral waste. In this segment the influence of investments in cleaner waste management technologies is statistically significant.

[4] See Eurostat Data, available at http://ec.europa.eu/eurostat/data/database.

TABLE 1: EQUATION RESULTS EXPLAINING THE CHANGE IN COLLECTED WASTE PER CAPITA AND $CO_2$ EMISSIONS

| | | Total waste | Total waste without mineral waste | Mineral waste | $CO_2$ emissions |
|---|---|---|---|---|---|
| | Constant | 171.5105 (8.0) | -6.5786 (-5.5) | 164.2262 (19.7) | -2873.658 (-2.7) |
| | Ecological taxes total | -0.0509 (-1) (-3.4) | -0.0055(-1) (-5.6) | | |
| Taxes and levies | Taxes on energy | | | | -1.6648(-1) (-1.7) |
| | Taxes on transport | | | | -28.549 (-7.1) |
| | Taxes on pollution and on natural resources | | | -0.6234(-1) (-2.7) | |
| Investments in cleaner technology | for cleaner air | | | | -34.193(-1) (-4.7) |
| | for waste treatment | -3.9679 (-3.1) | -0.9687 (-5.9) | -1.3173 (-1.6) | |
| Economic growth | GDP | 0.0005(-1) (1.7) | 0.0001 (3.5) | 0.0006(-1) (1.9) | 0.2872 (5.3) |
| Institutional conditions | share of general government revenue in GDP | -33.3827 (-3.3) | | | |
| Explanation | $R^2$ | 0.95 | 0.92 | 0.98 | 0.87 |
| | DW | 1.58 | 1.51 | 1.42 | 2.63 |

Source: Own calculations based on data published by Eurostat.

Household waste is influenced by total ecological taxes (there is no data indicating the direct tax burden of households for the disposal of waste in this segment). Higher taxes reduce the amount of landfilled household waste (negative sign in the equation). The impact of economic growth on the disposal of household waste is found to be statistically significant through a change in the cumulative wage bill (with a positive sign) and by changes in the unemployment rate (with the corresponding opposite sign). A higher wage bill (sum of all salaries in the economy) and lower unemployment indicate a situation in which households increase their quantities of waste, and vice versa.

TABLE 2: EQUATION RESULTS EXPLAINING THE CHANGES IN THE COLLECTED WASTE PER CAPITA

| | | Waste in the economy | Waste in the economy other than minerals | Construction waste | Household waste |
|---|---|---|---|---|---|
| | Constant | 0.8622 (0.0) | 11.9271 (2.3) | 1.3099 (0.4) | -2.1406 (-2.1) |
| | Ecological taxes total | | -0.0044(-1) (-2.1) | | -0.0018 (-2.2) |
| Taxes and levies | Taxes on energy | -0.032 (-1.6) | | -0.0101 (-1.4) | |
| | Taxes on pollution and on natural resources | -0.3234(-1) (-1.2) | | -0.1822 (-1.9) | |
| Investments in cleaner technology | for waste treatment | | -0.9010 (-4.0) | | |
| Economic growth | GDP | 0.0011(-1) (2.0) | | 0.0006 (4.0) | |
| | Salaries (sum at national level) | | | | 0.0003(-1) (4.6) |
| | unemployment rate | | -14.6114 (-2.9) | | -2.7833 (-4.6) |
| Institutional conditions | general government deficit to GDP | -17.7352(-1) (2.0) | | | |
| Explanation | $R^2$ | 0.36 | 0.78 | 0.49 | 0.58 |
| | DW | 1.61 | 1.53 | 1.36 | 1.56 |

Source: Own calculations based on data published by Eurostat.

## 6 THE IMPACT OF ENVIRONMENTAL TAXES ON THE AMOUNT OF WASTE

Based on the results shown in Tables 1 and 2, we have simulated the impact of changing ecological taxation on the amount of deposited waste. The results are presented in Table 3. Here we can see that a 1% increase in total environmental taxes after one year yields a 0.13% reduction in the amount of waste per inhabitant. In the economy and construction industry waste reduction is mainly influenced by taxes on the energy used but also by taxes on pollution and on the use of natural resources. The impact arrives within the same year. The same is true for households, but the lack of direct taxation data limits this research in terms of taking into account total ecological taxation.

TABLE 3: IMPACT OF VARIOUS ECOLOGICAL TAXES ON WASTE DISPOSAL

| Dependent variable | Independent variable (increase of 1%) | % variation of dependent variable first year after change | % variation of dependent variable second year after change |
|---|---|---|---|
| Waste per capita total | Ecological taxes total | 0 | -0.13 |
| Waste in the economy per capita | Taxes on energy | -0.07 | -0.07 |
| | Taxes on pollution and on natural resources | 0 | -0.03 |
| Waste in construction per capita | Taxes on energy | -0.08 | -0.08 |
| | Taxes on pollution and on natural resources | -0.06 | -0.07 |
| Household waste per capita | Ecological taxes together | -0.06 | -0.06 |

Source: Own calculations based on data published by Eurostat.

TABLE 4: HOW TAXES ON ENERGY AND ON TRANSPORT INFLUENCE $CO_2$ EMISSIONS

| Dependent variable | Independent variable (increase of 1%) | % variation of dependent variable first year after change | % variation of dependent variable second year after change |
|---|---|---|---|
| $CO_2$ emissions | Taxes on energy | 0 | -0.13 |
| | Taxes on transport | -0.53 | -0.54 |

Source: Own calculations based on data published by Eurostat.

In Table 4, we see that an increase in transport taxes of 1% yields a 0.5% reduction in $CO_2$ emissions, while an increase in taxes on energy of 1% after one year yields a 0.13% reduction in $CO_2$ emissions. The result is not linear and thus cannot be extended to any greater scale or percentages. Nonetheless, it is clear that ecological transport taxes are more efficient in reducing $CO_2$ emissions than energy taxes.

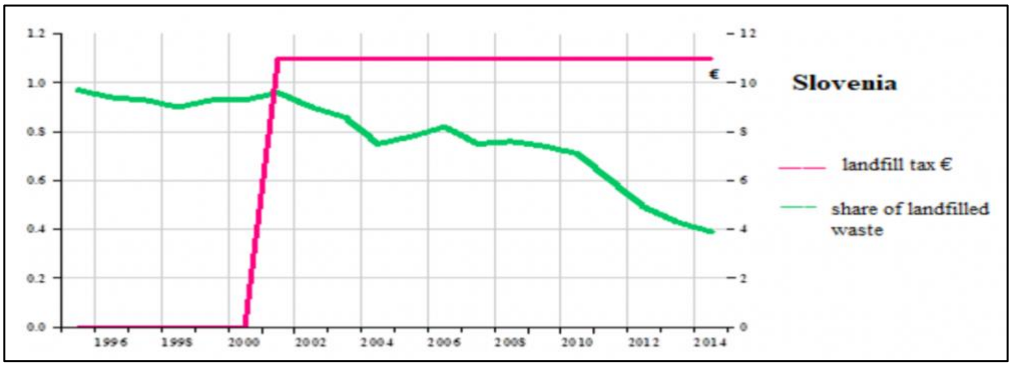
## 7 AN EXAMPLE OF THE EFFECTIVENESS OF LANDFILL TAXATION

In certain cases, there are technological and economic opportunities for producers and consumers to rapidly and thoroughly adapt behaviour through environmental taxes. Such a situation is evident in the tax on the disposal of waste at landfills (landfill tax).[5] Economic subjects can reduce this tax burden by shifting waste into recycling, composting or incineration. The effectiveness of the landfill tax in four EU Member States (Slovenia, Austria, the Netherlands and

[5] The results of the analysis of the efficiency of carbon tax in reducing energy intensity and electricity consumption in the UK showed similar effectiveness (Martin, Preux and Wagner 2014).

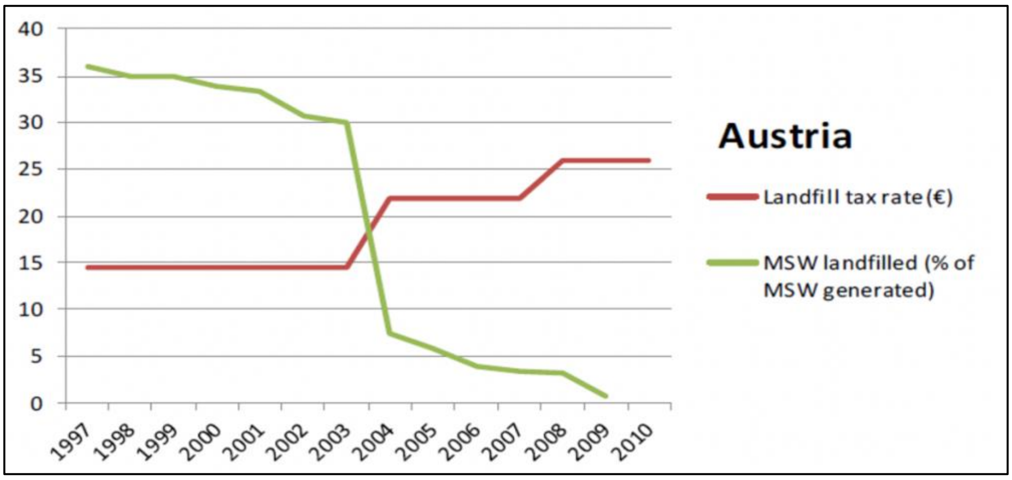
Sweden) is shown in Figures 1 to 4 (European Commission (DG ENV) 2012; Ministry of Finance 2015; Government of the Republic of Slovenia 2015).

FIGURE 1: LANDFILL TAX AND SHARE OF LANDFILLED WASTE IN SLOVENIA



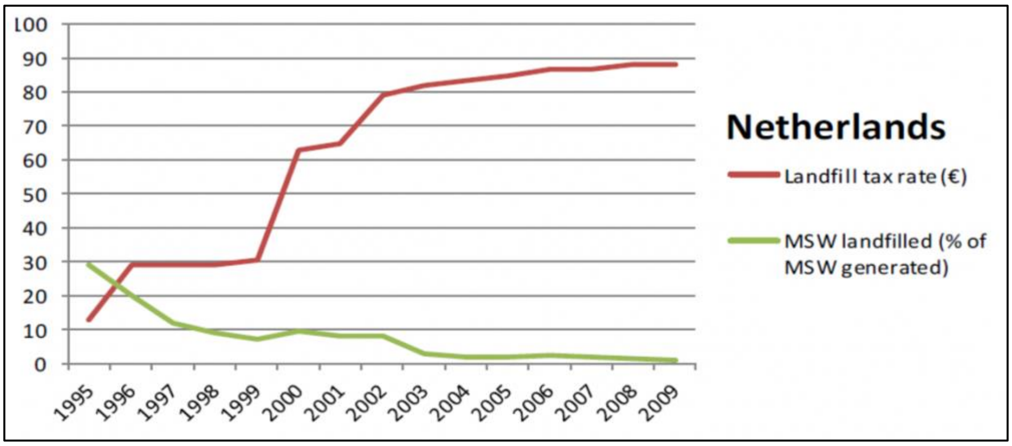

Source: Ministry of Finance (2015) and Government of Republic of Slovenia (2015).

FIGURE 2: LANDFILL TAX AND SHARE OF LANDFILLED WASTE IN AUSTRIA



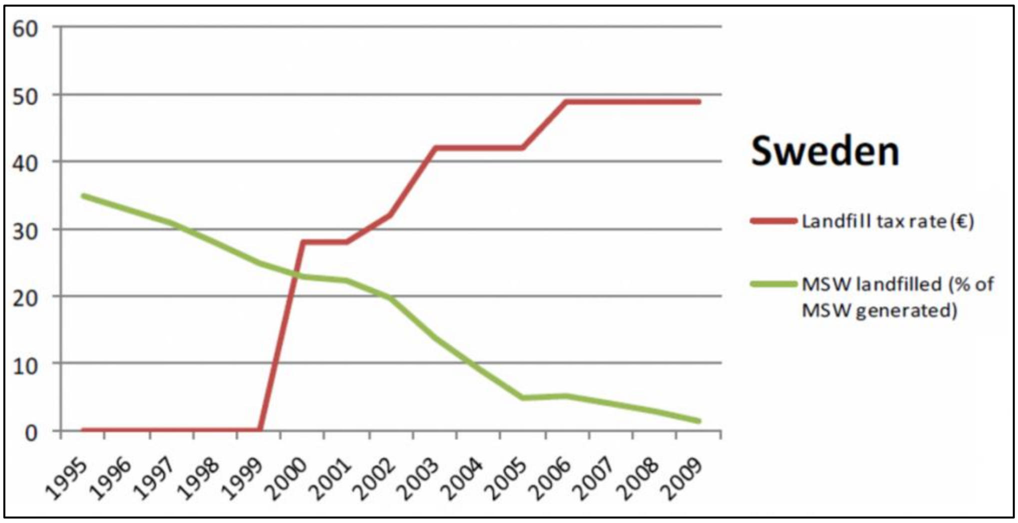

Source: European Commission (DG ENV), Bio Intelligence Service (2012, 60).

FIGURE 3: LANDFILL TAX AND SHARE OF LANDFILLED WASTE IN THE NETHERLANDS




Source: European Commission (DG ENV), Bio Intelligence Service (2012, 61).

FIGURE 4: LANDFILL TAX AND SHARE OF LANDFILLED WASTE IN SWEDEN




Source: European Commission (DG ENV), Bio Intelligence Service (2012, 62).

With this visual approach we are limited to an illustration, since the effect of tax rates cannot be separated from other influences (especially increased regulation). In any case, the increased tax rate is accompanied by a reduction in the proportion of deposited waste in the generated waste to the extent that the fiscal impact of the tax is significantly reduced. In this case the scope for the implementation of the "green reform" (increase in fiscal revenues from ecological taxes and the easing of labour taxation) is significantly limited.

## 8 CONCLUSIONS

The production and consumption of various goods often have external negative effects (negative externalities or external diseconomies) that are not included in prices set in the supply and demand relations. This is a market failure which requires a certain correction. One of the possibilities for such correction is the introduction of an ecological tax.

Environmental taxes serve to eliminate or reduce pollution of the natural environment on the one hand and to generate revenue for the state treasury on the other. It is important for the environmental impact of the tax or levy that it reduces environmental pollution and that the funds collected represent sources for the elimination of the damage incurred, while the fiscal effect of the environmental tax allows a reduction of tax rates in other areas such as workers' income (green reform).

In our analysis we measured ecological taxes in millions of euros, and not in tax rates. In this context, the change in the amount of collected ecological taxes may be connected to a change in the tax rate or to a greater or lesser intensity of tax enforcement, to changing the tax base, including or excluding taxpayers, changing tax incentives, etc.

In the analysis, we divided the impact on the amount of collected waste and $CO_2$ emissions among ecological taxation, investments in cleaner technologies, economic growth and an institutional framework in 17 EU Member States.

The simulation of the impact of changing ecological taxes on changing the amount of collected waste per capita shows that a 1% increase in total environmental taxes after one year yields a 0.13% reduction in the amount of waste per inhabitant. Ecological taxes obviously have an influence on the reduction of pollution, but the existing impact is not great.

In reducing $CO_2$ emissions the impact of ecological taxes on energy is similar (-0.13%). However, the impact of ecological taxes on transport is considerably higher (-0.5%).

When there are technological and economic opportunities for producers and consumers to adapt quickly and thoroughly to environmental taxes, pollution is reduced to the extent that the tax is effective from the point of environmental protection (the external diseconomy is eliminated), but the fiscal effects are no longer large enough to allow green tax reform. An example of this kind is the landfill tax.

## REFERENCES


Ambec, Stefan and Jessica Coria. 2013. “Prices vs quantities with multiple pollutants.” *Journal of Environmental Economics and Management* 66 (1): 123–140.

Carattini, Stefano, Baranzini, Andrea, Thalmann, Philippe, Varone, Frederic and Frank Vöhringer. 2017. “Green taxes in a post-Paris world: are millions of nays inevitable?” *Environmental and Resource Economics* 68 (1): 97–128.

Daubanes, Julien and Andre Grimaud. 2010. “Taxation of a polluting non-renewable resource in the heterogeneous world.” *Environmental and Resource Economics* 47 (4): 567–588.

Ekins, Paul and Terry Barker. 2001. “Carbon taxes and carbon emissions trading.” *Journal of Economic Surveys* 15 (3): 325–376.

European Commission (DG ENV), Bio Intelligence Service. 2012. *Use of Economic Instruments and Waste Management Performances*, Final Report, 10 April 2012.

Eurostat. 2001. *Eurostat Data.* Available at http://ec.europa.eu/eurostat/data/database.

Fullerton, Don and Gilbert E. Metcalf. 1997. *Environmental Taxes and the Double-Dividend Hypothesis: Did You Really Expect Something for Nothing?* Cambridge: National Bureau of Economic Research.

Government of Republic of Slovenia. 2015 Osnutek programa ravnanja z odpadki in program preprečevanja odpadkov Republike Slovenije. Ljubljana: Government of Republic of Slovenia.

Hettich, Frank. 1998. “Growth effects of a revenue-neutral environmental tax reform.” *Journal of Economics* 67 (3): 287–316.

Heuson, Clemens. 2010. “Weitzman revisited: Emission standards versus taxes with uncertain abatement costs and market power of polluting firms.” *Environmental and resource economics* 47 (3): 349–369.

Klenert, David, Schwerhoff, Gregor, Edenhofer, Otmar and Linus Mattauch. 2016. “Environmental Taxation, Inequality and Engel’s Law: The Double Dividend Redistribution.” *Environmental Resource Economics* 71 (3): 605–624.

Kneese, Allen V. and Blair T. Bower. 1979. *Environmental Quality and Residuals Management.* Baltimore: John Hopkins University Press for Resources for the Future.

Kneese, Allen V. and Russell S. Clifford. 1994. Environmental economics. In *The New Palgrave Dictionary of Economics, volume 2,* eds. Durlauf, Steven and Lawrence E. Blume. London: Palgrave Macmillan.

Križanič, Franci, Mencinger, Jože and Vasja Kolšek. 2016. *Strokovne podlage za preureditev sistema okoljskih dajatev v Republiki Sloveniji (končno poročilo).* Ljubljana: EIPF, Ekonomski inštitut.

Kuokštis, Vytautas. 2017. “Economic Conditions and tax compliance: the mediating effect of trust.” *Journal of Comparative Politics* 10 (2): 55–69.
Lanz, Bruno, Wurlod, Jyles-Daniel, Panzone Luca and Timothy Swanson. 2018. “The behavioural effect of Pigovian regulation: Evidence from a field experiment” *Journal of Environmental Economics and Management* 87: 190–205.
Martin, Ralf, de Preux, Laure and Ulrich J. Wagner. 2014. “The impact of carbon tax on manufacturing: evidence from microdata.” *Journal of Public Economics* 117(C): 1–14.
Ministry of Finance. 2015. *Okoljska dajatev na onesnaževanje zaradi odlaganja odpadkov na odlagališčih.* Ljubljana: Ministry of Finance.
Pigou, Arthur Cecil. 1920. *The Economics of Welfare.* London: Macmillan.
Romer, Paul M. 1986. “Increasing Returns and Long Run Growth.” *Journal of Political Economy* 94 (5): 1002–1037.
Romer, Paul M. 1990. “Endogenous Technological Change.” *Journal of Political Economy* 98 (5): 71–102.
Samuelson, Paul A. 1954. “The pure theory of public expenditure.” *Review of Economics and statistics* 36 (4): 387–389.
Soretz, Susanne. 2007. “Efficient Dynamic Pollution Taxation in an Uncertain Environment.” *Environmental and Resource Economics* 36 (1): 57–84.
Stavins, Robert N. 1996. “Correlated Uncertainty and Policy Instrument Choice**.”** *Journal of Environmental Economics and Management* 30 (2): 218–232.
Weitzman, Martin L. 1974. “Prices vs quantities.” *Review of Economics Studies* 41 (4): 477–491.

## ACKNOWLEDGMENT

*The authors acknowledge the financial support from the Slovenian Research Agency (research core funding No. P5-0287-0541-18 and P5-0027-0585).*