GÁBOR KUTASI

EU PRACTICES FOR CARBON TAXATION

Climate change is a long-term challenge. The possible threat of climate change demands actions from public polices and puts burden and responsibility on fiscal policy as well. One of the responsibilities is to make economic actors reduce CO_2 emissions, thus mitigate the potential change of temperature. The focus of the paper is on the application opportunities of carbon emission tax. The study overviews practices of EU countries, and refers to theoretical models of optimum taxation to create a possible framework for green taxation for EU members.

KEYWORDS: CLIMATE CHANGE, FISCAL POLICY, TAXATION, GREEN TAX, CARBON TAX

JEL H23, H21, Q52, Q54, Q58

1. INTRODUCTION

The global warming expected from climate change might be prevented by a restriction on carbon emission. This mitigation can be realized by several market friendly or discretionary institutional ways. A market friendly pricing of externalities is the carbon emission tax. The EU emphasizes the importance of environmental sustainability in relative outstanding extent in global comparison. The EU has been an initiator of international cooperation for the mitigation of climate change and has essential role in the creation of the Kyoto Protocol for example. The international cooperation can cope more easily with quantitative regulations like permit trade (namely quota trade), since taxation is part of sovereign fiscal policy. But therefore, green taxation is absolutely a national and a little bit single market responsibility to foster the mitigation. Therefore, it is important to check carbon tax practices of EU countries, whether are they so enthusiastic in national competence level as in global representation.

As it is written by O'Hara (2009), *"[...] global warming hypotheses have been a contested terrain as advocates sparred with critics, resulting in controversy and analysis, but no firm resolution either way at the level of public debate. All this has suddenly changed in the light of the 'global warming' thesis gaining the upper hand. The influence of [...] publication of the IPCC Report (2007a,b,c,d), the Stern Review (2007), the UNDP Report (2007), and the Garnaut Report (2008) [...]have meshed with the election of more moderate governments in several continents to*

The author was supported by TAMOP-4.2.1.B-09/1/KMR-2010-0005 project in the research for this paper.

change the public view of these matters. 'Climate change', as it is now called, has become an accepted institution, even by most of those who previously argued against 'global warming'." Climate change is a long-term challenge for the Earth, as action for prevention should be started very soon before the impacts, while it is very uncertain to forecast the exact far future damages of different regions when exact scale of regional warming is an unsure variable in the equation of economic impacts. The scenarios and action plans have been developed, but there is an important factor that makes the execution questionable: the hesitation of decision making stakeholders. Hesitation is rooted both in uncertainty and in the expectations on each others' strategy.

In most industrialized countries, there are many factors that could ruin fiscal sustainability before any mentioning of the cost of climate change. The aging population, the welfare state reform, the recovery from global crisis, the tax competition, the rigidities of labour markets already have resulted robust debt levels.* The determining debt level warns for an important constraint in the beginning: The fiscal cost of mitigation and adaptation can not be financed simply from public debt. Even a new type of taxes is not risk free in a very bounded fiscal room for manoeuvre.

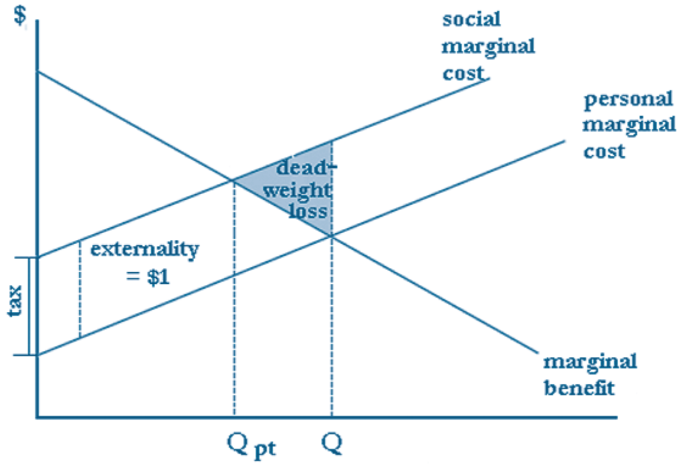
The Brundtland Report on sustainability of development issued in 1987 has early explained the responsibility of human activities for transition of natural environment. Peter S. Heller's book, the 'Who will pay?' (Heller 2003) set one of the first milestones in thinking about fiscal impacts of long-term processes of the 21st century global economy, among others the climate change. Since 'Who will pay?', the relevant particular economics literature has been enlarging. This study focuses on application opportunities of carbon taxation. The purpose is to estimate the impacts of introduction of carbon emission taxation in EU countries, implied by climate change mitigation and adaptation. The paper overview the practices of EU countries, and refer to theoretical models of optimum taxation to create a possible framework for green taxation for EU members. The purpose is to gather knowledge of practices on green taxation, reply for fiscal challenge from climate change, be a guide for policy makers warning for difficulties and giving solutions.

2. GREEN TAXATION FOR CLIMATE MITIGATION

Carbon tax is a practical version of the theoretical Pigou tax (or Pigovian tax). The Pigou tax is a solution for internalization of externalities. Pigou (1920) recognized that the market mechanism had failed to include external costs into market prices, which was why he recommended the implementation of a tax to solve this market failure. Baumol & Oates (1971) proved that tax is an efficient instrument to realize environmental goals, even in the case of unquantifiable externalities. The Pigou tax can be levied on the market activities creating negative externalities. The role

* The approximately debt to GDP ratios have been the followings in 2011: USA 100%, Japan 225%, France 80%, Germany 75%, Britain 70% etc. (source: Eurostat)

of the tax is to correct the market outcome. In the case of CO_2 emission, the externality is the global warming and its geographical, social, health, economic, fiscal etc. impacts. The externality distorts the economy from the Pareto optimum, while the Pigou tax can have the economy return to the optimum. The tax should be equal to the marginal externality (Pigou externality) for the expected effect. The challenge of the tax – just as general taxation – is its fine calibration for the wanted impact, in the case of green tax to counterweight the externality of CO_2 emission. Wrong setting, institutional failures in legislation and execution, or the polluters' political lobby can ruin the real efficacy of Pigovian type taxes. As the Pigou tax does not pursue fiscal revenue purposes, fiscal charges are to be regarded as small as the enterprises as possible. However, putting a tax into practice always demand the analysis of marginal tax burden impacts on the business (see fig. 1).



Source: Nye (2008), Qpt = production with tax, Q = production without tax

Figure 1. Microeconomic externality and the Pigou Tax

In the criticisms of Pigovian type taxes, there can be found an ignorance of whether the market structure is competitive or monopolistic, as in case of monopoly, the price is above and the quantity is below the competitive equilibrium. Thus, estimating optimum Pigou taxes ignoring the market structure could overestimate the rate of tax to impose. Buchanan (1969) and Nye (2008), for example, refer to the oil and gasoline market where suppliers can limit the production, and the impact of restriction on oil drilling or the impact of the alternative energy supply on oil based energy market price, which makes it difficult to calculate the exact tax. Nye (2008) also refers to the doubts written by Edlin & Karaca-Mandic (2006) on the case of heterogeneity. As for carbon tax, heterogeneity can mean different technological levels of production or different productivity levels and various value added, not just in the sense of geographical disparities, but also in small versus big companies or inter-industrial aspect, too. One percent or one dollar tax will burden less an industry with high profit margin than another with low return.

As any type of tax, Pigou tax has a deadweight loss impact, too, on consumers' benefit. (See figure 1) The question is whether this deadweight loss or the damage from warming is bigger. The calculation of deadweight demands the knowledge of the price elasticity, and the estimation of damage by warming needs the very uncertain probabilities of climate change. Thus, it is not simple to match the alternative losses.

Another critic on green tax is called the "green paradox" by Sinn (2008), who suggested that increasing emission taxes accelerate global warming because resource owners start to fear of higher future taxation and for this reason they start to increase near-term extraction. Edenhofer & Kalkuhl (2011) tested Sinn's model for increasing unit taxes on emission, and found that an accelerated resource extraction due to increasing carbon taxes (namely, the green paradox) is limited to the following specific conditions: *"The initial tax level has to be lower than a certain threshold and the tax has to grow permanently at a rate higher than the discount rate of resource owners."* Edenhofer & Kalkuhl 2011:2211) This means that most ranges of carbon taxes for warming mitigation is not risky for the green paradox. They suggest "quantity instruments" to avoid any risk of the paradox.

The expectation from implementation of carbon tax is to mitigate carbon emission by pricing the cost of future damage and thus enforcing emission efficiency. The function of carbon tax is to raise the price of CO_2 emission. However, to identify the real tax impacts on energy demand and CO_2 emission is a serious challenge for policy-makers. As it was established by IMF (2008), the conditions of success in mitigation policy are complex.

As any mitigation policies, the carbon taxation must be flexible, robust and enforceable. According to Kim et al (2011), carbon tax has an important advantage over other mitigation measures, namely, that they create a common price for emissions, which makes polluters more efficient in emission reduction. Efficiency of green tax can be understood as how much CO_2 emission can be reduced in energy use and production or in transportation, if a carbon tax is adopted in the mentioned industries.

In comparison to command and control, the advantages of carbon tax can be summarized in lower compliance costs, and a continuous incentive to adapt in the technology of energy use and conservation. (Cooper 1998, Pizer 1997)

The main advantages of market-based carbon taxation are the following according to Cooper (1998), Pizer (1997) Pearce (1991) Nordhaus (2007) and Kim et al. (2011):

- Creating a common price for emission taxation makes firms with lower abatement costs emit more. The carbon tax fixes the price of emissions effectively.
- The cost for CO_2 emission encourages a switch to low-emission technologies and activities, and the development of emission-reducing technologies.
- Carbon-tax systems can make use of existing tax collection mechanisms and require less intensive emission monitoring efforts.
- Carbon tax provides for greater flexibility and adjustment capability for both firms and public finances in case of changing economic conditions, allowing firms to reduce emissions more during the periods of slow demand growth, and providing opportunity for tax easing.
- The carbon tax can induce a technological change to avoid higher cost, which results in lower emission and at the same time technological shift toward better productivity or cost efficiency. (Gerlagh & Lise 2005)

The disadvantages are as follows:

- The new type of tax generates administrative and transaction costs.
- Without other tax easing, the higher tax burden results a crowding out impact by government.
- Under carbon tax, the quantity of emission reductions is uncertain. Impact of tax is very dependent on non-constant price elasticity and income elasticity.
- Taxes may be politically difficult to implement. (Kim et al. 2011.)
- Market structure and energy consumers' heterogeneity is not treatable in a homogenous tax system. (Edlin & Karaca-Mandic 2006)
- The range of applicable green tax is limited by the existing total tax burden on economy, or, from contrary view, the level of green tax determines the necessity of tax cuts in other types of tax burden. (Bossier & Bréchet 1995)

Some literature estimation on tax elasticity expresses a very skeptic view on carbon tax efficiency. Sipes & Mendelsohn (2001) made the evaluation of the effectiveness of gasoline taxation as an air pollution management. Their conclusion was that an environmental surcharge added to gasoline taxes can decrease gasoline consumption only with very low price elasticity of demand. The estimation of Davis & Kilian (2009) confirmed this inelastic behavior, as their result showed that a 10 percent tax increase could decrease carbon emission of the transportation sector by about 1.5 percent and reduce the total carbon emission by about 0.5% in the USA. (see Kim et al. 2011)

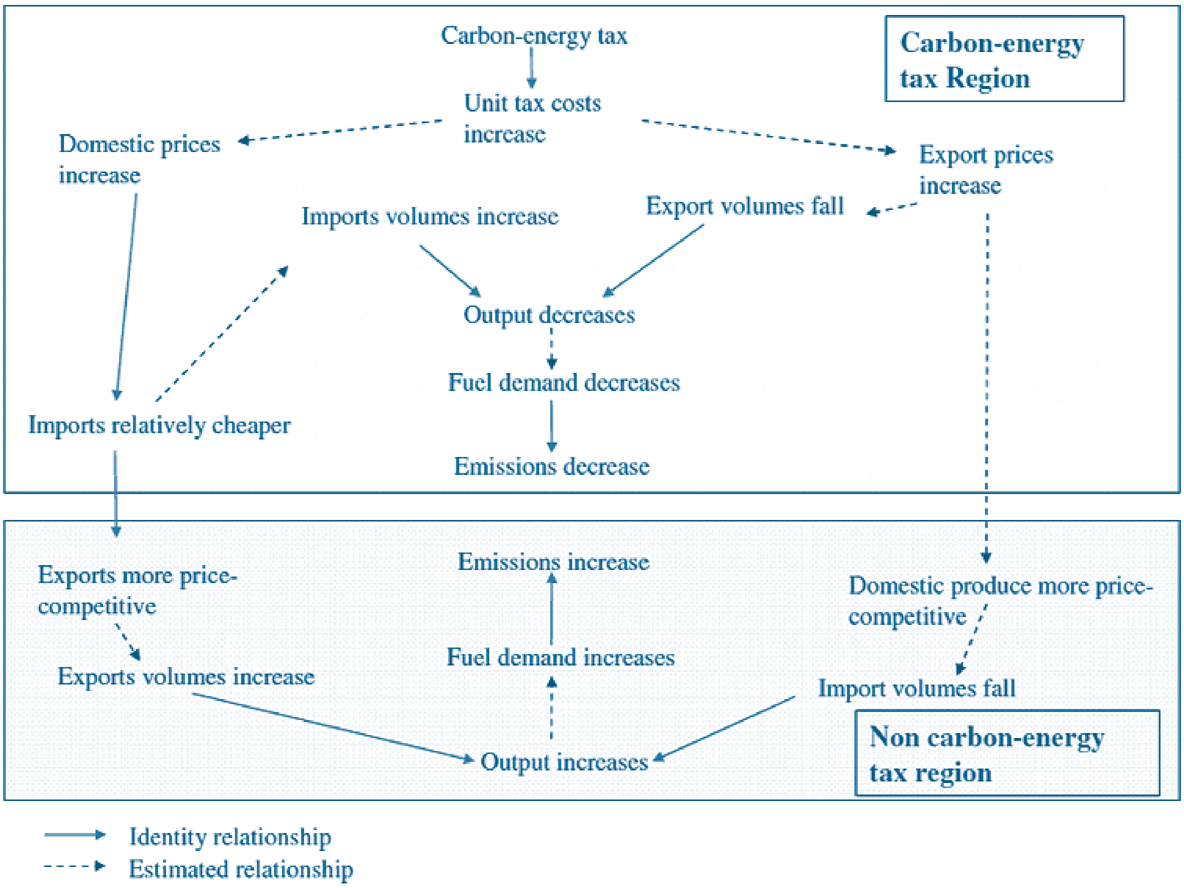
The impact of carbon taxes on international competitiveness of energy intensive industries is determined to a certain extent, because additional cost factor appears in the countries devoted to mitigation, meanwhile free riders of international relations try to avoid the implementation of green taxes. However, the empirical econometric survey of Zhao (2011) concluded that empirics do not support this hypothesis. As it is established in the analysis, when only the importing countries have carbon tax, it exerts negative influence on exporters' competitiveness in energy-intensive industries. If only the exporters use carbon tax, impact on competitiveness is insignificant. When every trade partner countries harmonize the carbon taxation, the impact on competition is still not completely cancelled mutually, but there remain some net negative impact on exporting countries.

Baranzini et al. (2000) and later Zhang & Baranzini (2004) shed light on the relation of green tax introduction to fiscal reform necessity, as introduction of a new type of tax has impacts on competitiveness, distribution and environment, at least at the same time. Galinato & Yoder (2010) experiences that, environmental taxes on energy are politically unpopular, especially in the USA, particularly because it is hard to accept increasing energy prices any way. That is why they suggest the implementation of a combined tax and subsidy system, because subsidies on alternative energy and fuel are financed by general budget from already existing taxes. However, these types of indirect subsidies are found to be weak in their efficiency to reduce carbon emission. The model contained a tax-subsidy mix for political boundaries. The essence of this model is that revenues from emission taxes finance the subsidies alternative energy.

3. EUROPEAN PRACTICES AND EXPERIENCE

Bossier and Bréchet (1995) described the first European Community initiation on harmonized green tax as follows: *"As it was defined by the European Commission (EC1992), the tax considered in this study is a mixed tax. One of the basic arguments lying behind the proposal was to improve energy efficiency and to curb carbon emissions at a European level. A mixed tax meets both of these purposes since it is based both on the energy and on the carbon content of the different types of fuels (for a discussion of the use of a mixed tax. (see Hoornaert, 1992; Manne and Richels, 1993). The tax is imposed at a level of 17.75 ECUs/toe the first year which is roughly equivalent to a tax of US$3 per barrel of oil. The energy and carbon components represent 50% of the tax each. The energy component (0.21 ECU/GJ) is levied on all fuels while the carbon component (2.81 ECUs per tonne of CO_2) depends on the carbon content of each energy product."*

The global "early birds" in carbon taxation have been the North-European countries such as Norway, Sweden, Denmark, Finland, and the Netherlands, who introduced green taxes in the early 1990s. In other European economies, around the millennium, the carbon charges and taxes were only topic of disputes. (Baranzini et al. 2000)



Source: Barker et al (2007:6286, fig.1)

Figure 2. Carbon leakage in the energy-environment-economy model of the EU

Barker et al. (2007) warned the community of European countries that unilateral environmental tax reforms leads to imperfection when participation is particular. It is called carbon leakage, when the efforts made by unilaterally green reforming countries are ruined by the non-reforming countries in two ways. First, the sustained emission level of non-reforming countries ruins the mitigation of reforming ones. Second, the reforming countries suffer from unilateral degradation in their competitiveness since their additional tax. However, very similarly to the weakness of green paradox, Barker et al (2007:6291) found very few proof for carbon linkage: *"Only in a highly competitive, export-driven market does the small industry price increase lead to a decrease in output, namely the UK and German basic metals industries. The absence of strong evidence for carbon leakage is most likely due to the fact that the ETR* [environmental tax reform] *energy taxes are relatively small and so they do not have a large enough effect on unit costs to justify the cost of relocation."* That might be explained by the generally weak impact of green taxes on economy and emission.

There are several studies assessing national industrial impact of tax burden on carbon emission. Most of them found weak impacts of carbon tax on European national markets in price elasticity and demand structure. In the case of reduction of emission, the studies recognize significant contraction, however, it is not sure, whether the change was enforced by the green tax or a natural part of the technological development cycle, or other regulation. Floros & Vlachou (2005) investigates the carbon tax impact on Greek manufacturing. Their findings showed that energy demand is inelastic, and the diesel demand exhibited the highest price responsiveness. €50 tax per ton of carbon, with no independently initiated electricity restructuring, resulted in an overall reduction of 17.6% in CO_2 emissions between 1998 and 2004. Their sensitivity analysis revealed that this reduction falls within the interval from 11.4% to 26.5%.

Giblin & McNabola (2009) examined the vehicle tax related to carbon emission in Ireland. They estimated a reduction of 3.6 to 3.8% in CO_2 emissions intensity, perpetuated by a shift in purchase patterns to smaller vehicles and diesel engines and amounting to a 3% reduction in total CO_2 emissions from private transport. The price or tax of fuel was measured to be relatively ineffective in influencing car purchase decisions. This resulted little change in the carbon emissions intensity of vehicles. Besides, Wissema & Dellink (2007) analyzed the Irish carbon related energy tax. The Irish economy decreased its carbon emission by 25.8% in the period from 1998 to 2006. Substitution possibilities made it possible to achieve this with relatively lower tax level. The welfare impact of Irish carbon tax was very slightly negative, by –1%, as the tax resulted in adjustment in the form of shift in demand structure. The biggest welfare damage was caused among the poorest households.

Bureau (2011) estimated the impacts of French carbon tax on car fuels. The conclusion on the French regime was that the 7–8 Euro cent / liter tax caused income loss for households, where the poor suffered more. The poorest households lose 6.3‰ of their income, as compared to 1.9‰ for the wealthiest. This actually means regressive taxation. However, the recycling of tax revenues toward the poorer households has been measured to be more intensive than toward the wealthiest.

Despite the latter gross trend, the net loss of poorer households still exceeded the loss of richer ones.

Bruvoll & Larsen (2004) were interested in the functionality of Norwegian carbon taxes on CO_2 and N_2O gases. In Norway, carbon taxes were implemented in 1991. The Norwegian emission of CO_2 increased by 19% in the period from 1990 to 1999. The authors understood this growth to be lower than the 35% GDP growth; namely, GDP was reduced by 12% by emission cuts. The energy intensity and structure created particularly a 14% reduction of emission in the surveyed period. However, it could happen because the carbon taxes in Norway have been dominated by the national oil and gas industry. In case of non-oil producing industries, the carbon tax effect on emissions was measured only as 1.5%. The competitiveness related exemptions weaken the impacts very much in a broad range of fossil fuel intensive industries. The existence of zero-tax industries such as metal and industrial chemicals explain why there has been close to zero effect by green taxes.

4. GREEN TAXATION FOR GROWTH AND EMPLOYMENT

Kohlhaas (2000) described the green tax reform concept as follows: *"A core concept of ecological tax reform is to levy environmental taxes (or charges) and use the subsequent revenue to reduce other existing taxes by an equivalent amount. This revenue-neutral approach ensures that the business sector and private households, taken as a whole, will not face a higher overall tax burden. Ideally, this method enables policymakers to reduce economic distortions that the tax system currently causes by reducing taxes that are considered harmful to the economy."* According to the findings by Bossier & Bréchet (1995), carbon pricing (e.g. through green tax) can be connected to employment problems, especially in developed European countries. Their recommendation toward policy makers is to pay attention on the total tax burden. Although the primary purpose of green tax is not to secure government revenues, it is eventually a budget resource. Thus the volume of carbon tax revenues can be redistributed through cuts of other duties, especially if this results in growth impacts. Europe suffers mostly by relative low employment causing high social fiscal costs. So, it seems reasonable to ease the burden on labour cost.

The simple version of tax compensation means only a redistribution of the funds in social service systems. In this case, green tax must finance the loss of revenues from the easing of social security contribution. Of course, in a complex social security reform (pension reform and health care funding reform), the tax easing anticipating the green tax can be broader. The latter approach indicated by "green tax for employment" slogan sets the carbon taxation issue in a complex economics model. The efficiency of this policy instrument will be indicated not only by carbon reduction, but also by its impact on employment, energy use efficiency, prices, wages and ultimately on global competitiveness and external balance. (Bossier & Bréchet 1995)

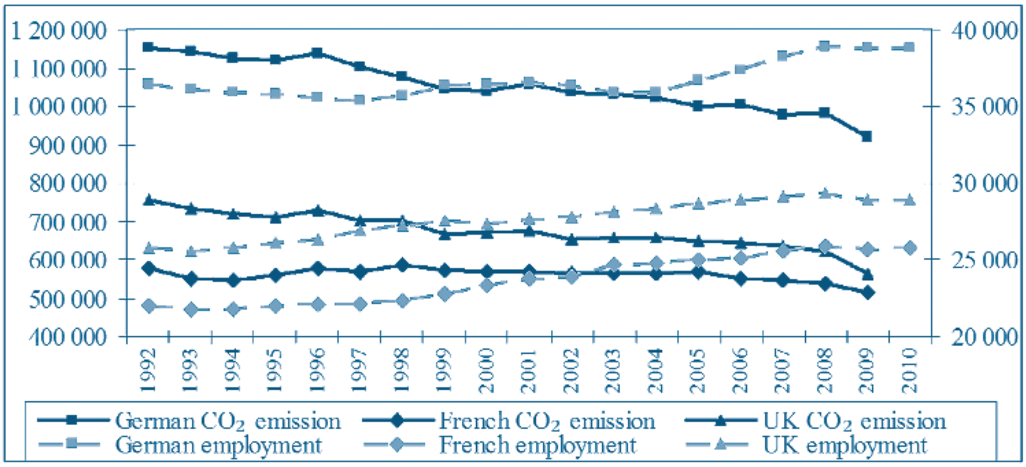
In European relevance, two ways of so-called targeted cuts in social security contribution have proved to be practical. The targeted cuts in contribution paid either by sectors exposed to international competition or by sheltered sectors like single market services. The other way, recommended by Drèze et al (1994), means targeted cuts in contribution paid by sectors employing low-skilled workers. The latter one can help a serious problem caused by the quickly growing value added by technological development, which excluded about 10% of the European society from the labour market. (Bossier & Bréchet 1995)

There is a good practice on green tax reform combined with employment objectives in Germany. The *Gesetz zum Einstieg in die ökologische Steuerreform* (First Step toward an Ecological Tax Reform Act) took effect in 1999. Green tax was levied on primary energy consumption, in parallel with cuts on the employers labour-related cost. (Bach et al. 2002) As it is described by Kohlhaas (2005), Knigge & Görlach (2005) and Kohlhaas (2000), the ecological tax reform was started in 1999, and finalized by a later modification in 2003. This tax reform gradually raised the tax burden on petroleum and gas and introduced the electricity tax. Parallel, the wage cost was decreased in public budget revenue in a neutral way. The modification in 2003 was simply differentiation between renewable and non-renewable energy use, as the Act introduced the subsidies for renewable energy and for energy saving reconstructions of buildings.

The German green tax revenue rose up to 18.7 billion EUR in 2003, but the emission reduction impact stabilized later the green revenue around 16 billion EUR in the following years. This financial room created opportunity to lower the total volume of public pension insurance contribution by 1.7%. In wage cost, this made possible to lower the social insurance rate from 42.3% to 40% of gross wage. (Kohlhaas 2000, Kohlhaas 2005, Knigge & Görlach 2005)

As shown in table 1, the reduction of emission speeded up exponentially from the start-up year 1999. The –2.39% change of CO_2 emission in 2003 meant 20 million tons less carbon air pollution. In parallel, employment grew by approximately 250 thousand people until 2003 which already meant an employment ratio of +0.75%. However, the impact of reform on GDP growth was measured to be insignificant, close to zero. Among the sectors of national economy, the private sector felt lower social security cost and higher energy and fuel prices, the government balance was not affected, the investments were diverted toward energy saving technologies, which resulted high fluctuation among industries. Thus, the industrial level impacts proved to be very various. (See table 2.) The current account impact is negative, the higher cost of import energy ruined the export competitiveness of German industries; thus, export sank and import grew. Especially the transportation and the construction sector suffered from the highest increase of cost as they have been the most energy intensive sectors, at the same time the agriculture suffered the biggest contraction by higher energy price for being more price elastic than former industries. (Kohlhaas 2005, Knigge & Görlach 2005)

Kohlhaas (2005) created *ex post* and *ex ante* model to estimate the effect of German green tax reform on GDP and employment. The German green employment shows effective characteristics, as during the global recession the German unemployment could have decreased from 10% to 7%, in period of 2008–2011 *(see figure 3)*.



Source: Eurostat, data download in June, 2011.

Figure 3 Emission (left axis, 1000 tons/year) and employment (right axis, 1000 persons) in Germany, France, United Kingdom.

Table 1 Annual changes in emission, employment and GDP as impact of German ecological tax reform, %

	1999	2000	2001	2002	2003	2004	2005	2010f
Change in CO_2 emission	-0.55	-1.33	-1.75	-1.95	-2.39	-2.47	-2.61	-3.10
Change in employment	0.64	0.76	0.67	0.41	0.76	0.63	0.52	0.46
Change in GDP	0.39	0.47	0.44	0.29	0.45	0.38	0.30	0.13

Source: Kohlhaas (2005:13, Tabelle 3-1), f = forecast

Table 2 Effects of the ecological tax reform on the real production output of industries, deviations from the reference growth values, %

	1999	2000	2001	2002	2003	2004	2005	2010f
Agriculture	-0.08	-0.31	-0.27	-0.37	-0.41	-0.33	-0.31	-0.57
Energy	-0.41	-1.19	-1.79	-1.94	-2.31	-2.52	-2.66	-3.37
Raw material and chemical	0.02	-0.13	-0.25	-0.27	-0.11	-0.09	-0.01	-0.19
Investment goods	0.24	0.18	-0.10	-0.07	0.18	0.11	0.11	-0.02
Consumer goods	0.06	-0.06	-0.09	-0.10	0.11	0.06	0.10	-0.06
Construction	0.82	1.06	0.87	0.19	0.52	0.24	-0.02	-0.18
Transport	0.20	0.07	0.05	-0.12	0.02	-0.03	-0.06	-0.15
Services	0.44	0.43	0.40	0.32	0.43	0.34	0.25	0.07
Government	0.16	0.50	0.67	0.67	0.62	0.73	0.64	0.48

Source: Kohlhaas (2005:13, Tabelle 3-2), f = forecast

CONCLUSION

A carbon tax could be one of the most effective policies to mitigate carbon emissions. The implementation of green tax is expected to price the externalities cost-effectively, thus, really enforce the mitigation of the private sector. However, there are some limits of the policy making by taxation. The carbon tax impact is not absolutely certain if price and income elasticity can not be empirically forecasted. The flat tax rate can have various impacts on industries or different size of companies having various productivity or profitability.

The ideal fiscal policy affected by climate change would be a green stimulus combining spending and green tax, meanwhile keeping the scale and balance of the budget, but restructuring the fiscal preferences, thus, cutting the wage related cost of employment and improving the international competitiveness of the national economy.

A multilateral ecological tax reform seemed to be more effective than a unilateral one, however, the assumption that the impact on competitiveness would be smaller if more countries participated or took equivalent measures was not proved by empirical studies. Anyway, after the proposal of the German government, the EU accepted tax rate minimum limits for ecological taxes like environmental protection product fee, environmental charges, and energy taxes on electricity, natural gas and coal. (See Directive 2003/96/EEC) However, a EU-wide counter tax easing was not harmonized for higher employment.

In the case of complex environmental tax reform, the extent of increase and cuts on tax rates will be cautious and prudent since the impact of green tax on medium or long term emission reduction will result a fall in tax revenues, too.

The European experience from green tax shows small impact on emission, welfare and competitiveness. Because substitution opportunities on carbon-related fuel and energy are income dependent, households with lower income take relatively more burden. This means that the theoretically flat carbon tax actually works as a regressive tax.

The empirical studies measure low efficiency and low elasticity in the case of green tax implementation, which can be explained with a broad range of exemptions in energy use and rigid, inelastic demand in gasoline consumption.

REFERENCES

Bach S.–Kohlhaas M.–Meyer B.–Praetorius B.–Welsch H. [2002]: The effects of environmental fiscal reform in Germany: a simulation study *Energy Policy* 30 [2002] 803–811

Baranzini, A.–Goldemberg, J.–Speck, S. [2000]: A future for carbon taxes *Ecological Economics* 32 [2000] 395–412

Barker T. [1998]: The effects on competitiveness of coordinated versus unilateral fiscal policies reducing GHG emissions in the EU: an assessment of a 10% reduction by 2010 using the E3ME model *Energy Policy*. Vol. 26, No. 14 pp. 1083–1098, 1998

Barker, T.–Junankar, S.–Pollitt, H.–Summerton, P. [2007]: Carbon leakage from unilateral Environmental Tax Reforms in Europe, 1995–2005 *Energy Policy* 35 [2007] 6281–6292

Baumol, W. J.– Oates, W. E. [1971]: The Use of Standards and Prices for Protection of the Environment. *Swedish Journal of Economics* 73 [1971]

Bossier, F.–Bréchet, T. [1995]: A fiscal reform for increasing employment and mitigating CO_2 emissions in Europe *Energy Policy* . Vol. 23, No. 9, pp. 789–798. 1995

Bruvoll, A.–Larsen, B. M. [2004]: Greenhouse gas emissions in Norway: do carbon taxes work? *Energy Policy* 32 [2004] 493–505

Buchanan, J. [1969]: External Diseconomies, Corrective Taxes, and Market Structure *American Economic Review*, Vol. 59, March

Bureau, B. [2011]: Distributional effects of a carbon tax on car fuels in France *Energy Economics* 33 [2011] 121–130

Cooper, R., [1998]: Toward a real treaty on global warming. *Foreign Affairs* 77, 66–79.

Davis, L.W.–Kilian, L. [2009]: Estimating the effect of a gasoline tax on carbon emissions. *Working Paper*, Department of Economics, University of Michigan.

Drèze J.–Malinvaud, E. [1994]: Growth and employment: the scope of an European initiative *European Economy* [I] 77–106

EC [1992]: The climate change: economic aspects of limiting CO 2 emissions *European Economy* No 51 [European Commission]

Edenhofer, O.–Kalkuhl, M. [2011]: When do increasing carbon taxes accelerate global warming? A note on the green paradox *Energy Policy* 39 [2011] 2208–2212

Edlin, A.–Karaca-Mandic, P. [2006]: The Accident Externality from Driving, *Journal of Political Economy*, Vol. 114, No. 5,

Floros, N.–Vlachou, A. [2005]: Energy demand and energy-related CO_2 emissions in Greek manufacturing: Assessing the impact of a carbon tax *Energy Economics* 27 [2005] 387– 413

Galinato, G. I.–Yoder, J. K. [2010]: An integrated tax-subsidy policy for carbon emission reduction *Resource and Energy Economics* 32 [2010] 310–326

Garnaut, R., [2008]: *The Garnaut Climate Change Review: Final Report*. NY. Cambridge University Press, Cambridge, UK.

Gerlagh R.–Lise, W. [2005]: Carbon taxes: A drop in the ocean, or a drop that erodes the stone? The effect of carbon taxes on technological change *Ecological Economics* 54 [2005] 241– 260

Giblin, S.–McNabola, A. [2009]: Modelling the impacts of a carbon emission-differentiated vehicle tax system on CO_2 emissions intensity from new vehicle purchases in Ireland. *Energy Policy* 37 [2009] 1404–1411

Heller, P. S. [2003]: *Who Will Pay? Coping with Aging Societies, Climate Change, and Other Long-Term Fiscal Challenges* International Monetary Fund, Washington

Hoornaert, L [1992]: The use of taxation as a policy instrument aimed at limiting the Community's CO_2 emissions: practical dimensions of implementation *European Economy* special edition No I, 63–90

IMF, [2008]: Climate change and the global economy *World Economy Outlook* April 2008, International Monetary Fund.

IPCC [2007a]: Solomon, Susan, Qin, Dahe, Manning, Martin, Marquis, Melinda, Averyt, Kristen, Tignor, Melinda, Henry Jr, Miller, Chen, Zhenlini [Eds.], *Climate Change 2007 – The Physical Science Basis*. Contribution of Working

Group I to Fourth Assessment Report. Cambridge University Press, New York. [Intergovernmental Panel on Climate Change]

IPCC [2007b]: Climate Change 2007 – Impacts, Adaptation and Vulnerability. In: Parry, Martin, Canziani, Osvaldo, Palutikof, Jean, van der Linden, Paul, Hanson, Clair [Eds.], *Contribution of Working Group II to Fourth Assessment Report*. Cambridge University Press, New York. [Intergovernmental Panel on Climate Change]

IPCC [2007c]: Climate Change 2007 Mitigation of Climate Change. In: Metz, Bert, Bosch, Peter, Dave, Rutu, Davidson, Ogun, Mayer, Leo [Eds.], *Contribution of Working Group III to Fourth Assessment Report.* Cambridge University Press, NY. [Intergovernmental Panel on Climate Change]

IPCC [2007d]: Climate Change 2007. *Synthesis Report*. IPCC. 73pp. [Intergovernmental Panel on Climate Change]

Kim, Y-D.–Han, H-O.–Moon, Y-S [2011]: The empirical effects of a gasoline tax on CO_2 emissions reductions from transportation sector in Korea. *Energy Policy* 39 [2011] 981–989

Kohlhaas, M. [2005]: *Gesamtwirtschaftliche Effekte der ökologischen Steuerreform* Band II des Endberichts für das Vorhaben: "Quantifizierung der Effekte der Ökologischen Steuerreform auf Umwelt, Beschäftigung und Innovation" Deutsches Institut für Wirtschaftsforschung, Berlin www.diw.de

Kohlhaas, M. [2000]: Ecological Tax Reform in Germany. From Theory to Policy *Economic Studies Program Series* American Institute for Contemporary German Studies, The Johns Hopkins University

Knigge, M.–Görlach, B. [2005]: *Die Ökologische Steuerreform – Auswirkungen auf Umwelt, Beschäftigung und Innovation Zusammenfassung des Endberichts für das Vorhaben: Quantifizierung der Effekte der Ökologischen Steuerreform auf Umwelt, Beschäftigung und Innovation*. Institut für Internationale und Europäische Umweltpolitik gGmbH, ww.ecologic.de

Manne, A. S.–Richels, R. G. [1993]: The EC proposal for combining carbon and energy taxes *Energy Policy* 21 [I] 5–12

Nordhaus, W. D. [2007]:. To tax or not to tax: alternative approaches to slowing global warming. *Review of Environmental Economics and Policy* 1, 26–44.

Nye, J. V. C. [2008]: The Pigou Problem. It is difficult to calculate the right tax in a world of imperfect Coasian bargains. *Regulation* Summer 2008, CATO Institute http://www.cato.org/pubs/regulation/regv31n2/v31n2-5.pdf

O'Hara, P. A. [2009]: Political economy of climate change, ecological destruction and uneven development *Ecological Economics* 69 [2009] 223–234

Pearce, D. W. [1991]: The role of carbon taxes in adjusting to global warming. *Economic Journal* 101, 938–948.

Pigou, A. C. [1920]: *The Economics of Welfare*. London, 1920.

Pizer, W. A. [1997]: Prices vs. quantities revisited: the case of climate change. *Resource for the Future Discussion Paper* 98–02, Washington.

Sinn, H. [2008]: Public policies against global warming: A supply side approach. *International Tax and Public Finance* 15, 360–394.

Sipes, K. N.–Mendelsohn, R. [2001]: The effectiveness of gasoline taxation to manage air pollution. *Ecological Economics* 36, 299–309.

Stern, N. [2007]: *The Economics of Climate Change: The Stern Review*. Cambridge University Press, Cambridge, UK.

UNDP [2007]: *Human Development Report* 2007/2008: Fighting Climate Change: Human Solidarity in a Divided World. Palgrave Macmillan, New York. Available on the Internet. [United Nations Development Program]

Wissema, W.–Dellink, R. [2007] AGE analysis of the impact of a carbon energy tax on the Irish economy *Ecological Economics* 61 [2007] 671–683

Zhang, Z. X.–Baranzini, A. [2004]: What do we know about carbon taxes? An inquiry into their impacts on competitiveness and distribution of income *Energy Policy* 32 [2004] 507–518

Zhao, Y-H. [2011]: The Study of Effect of Carbon Tax on the International Competitiveness of Energy-intensive Industries: An Empirical Analysis of OECD 21 Countries, 1992–2008 *Energy Procedia* 5 [2011] 1291–1302