

# **Modeling the Fiscal Impacts Caused by Climate Change**

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## **Abstract**

**Aim of the paper:** The purpose is to gather the practices and to model the impacts of climate change on fiscal spending and revenues, responsibilities and opportunities, balance and debt related to climate change (CC).

**Methodology of the paper:** The methodology will distinguish fiscal cost of mitigation and adaptation, besides direct and indirect costs. It will also introduce cost benefit analyses to evaluate the propensity of policy makers for action or passivity. Several scenarios will be drafted to see the different outcomes. The scenarios shall contain the possible losses in the natural and artificial environment and resources. Impacts on public budget are based on damage of income opportunities and capital/wealth/natural assets. There will be a list of actions when the fiscal correction of market failures will be necessary.

**Findings:** There will be a summary and synthesis of estimation models on CC impacts on public finances, and morals of existing/existed budgeting practices on mitigation. The model will be based on damages (and maybe benefits) from CC, adjusted with probabilities of scenarios and policy making propensity for action. Findings will cover the way of funding of fiscal costs.

**Practical use, value added:** From the synthesis of model, the fiscal cost of mitigation and adaptation can be estimated for any developed, emerging and developing countries. The paper will try to reply, also, for the challenge how to harmonize fiscal and developmental sustainability.

# Modeling the Fiscal Impacts Caused by Climate Change

Gábor Kutasi<sup>1</sup>

*A forward-looking perspective is always useful in policymaking,  
and it is especially useful for fiscal planners.*

Peter S. Heller (2003:10)

## 1. Introduction

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) can be called one of the first mile stones in thinking about fiscal impacts of long-term processes of the 21<sup>st</sup> century global economy, as the climate change among others. Since the 'Who will pay?', the particular specified economics literature has been enlarging.

This study overviews the public finances aspects of climate change. The sustainability is in focus, but this time the fiscal one and not the development aspect. The purpose is to gather the practices and to model the impacts of climate change on fiscal spending and revenues, responsibilities and opportunities, balance and debt related to climate change.

The horizon of global problems and regional social changes in the 21<sup>st</sup> century demands more long-term, forward-looking awareness and planning from national governments. Heller (2003) named the demographic changes, the global climate change and the globalization as main channels of very long-term challenges. These processes open new dimensions, also, in fiscal planning by causing cost of anticipation, mitigation, adaptation or other way of treatment.

In most of the industrialized countries, there are many factors ruining fiscal sustainability beside the climate change costs. 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 approximately debt to GDP ratios have been the followings in 2011: USA 100%, Japan 225%, France 80%, Germany 75%, Britain 70% etc. source: Eurostat) The determining debt level warns for an important constraint in the beginning: The fiscal cost of mitigation and adaptation can not be financed simply with public debt.

It is preferable to examine the impacts of climate in the fiscal environment drafted above. Nevertheless, the climate change is an expected occurrence in the future of the 21<sup>st</sup> century, which depends on many factors. This uncertainty or probability creates a more complex challenge for fiscal strategy. The regional variability of extent of warming or frequency and intensity of extreme weather events (cyclones, hurricanes, storms) or importance of coastal rise in the sea level still increases the complexity of fiscal analysis.

The mitigation and adaptation to climate change means any private or public action to prevent the change of temperature or adjust to a changed climate. Aaheim & Aasen (2008) distinguish autonomous and planned ways. The autonomous adaptation is the case, when private individuals do something for adjustment in uncoordinated way. This could have been a cheap way for public finances, but also results suboptimal solution because of bias for individual free riding, emergence of common pool resource problem, or uncertainty. That is why planned adjustment, namely fiscal adaptation is necessary, too, to motivate the private sector for (pro-)action. Nevertheless, the autonomous adjustment also has impact on tax revenues

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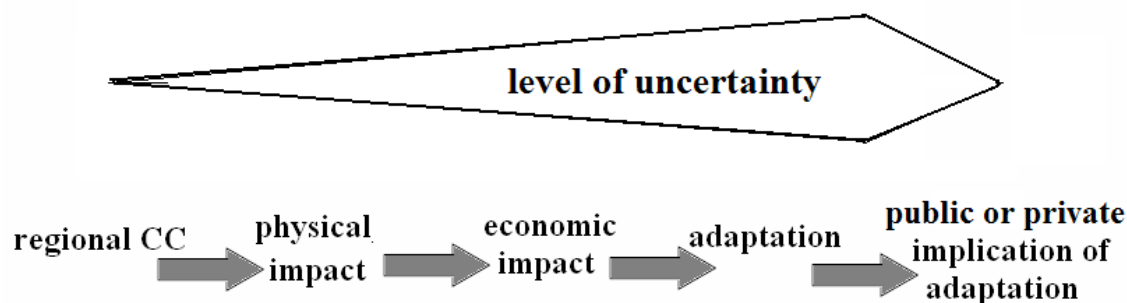
and public transfers. E.g., energy saving means less pollution-related tax payment, or direct investments in renewable energy equipment can create right to get public subsidy.

To adopt the debt sustainability aspect into the frame of climate change aspects, the long-term solvency, the budget constraint, the primary gap indicator has been applied. Besides indebtedness, refocusing fiscal spending and resetting the extent of public budget invoke the Keynesian fiscal crowding out impact.

## 2. Methodology of climate change

As a methodological simplification, the climate change can be translated as significant shift in average temperature, thus there is a variable or factor for calculations.<sup>2</sup> The modeling of fiscal impacts shall be examined in the frame of temperature change causing damages or benefits, and cost of mitigation or adaptation. If climate change got realized globally, it does not mean a generally same extent of change of temperature in every region and territory of the Earth. (It is possible more or less warming in temperature or even cooling is a likely outcome in certain regions.) As warming may be so different, the physical impact can be various. In some region, the rise of sea might will take coastal territories, in some region the hart illnesses might will rise by warmer climate, in other territories the agricultural lands will dry out, somewhere else the disappearance of ice and snow create land cultivation opportunities or ruin the winter tourism etc. But what is the likelihood in a continent, a country, a county or a city/village level? If there are more scenarios, what are the effective mitigation and adaptation actions? What is the critical mass or scale of action? Will the actors wait for each other to act? Who should act first? Should the state intervene, motivate, initiate? And so on. If such uncertain probabilities are accumulated (namely multiplied), finally the likelihood of effective actions can be low. (see fig. 1 and fig. 2)

Figure 1. Increasing uncertainty in climate change (CC)



Source: Simplified adaptation from Stern (2007) and O'Hara (2009)

Heller (2003:19) refers to the IPCC (2001) projections on expectable change of temperature in 100 years term horizon, which forecasts 1.9 – 5.8 Celsius (3 – 10 Fahrenheit) gradual warming by the concentration of greenhouse gases in the atmosphere. The uncertainty of temperature change can be illustrated in a fan chart of probable further future expectations.

Besides high uncertainty, the economic actors should agree in the distribution of financing between public and private players. The economic motivation for participation can be established, if the participants can get at least so much benefit from mitigation and adaptation actions as much cost they invest. Nevertheless, there are private actors (or maybe even state

<sup>2</sup> The estimation of global and regional probability, extent and direction of temperature change is a natural science question, thus in public finances study, it will be treated as an external factor.

actors in the international relations), who are not able to finance themselves the adaptation. Thus, the public decision makers must determine the extent of equity toward poor economic actors. (CEPS & ZEW 2010) This aspect raises the equity vs. efficiency trade-off dilemma, whether the fiscal resources should be used for subsidizing rich or poor actors (by direct spending or tax refunding). To resolve the dilemma, the economic theory knows the utilitarian approach and the Rawls approach. In case of climate change mitigation, the specific carbon emission per household of different social groups can guide the balancing between equity and efficiency. However, equity is not just a dilemma in social classes dimension, but in geographical view, too. Which are the populated and industrial areas deserving protection against higher sea level or other natural damages? See the bad practice case of New Orleans in 2005. How well developed hurricane warning system has it done worth to be financed? How big efforts and how quickly has it done worth to save people right after the catastrophe? Or see the Dutch agricultural lands under the sea level. How far should they be protected? Do these lands produce enough income to protect them from the sea?

The policy making – in relation to market motivation – must decide another dilemma between short-term profit and long-term supply what can be called supply security dilemma. (CEPS & ZEW 2010) In which territories should the state sustain the supply of energy, food, transportation, safe water and sewage system, pipelines? The prices and the (in)elasticity of the (network) service markets, the intensity of destructive competition<sup>3</sup>, will decide the short-term profit. When the profit is negative, the state may force the service companies to supply – or maybe not.

In case of climate change, the likelihood of irreversibility is important determinant. Although an early mitigation action can look like unworthy because of high uncertainty and low probability of occurrence of damages far before the forecasted warming or disasters, an overdue mitigation can not reverse the natural, environmental changes. In this case, only adaptation remains as option. (CEPS & ZEW 2010) The economics of decision theory suppose to use the net present value (NPV) to choose the more worthy option. In climate change relation, the comparable options are the NPV of an earlier mitigation or the NPV of a later adaptation.

To estimate the fiscal costs, the market capacity, propensity and perfection is preferable to be examined. It should be estimated, how far can the government levy the burden of adaptation on the private sector (solvency, marginal proactive propensity etc.), and can the market manage the risk to have demand and supply to meet and avoid the market failures. In climate disasters, first of all, the insurance sector should be helped to be able to manage the risk as far as possible.

To treat the impacts of climate change, it is possible to mitigate, what – according to Heller (2003:25) – means much effort *devoted to reducing emissions of greenhouse gases*.

*Here public sector involvement may involve replacing existing taxes with new ones that promote reduced emission. Or there may be more active use of regulation, whether of the command-and-control or the market-based type [...], in which case the fiscal consequences are likely to be more limited.* Heller (2003:25)

If mitigation is too late, or it is too expensive for preventing a not too likely event, the adaptation to new/changed circumstances can be another response. According to Heller (2003:23), the extent and cost of adaptation is regional or country specific, as it depends on

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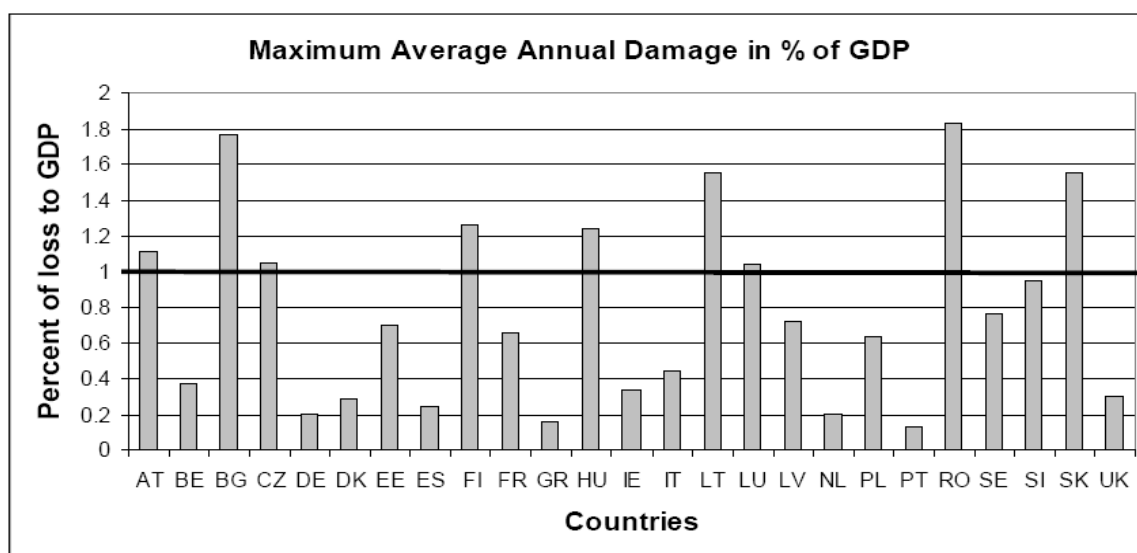
<sup>3</sup> Destructive competition: In such service markets, (1) where the fix cost (exit cost) is high, (2) the competition is intensive and presses the price to low level and (3) the demand is very volatile (some times much, some times few), the three characteristics together cause frequent bankruptcy what endangers the supply security.

the intensity of climate change, the embodiment of environmental or geographic changes, and the side effects on economy and physical assets. Heller thinks the followings:

*Although much of the burden of relocating resources and financing new investment will undoubtedly fall on the private sector, it is unlikely that the public sector will remain unscathed, especially in countries, such as many developing countries, where the net economic impact of climate change is expected to be negative. Areas of potential public sector involvement include outlays on infrastructure [...], other public goods in the areas of disease prevention and agricultural extension and research [...], and subsidies (to facilitate the resettlement of population). Heller (2003:23)*

As the significant warming is forecasted for century long, the public fiscal intervention is far more necessary in case of produced capital stocks, buildings, physical infrastructure with lifetime over 50. Especially, if unexpected or unlikely, radically destructive disasters or abrupt changes cause high scale of short-term cost.

Figure 2. Example for uncertainty: does it worth to have protection against flood?



Source: CEPS & ZEW (2010:55, fig.3.4)

The methodology on surveying fiscal impacts by climate change distinguishes fiscal cost of mitigation and adaptation, besides direct and indirect costs. It also introduces cost benefit analyses to evaluate the propensity of policy makers for action or passivity. Scenarios shall be drafted to see the different outcomes. The scenarios shall contain the possible losses in the natural and artificial environment and resources. Impacts on public budget are based on damage of income opportunities and capital/wealth/natural assets. In the followings, there is a composed list of actions when the fiscal correction of market failures is necessary.

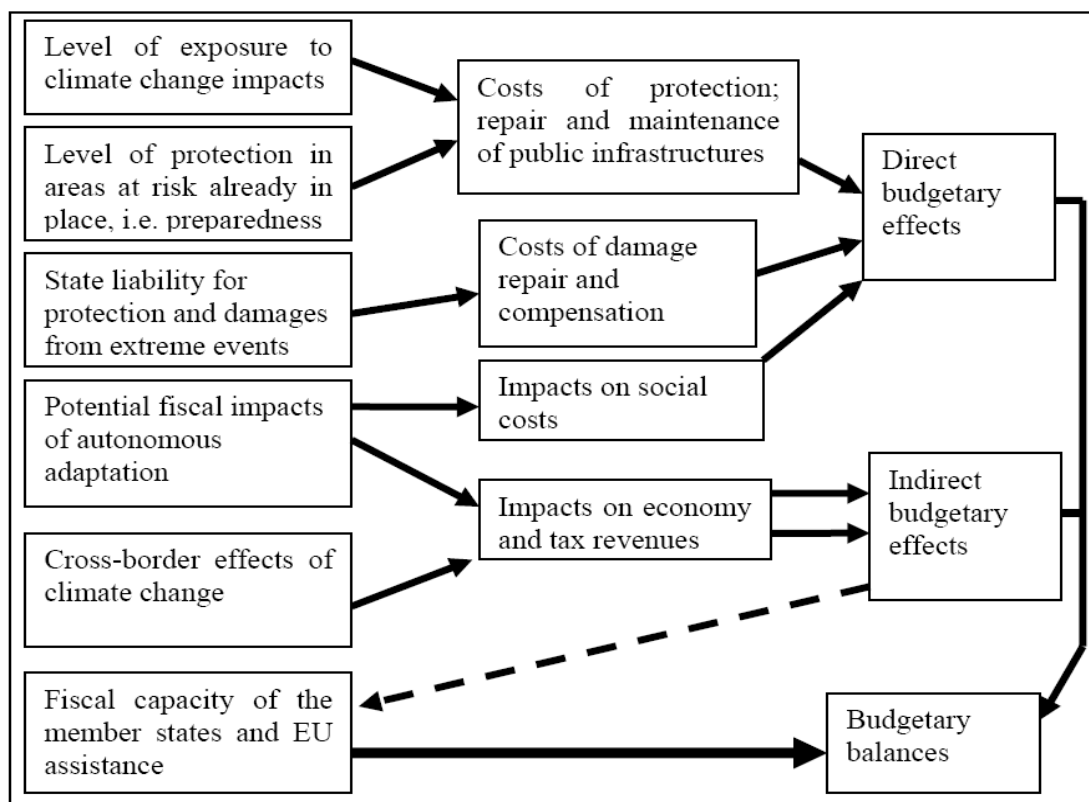
When fiscal cost of climate change is under survey, two main type of cost, the direct and the indirect costs can be distinguished. The direct costs are easily identifiable, however it is assumed to be smaller part of total costs. The difficulties with the identification of indirect costs alert for efficiency challenges, because the transparency of total cost of adaptation gets deteriorated. If costs are not transparent, economic participants will not be willing to finance it or support it, thus, the absent funding ruins the efficiency of any actions. The mechanism of direct and indirect costs can be described by the model on drivers of fiscal impacts.

### 3. Modeling the impacts

In the model on drivers, the CEPS & ZEW (2010) gathered the fiscal implication of climate change and identified six drivers that determine the size and importance of the fiscal implications. These are the followings: (1) the degree of exposure to gradual and extreme climate events; (2) the level of protection already in place in areas at risk, i.e. preparedness; (3) the state's liability for damages; (4) the potential and impacts of autonomous adaptation and remedial actions; (5) the cross-border effects of climate change; and (6) the fiscal capacity of the member states and the role of the EU.

The mechanism of drivers is illustrated in Figure 3, below. Direct fiscal costs are the construction and maintenance of protective infrastructures, the additional maintenance of public infrastructures affected by climate change, the changes in social expenditures mainly from potential repercussions on employment or alterations in health expenditures. A certain type of direct "cost" can be the revenue changes of the budget because of shifts in the economic and trade structure or in the consumption. The indirect fiscal costs appears as impacts on fiscal capacity to deal with very long-term challenges, like climate change, by definition of CEPS & ZEW (2010:52).

Figure 3. Drivers of impacts, various national concerns



Source: CEPS & ZEW (2010:52, Fig.3.2)

The degree of exposure means the above mentioned region-specific characteristics related to local geography, climate and location in climatic belt. (E.g. average temperature, rainfall, coastal facilities etc.) The level of protection means the existing infrastructure for protecting or monitoring and early warning systems against natural disasters endangering lives and economic values, extreme weather conditions endangering human health. High level of existing protection saves a lot of investments for the budgets in the future. However, it has

been meaning a high level of permanent operating cost to keep the condition of systems and edifices. Early mitigating investments and intensive technological developments can reduce such type of cost factors. State liabilities for damages are any type of promise of state or expectable aid and help from the state which are paid or financed for victims of natural catastrophes, or financing the natural disaster relief. To reduce the scale of such liabilities, sophisticated and well developed private insurance sector is necessary, and thus the public support for its development is recommended.

Autonomous adaptation as driver of fiscal impacts represents the cooperative, initiative and supportive propensity of the private sector individuals. The actual occurrence of autonomous adaptation is the result of private utility-maximization objectives and their assessment of risks. The cross-border effects as impact drivers include two types of cost factors. One is the residual costs from actions in another country, the other type is the aid transfers for developing countries to adapt to climate change, or technology transfer to mitigate. Fiscal capacity as determinant of scale of spending for mitigation and adaptation shall be understood in dynamic approach. Not only the given balance of revenues and expenditure matters, but the potential changes of them do, too. This is called fiscal flexibility what means the taxation and spending room for maneuver of the fiscal government, the realizable potential scale of change of tax burden and expenditure by discretionary decisions. Standard & Poor's rating agency has even developed an indicator, the Fiscal Flexibility Index with sub-indices such as Expenditure Flexibility Index and Revenue Flexibility Index. (See Standard & Poor's 2007a and Standard & Poor's 2007b.) The fiscal flexibility can be extended through – first of all – the minimized indebtedness, the economic growth friendly economic policy and the lower scale of public finances, namely, lower total tax burden and public spending intensity with same balance. (Benczes & Kutasi 2010:95)

Generally, the cost impact of the drivers can be reduced by technological (R&D) investments, supranational provision and assistance, internationally integrated financial and technological resources, expansion of insurance market, regulation of land and water use, information provision for awareness, direct fiscal incentives to help individual actors for autonomous mitigation, review of state liabilities. (CEPS & ZEW 2010:59-62)

As mentioned above, fiscal impacts can be derived from the economic impacts which are preferable to be anticipated by the economic actors. Such general impacts are the average temperature in the seasons, along with an expected rise in temperature extremes; precipitation patterns; snow cover; water systems – particularly river flows (flood and drought risks) and groundwater levels; and coastal regions – with sea level rise and flood risks.

The following economic and natural impacts are expectable, what might demand autonomous and/or planned adaptation. (UNFCCC 2007, World Bank 2009, Fischer et al. 2007, Bosello et al. 2009, Bräuer et al. 2009)

- In the agriculture, change in cultivation to more thermophile plants, redesigning drainage systems, building and reconstruction droughts, rethinking short land tenancy period, earlier seeding, potentially an additional crop rotation, expanding variety of crops and plants, developing of new crop types, increased use of fertilization and plant protection; water-saving cultivation; development of plant and animal disease and pest monitoring; new insurance regulation;

- In the forestry, the needful actions: control of pests and diseases; enhance resistance of forest by mixed stands; earlier evacuation of trees after pests damage; forest fire and related monitoring system; rapid harvesting after wind damages; forest transformation to higher diversification of tree types;

- In health sector, the heat stress, vector-borne diseases, increasing use of the health service capacity.
- Water related factors are the floods, heavy rains, coastal sea level, droughts, ice accidents, fertilizer in water reservoirs.
- Tourism related impacts: less snow for winter sport, algal blooms, sea level, hotter or longer summer periods.
- Energy sector related impacts are less heating, more cooling, unreliable water transport, limited water cooling, better temperature for biomass, increase in precipitation, power cable damages, changes in wind velocity, research demand.
- Transportation related impacts: drainage, resisting capability of infrastructure, risk of accidents by hot weather, erosion and flood damages, shorter ice and snow period, dried canals.

According to CEPS & ZEW (2010) the following type of fiscal cost impacts can be derived from the economic and natural impacts of climate change:

- Incentives for innovation and technological development
- Agricultural subsidies for guiding to new climate, and compensation for loss of agricultural lands by desertification or higher sea level.
- Relocation of infrastructure in coastal areas and building protective infrastructure (e.g. dykes)
- Restructuring tourism and energy sector and related transportation systems
- Compensation for lost real estates taken by the sea or nationalized territories for relocated infrastructure
- Adaptation cost of public buildings
- Cost of monitoring and providing early warning information
- Cost of health problems caused by changed climate
- Restructuring of employment
- Damages by natural disasters
- Compensation of poor part of society

The tax impacts can realize in the tax revenues depending on income and energy consumption. The transparency of carbon pricing in taxation will also determine the energy consumption propensity, thus the energy related tax revenues.

#### 4. Climate change as one of the fiscal sustainability factors

As it was written by Heller (2003), the public finances are challenged by long-term structural problems like aging population, sharp increase of population in emerging and the least developed countries, health and disease problems, technological change, globalization of capital, labour and consumer markets, and of course last but not least the climate change.

Before mentioning any practical issues of public financing, there is a theoretical frame what must be taken into any account. Namely, sooner or later any public expenditure must be covered, otherwise debt crisis is expectable. To avoid the default, budget constraint is guiding principle, which means that the present value of future expenditures and revenues and the liabilities accumulated in the past should be in balance. (Benczes and Kutasi 2010)

$$PV(\text{debt} + \text{future expenditures}) = PV(\text{future revenues})$$



If the budget constraint is continued through the findings of Fatás et al. (2003), Grauwe (2000), Buiter and Grafe (2004), Chalk and Hemming (2000), the affordable deficit can be concluded from the budget constraint:

$$\Delta b = g - \tau + (r-n)b - m,$$

where  $\Delta b$  is the change of debt in % of GDP (namely, the budget balance),  $g$  is the public spending in % of GDP,  $\tau$  is the tax revenue in % of GDP,  $r$  is the real interest rate,  $n$  is the growth rate of GDP,  $b$  is the debt to GDP ratio, and  $m$  is the seigniorage revenue. This constraint still can be fined with overlapping generation aspects (see Zee 1988) and with crowding out impact (see Tobin and Buiter 1976, Bagnai 2004).

To evaluate the fiscal room for maneuver – e.g. before raising the green spending, – there is opportunity to form sustainability indicators from the budget constraint. A generally used one is the primary gap indicator by Blanchard (1990).

$$\tilde{d} = (n_t - r_t) * b_t$$

and

$$\tilde{d} - d_t = (n_t - r_t) * b_t - d_t$$

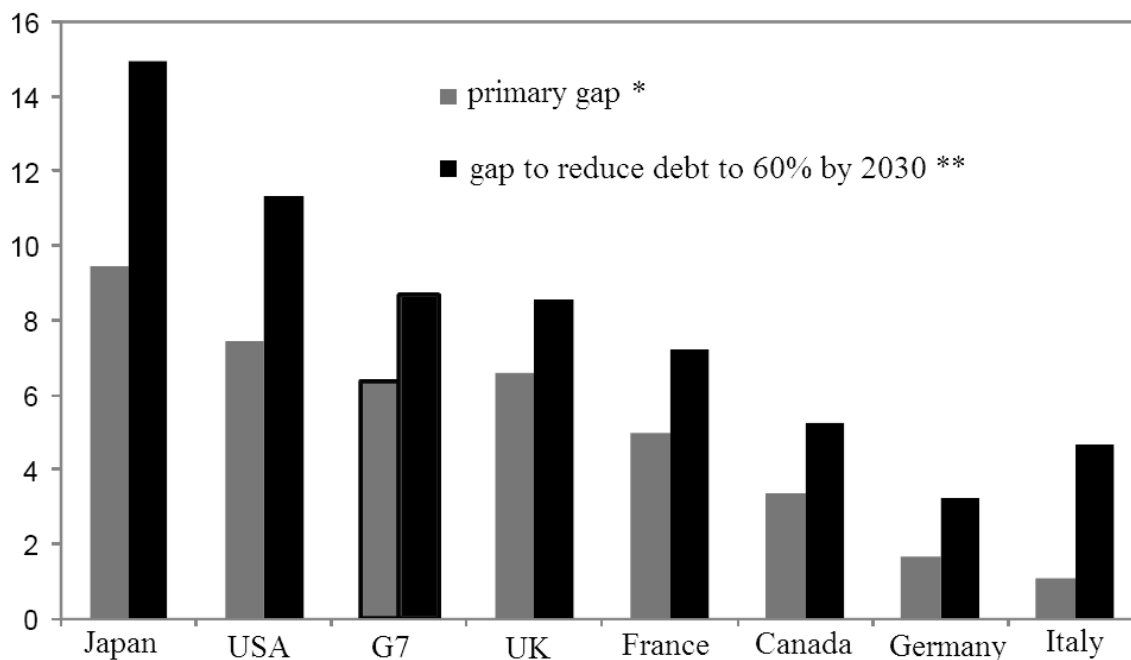
where  $\tilde{d}$  is the primary deficit,  $d_t$  is the realized general budget deficit,  $r$  is the real interest rate,  $n$  is the growth rate of GDP,  $t$  is a given year. If  $\tilde{d} < d_t$ , there is excessive budget deficit which destabilize the public financing. Real interest rate is calculated from the Fisher equation:

$$1 + i = (1 + r) * (1 + \pi),$$

where  $i$  is the nominal interest rate,  $\pi$  is inflation.

$$r = [(1 + i) / (1 + \pi)] - 1$$

Figure 4. Primary gap in G7 countries, 2010, %



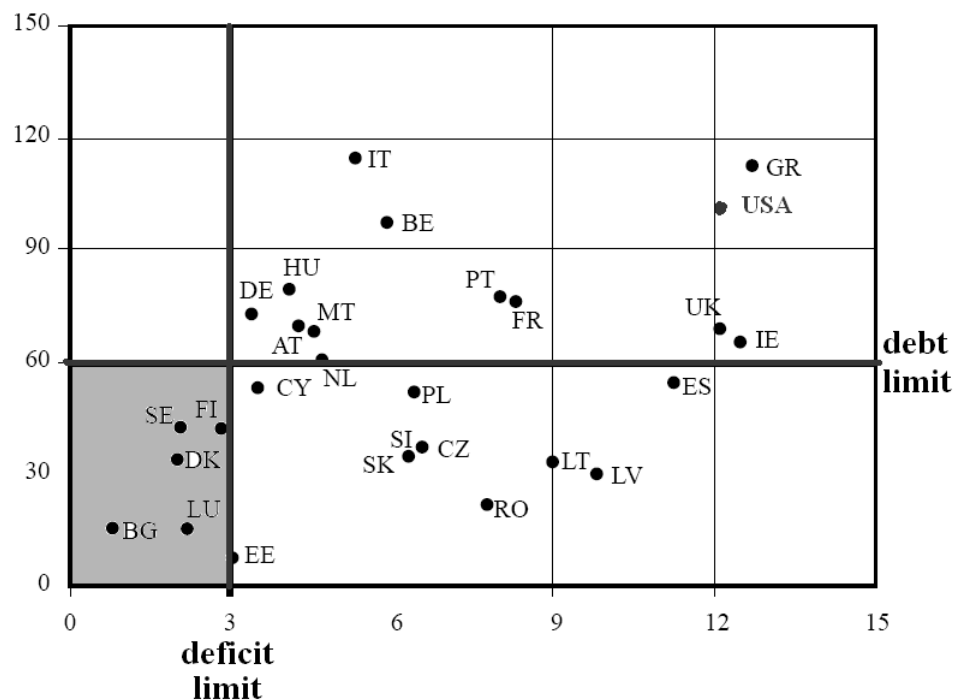
Source: IMF Staff Position Note SPN/10/13 (Long-Term Trends in Public Finances in the G-7 Economies) Fig. 7., p. 14, based on IMF Fiscal Monitor May 2010, IMF World Economic Outlook July 2010 Update, and IMF staff calculations and estimates.

\* The primary gap is the difference between the primary balance for 2011 that is needed to maintain the 2010 debt-to-GDP ratio and the cyclically adjusted primary balance (CAPB) in 2010.

\*\* The scenario assumes that the CAPB improves gradually from 2011 to 2020; thereafter, the CAPB is maintained constant until 2030. The CAPB path is set to reduce the debt-to-GDP ratio to 60 percent by 2030. For Japan, a gross debt target of 200 percent of GDP (net target of 80 percent of GDP) is assumed. The scenario uses country-specific interest rate-growth differentials.

As it is clear from the crude data of figure 5, and the primary gap indicator in figure 4, most of the high developed countries have trouble with the general budget balance. Besides, the primary gap indicator even represents a longer term fiscal adjustment period necessity for these countries. Especially the big key economies (USA, Japan, Germany, France, UK) must face to drastic return to balance during decades after many years of fiscal stimuli. The global crisis of 2008-2010 caused a serious turmoil in many EU states' public finances. Only six EU countries could keep the deficit criterion in 2009 (see graph 1.), four of them (Sweden, Denmark, Estonia, Bulgaria) have not introduced the euro. The other countries have diverged both in debt and deficit. Since 2010, during one and a half year many euro zone countries had difficulties in debt financing (Greece, Portugal, Ireland, Spain). Some euro zone members also have got closer to non-credible indebtedness (Italy, France). In USA, the solvency gets also questionable in the middle of 2011 because of political disputes on debt ceiling. Big countries budgetary troubles spill over to their economies and to partner economies, thus causing them fiscal troubles, too. Such a global situation is not favourable for quick fiscal adjustment to the challenge by climate change.

Figure 5. Fiscal sustainability problem of EU and USA. Fiscal impact of crisis on debt (vertical axis) and deficit (horizontal axis) in 2009, % of GDP



Source: Eurostat

In case of a new type of spending forced by external natural factors, just like the prevention or damages from climate change, the sustainability question can be composed also as a dilemma of hard or soft budget constraint. Hard constraint means budget balance beside restructuring of expenditures or tax revenues increasing together with spending. Soft constraint means

unilateral rise of spending what results higher overall deficit. (Kopits 2000) The hard constraint is not attractive for political deals. The soft constraint causes increasing default risk. If sustainability is a primary objective, soft budget constraint is not an option, however political deals can frequently overwrite the economic rationale.<sup>4</sup>

Besides, any case of increasing scale of public budget, also because of green spending or taxes, raises another policy dilemma. Namely, does it worth to strengthen the fiscal crowding out impact? (Tobin & Buiter 1976) The increasing spending (indifferent whether form tax revenues or debt) results higher market interest rate as cost of credit. The increasing public spending turns the private investments and consumption to be declining. This crowding out impact will be important, also, to explain why the private sector becomes more and more passive in mitigation and adjustment when high government activity is observable. So not only free riding is behind the passivity of the private sector, but crowding out can be another explaining factor. The extent of any crowding out will be determined by the elasticity of money demand, the capital income to total income ratio, the wealth to out-put ratio, the level of taxation and interest rate and the speed of growth.

## 5. Fiscal policy dilemmas related to climate change

Through the recognition of indebtedness of highly developed (and climate sensitive) countries, the climate dilemmas of public finances can be worded. The first dilemma is the following: As there is no satisfying room for issuing more debt to cover the fiscal climate adaptation, the two options for fiscal policy are the redistribution among the items of taxes and spending or levy as much cost as possible on the private sector through perfect markets, like a sophisticated insurance sector. However, the two horns of the dilemma demand challenging balancing. If the private sector with limited time horizon got no fiscal (public) impulse at all, the private perception on net present value of adaptation will be considered to be negative, as individuals of the private sector can not optimize for the endless future, or more then a few generation. (See the paradox of Ricardian equivalence.<sup>5</sup>) In the contrary case, getting excessive fiscal subsidies, the community of individuals of the private sector will expect any adaptation from the state, thus remain passive.

The second dilemma rooted also in the limited room for issuing debt. The fiscal decision makers are forced by indebtedness to select among private actors, and create preference lists. Who should be compensated for damages, and who not? If rising sea level swallows coastal real estates, should the owners get subsidies, and how much? If productivity of agricultural lands were ruined by desertification, should the state bother with ensuring alternative income for rural workers and entrepreneurs? Should the ski parks get public or EU subsidies for snow guns if climate warming means too high temperature for snowing? etc.

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<sup>4</sup> About political factors of fiscal decisions see the literature represented by A. Alesina, R. Perotti, G. Tabellini, T. Persson, J. von Hagen, etc.

<sup>5</sup> In the economics models, it is a reasonable assumption, that the states as actors are immortal, so they should be considered as infinite ones. That is why, the Ricardian equivalence can presume, that it is indifferent for the state to finance a new item of spending either from raising tax or from public debt. If it was true, this aspect gives opportunity for infinite Ponzi game for states, and just always accumulate higher and higher debt by promising higher and higher future tax revenues. However, O'Connell & Zeldes (1988) and also Buiter (2004) emphasized, that it is not possible because of the finite or limited horizon of individual households as buyer of public bonds. As the buyers are thinking in finite future and they are in limited number, the assumption of public bonds with infinite maturity is unrealistic. Besides, the imperfection of capital markets can not treat perfectly the uncertainty of the future. That is why it is expectable from the state to pay all the debts in the unseen future, namely what is expressed in the form of  $PV(\text{debt} + \text{future expenditures}) = PV(\text{future revenues})$ .

The increasing green tax burden, bond issue and funding for mitigation and adaptation raises the dilemma whether does it worth to increase the fiscal crowding-out effect in the capital markets or not. This effect is very regional market specific because of the interest rate elasticity and marginal propensity of saving and investment. Of course, less investment can mean less carbon emitting production growth, but also slower technological development in carbon reduction, too.

Heller (2003:120-150) recommends conceptual aspects for long-term fiscal planning to finance long term mitigation and adaptation to any sustainability problem. Certain aspects are the limits or “stop sign” for certain ways of adaptation. First of all, the public financing has social welfare function, namely, the support for more vulnerable groups in the society. The climate change enlightens, too, that decisions makers should take into account the interest of the future generations as one of the most vulnerable group. Thus, the aims of policy making shall contain the objective of achieving fairness across generations, what means excluding Ponzi games<sup>6</sup> in budgeting, counter-weighting short-term political interest and eventually a kind of self-limitation in long-term borrowing for financing current outlays. The necessity of self-limitation rotted in the political economy recognition that there are individual interests behind the decisions, the principal-agent problem is an existing occurrence in public policy, and short-term interests are overweight, long-term interests are underscored in discretionary decisions. Institutional solutions, like fiscal rules, fiscal councils can improve the transparency and suppress political myopia, thus, treat the political obstacles.

Besides, the government must be able to assess correctly and ensure the financial sustainability, namely, the long-term public solvency. Sustainability means not only focusing on budget balance, but also, the sustainability of the tax burden, the adequate risk management on fiscal threats and weaknesses, the sustainable institutional mechanisms to ensure the far future balance, and the limitation on future policy makers’ discretionary decisions. The decision makers must preserve the scope for stabilization measures, even though they prefer to use the fiscal policy as an instrument for having influence on the economy. The efficiency of allocation for Pareto efficient income production means practically the elimination of distorting effects in tax system, the distribution of spending in optimal structure referring to the equity vs. efficiency trade-off, and the suppression on red tape concerning the public finances. Of course, not just the present, but the legacy of fiscal policy will disperse the position of countries or regions. Simply, the fiscal legacy can be expressed in the current scale of public debt. And not only the extent of debt, but its structure will matter, since in dynamic view, it can be the root of suddenly intensifying side effects. For example, indebtedness in foreign currency can modify significantly the solvency of debtors in a foreign exchange rate shock without short term risk management instruments. (Such impacts are called nonlinearities by Heller (2003:149).)

According to Heller (2003), state must be ready to anticipate market reactions driven by short-sighted interest. Private sector’s propensity for funding or resource saving can determine crucially the effectiveness and scope of public policy actions for adaptation. The governments must think about market side effects of the structure of realizing the long-term sustainability. Will the market help or weaken certain stimulating or restricting actions? What will be, for example, the effect of lower or higher risk premium on private savings and investments? E.g., it is well known about debt crisis impacts, that when the direct danger of collapse get milder the private interest groups get less devoted to public finances reforms, so, the politicians will ease the previous restrictions and deteriorate the previously improved fiscal balance or balancing program.

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<sup>6</sup> About Ponzi game in budgeting see more in Buiters & Kletzer (1992)

The items mentioned in the followings and serving the green adaptation causes structural changes in public finances. This aspect supposes to treat the green reform, also, as a structural fiscal reform together with balancing. The simplest way to move toward fiscal balance is, when the incomes grow faster than the expenditures in absolute share. Thus, at once, the collapse of economic growth dynamics can be avoided.

That means, the absolute growth of tax burden should be lower than the GDP-growth, and comparing even to tax increase, the growth of public expenditures should be much lower. However, this demands the public green spending not to be automatic, because the rigid expenditure types insensitive for business cycles will make the adjustment of spending unmanageable to the governmental solvency. Nevertheless, the tax incomes can not be decreased until the expenditures will not decline at least in the same scale. Besides, the expansion possibility of state debt means also limit in the play of tax reduction. (Tomkiewitz 2005)

The green reform basically is making an attempt to increase the net present value achievable through the fiscal policy, explained with the instruments of cost-benefit analysis is the following:

$\max PV \{ \text{benefit of society} - \text{cost of society} \}$

However, this cost-benefit analysis is fairly complex, that is why the results must be treated carefully to avoid misleading understandings. First of all, it is hard to measure any side effects of public expenditures and absorption. During the estimation of benefits the experts must face the comparison problem, how commensurable are the individuals' subjective utility. Wildawsky (1997) guess, the appraisal methods used in practice are very uncertain – at least in case of public services. The net present value calculation is uncertain in dynamics, as the costs can vary in the future. (Kutasi 2006)

The structural green reform of public finances is not simple corner-cutting or spare of expenditure targets. Any kind of efficiency-seeking restructuring related to revenues or expenditures can be mentioned under this category that will have a positive long-term impact for years or decades. In certain circumstances, the previous level of expenditures can be held. The essence of reform of public finances is, that the previous financing mechanisms get changed or reorganized to create more efficient structure independently from the current budget deficit or surplus.

In Drazen's (1998) approach, the fiscal reform is a common pool. Everyone consider this common pool to be made, but everyone wants it to be financed by others. This way, the possible utility created by a possible reform for everyone is in vain if there is high probability for burdening the cost on the certain individuals. This will be a 'war of attrition' impact on the reform, as most of the individuals will not support it. Moreover, the distribution of costs means actually a dispute on distribution of tax burden in the planning stage of restructuring, what will impede more the execution. Besides, the support of reform will be ruined much more in case of uncertainty of individual benefits. Many researches were made to find relation between the success of reform execution and the political institutional system. (see e.g. Strauch & von Hagen 2000, von Hagen, Hughes-Hallett & Strauch 2002, Alesina & Perotti 1999, Poterba & von Hagen 1999, Benczes 2004, Benczes 2008 etc.) These surveys concluded that mostly the plurality of decision makers, the pressure for consensus or the multi-party government usually weaken the fiscal discipline as well the not transparent budgeting procedures or the strong bargaining power of spending ministers against financial minister. Although, the political and multi-party system can not be question of restructuring, making efforts for transparency of budgeting procedure and dealing can do a lot for disciplined public finances. (Kutasi 2006)

## 6. Fiscal risk management of climate change

The general risk management of sustainable budgeting has broad range of instruments with many experience of practical implementation. The fiscal rules have become often used since the 1990s. (See Kopits 2001, Kopits & Symansky 1998, Kumar et al. 2009, Benczes 2008, Benczes & Kutasi 2010:122-144) The different types of rules are the balanced budget rule<sup>7</sup>, the public debt rule<sup>8</sup>, the golden rule<sup>9</sup>, the expenditure rule<sup>10</sup>. These rules are useful to restrict the short-sighted political decision makers in discretionary decision enforcement.

Besides rules, revising bodies can be established, which are typically called fiscal councils or fiscal boards with right to publish opinion, or, maybe, to veto on fiscal related decisions. Numerous example can be mentioned: the U.S. *Congressional Budget Office*, Dutch *Budget Inspectorate*, *Budget Directorate* (Blöndal & Kristensen 2002) and *Centraal Planbureau* (Debets 2007), the Belgian federal *High Council of Finance* (Buti et al. 2002, Stienlet 2000) , the Spanish *Consejo de Política Fiscal y Financiera* (Quintana & Torrecillas 2008) the German *Finanzplanungsrat* (Lübke 2005), the Portuguese *Program Financing Committee* and the *Unidade Técnica de Apoio Orçamental*, the British *Office for Budget Responsibility* etc.

In financing the very long-term impacts, just like the adaptation to climate change, the efficient solution for smooth, gradual accumulation is the fiscal funding (if the private insurance services can not create opportunity to shift the cost toward the private sector). Its weakness is that mostly those countries can easily establish such funds who have any way fiscal surplus typically from natural resource (oil) export. Such row material export based funds are e.g. the Norwegian and Russian oil funds for future pensions. Nevertheless, some member states of USA has also stability funds, or Australia has the *Future Fund* for public and military officers pension, the *Higher Education Endowment Fund* for college and university infrastructure development etc. (Blöndal et al. 2008)

The funding specified for climate change is called financing by green funding. In national level, it would be possible to select a certain type of fiscal revenue (just like the oil exporting countries do with oil trade revenues), and indicate it as a source of a fund. In high developed countries, year by year, there are specified items in the annual budget for subsidizing the modernization of carbon emission related technologies. But such spending frames are result of discretionary annual decisions made by the current government. This does not ensure the long-term financing of mitigation and adaptation. An automatic fund could not only ensure the current scale of subsidy, but also the security of long-term financing by accumulating the revenues.<sup>11</sup> Unfortunately, as it was already mentioned, the public budget has other long-term challenges related to demography, demanding funding for the future.

Especially in the developing countries, the national accumulation of green fund has no source. Besides, eventually the climate change is a global problem, so national, unilateral adaptation does not seem to be the most efficient. Alternative option is the international funding, where national budgets contribute as their quota prescribes. Its advantages are cooperation of low income and high income countries, and the stronger governmental commitment to the long-

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<sup>7</sup> Limitation on general government balance or primary balance.

<sup>8</sup> Limitation on public debt level.

<sup>9</sup> Debt financing is allowed only in case of public capital investment, infrastructure investment.

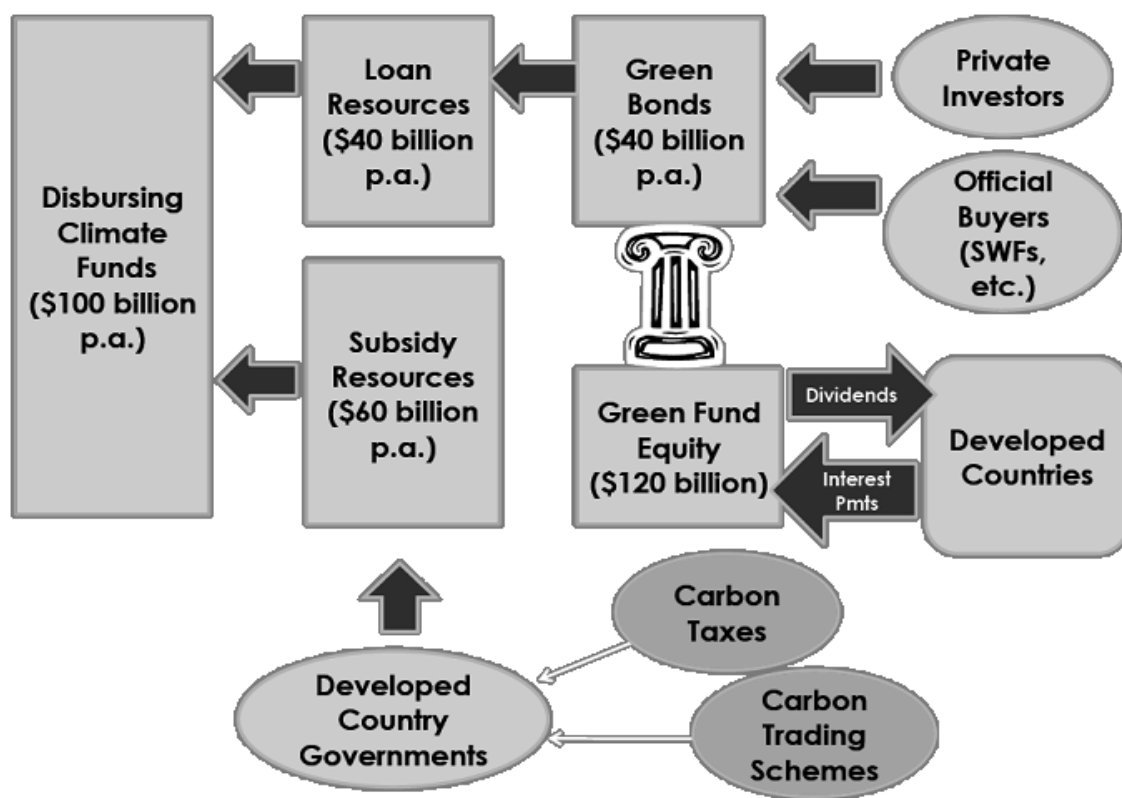
<sup>10</sup> Limitation on overall spending scale.

<sup>11</sup> Of course, ultimately the law-makers can reintegrate any fund back to the annual budget, if that is the will of the significant political majority. So national level green funding is neither the absolute solution for financing the long-term objectives.

term objective as giving up an international membership has more transaction cost (diplomacy damage) for a country than splitting a national fund. International green fund can be a mixture of national quotas, green tax revenue as direct income of the fund and market bonds financed by Sovereign Wealth Funds and other private investors. (See Fig.6.)

Such operating fund is the Caribbean Catastrophe Risk Insurance Facility (CCRIF) in the CARICOM, described by IMF (2008:31). CCRIF is multi-country risk pool and also insurance instrument backed by both public finances and capital markets. It was set to help CARICOM countries mitigate the short-term cash flow problems in disaster situations. It is a regional catastrophe fund for Caribbean governments, CCRIF operates as a public-private partnership, and is set up as a non-profit 'mutual' insurance entity. The CCRIF pays out in the event of parametric trigger points being exceeded. It provides rapid payment if disaster strikes. The CCRIF has coverage for hurricane, earthquake and excess rainfall. The facility is a fund operating particularly like insurance. There is plan to involve the agricultural sector and the energy companies.<sup>12</sup>

Figure 6. Financing by green funding



Source: Bredenkamp & Pattillo (2010:10)

Similar international green fund is in the period of formation. According to the Copenhagen Accord issued at the 2009 United Nations Climate Change Conference in Copenhagen, international Green Fund shall be ready in 2020 to ensure financial aid for developing countries. The design of the exact financing is illustrated by Figure 6. (Bredenkamp & Pattillo 2010) It seems, it is possible to capitalize a climate change adaptation from the private sector.

<sup>12</sup> For more see [www.ccrif.org](http://www.ccrif.org)

The international Green Fund will stand on private and public pillars. The public pillar is composed from national contribution quotas, national carbon tax incomes and national revenue from CO2 quota trade. The private pillar means issuing market bonds for private investors.

However, any public funding raises the dilemma of crowding-out mentioned above, as the CCRIF and Green Fund backed by states pumps the financial resources from private investments. Moreover, as a general international aiding problem, appearing also in critics on ODA (Official Development Aid) operation, that international organizations (funds) are not able to achieve critical mass of capital to swing off the developing countries from the problem of undercapitalized position blocking the efficient risk management. The credibility of such funds will be decided on its operation, the effective commitment of the members and the realized results.

To share the financing between public and private actors, namely planned and autonomous adaptation, beside the funding, there is an other item have been already mentioned in this paper, the insurance. However, simply private insurance is not enough to have efficient mitigation or adaptation. Phaup & Kirschner (2010) assume that public risk management is more efficient than individual, especially if it is preventive. On the other hand, it can become very expansive for the state, if private sector individuals see that they can get every protection from the state. The only state financed actions are called *ex post* budgeting, as it does not motivate the individuals to be preventive. That is why the optimum is the *ex ante* budgeting which accumulate reserves for the cost of catastrophe in the future, both from tax revenue and private income. The following options can be combined in the insurance sector for *ex ante* budgeting:

(1) The state makes market transactions by purchasing insurance service from insurance companies. Its advantage is that government can secure insurance for anything considered to be necessary. The disadvantage is that the insurance sector may will not be able to pay the compensation for all the damages.

(2) The state prescribes mandated purchase of insurance for the private asset owners. The advantage will be that the market will evaluate every object to be or not to be worthy for insurance. The disadvantage is that the private risk premium is very likely higher than the public risk premium.

(3) The government-provided insurance means that the state establish a state insurance company, e.g. New Zealand Earthquake Commission. In this case, the state can control the whole process of insurance, but the possibility of political intervention is very likely, that is why the efficiency of this option is questionable.

(4) Contingency Fund is the forth option, which is actually the government saving fund or green fund mentioned above.

Johns & Keen (2009) based their recommendations on situation of broadly afflicting heavy indebtedness and high deficit problems. They suppose to charge the CO2 emission with green tax to mitigate the warming and to avoid the higher deficit. Of course, introduction of a green tax has many side effects. If it hits the emission target, and CO2 pollution decreases, the tax revenue on CO2 scale will also decrease. If the green tax automatically increases the tax burden (tax wedge) on the economy, it can have the economic growth to slow down.

To manage the growth risk of crowding out and to cope with the crisis and recession of 2008, Jones & Keen (2009) proposed “green recovery”, namely state investment into green energy sector and CO2 saving technologies. Anyway, because of recovery, governments have been spending on stimulus packages. Such green stimuli could serve both the objectives of

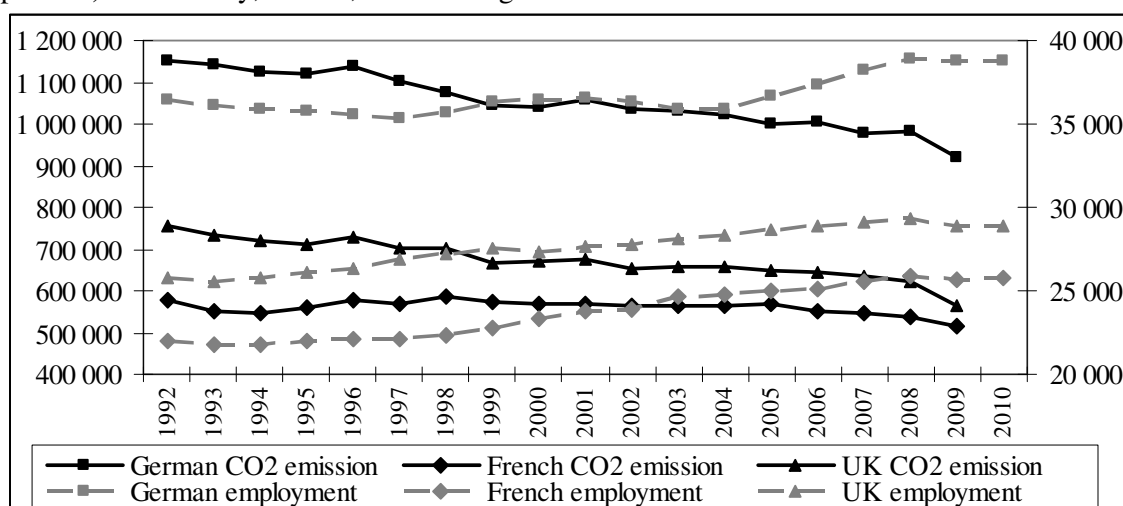


recovery and the mitigation through the multiplying impact of fiscal spending. This green recovery can be associated with employment objectives which are especially a sensitive field of economic policy, nevertheless in USA where the after crisis 2008 level of unemployment got up to 9.5-10%. Bossier & Bréchet (1995) has already recommended in the middle of 1990s that carbon tax can be connected to the cost problems of employment in Europe. As much scale of green tax burden would have been levied on the economy, so much scale of social contribution (or any other labour-related employer cost) should be eased by labour tax cut.

Even though it sounds simple, many side effects must be taken into account. How does the carbon emission tax raise the price of energy and fuels? If CO2 emission decreases, it means lower tax base, thus lower tax revenue. How to sustain the financing of social service systems if social contribution (health and pension contribution) has got decreased? Would labour tax really an incentive for more employment for companies? Is the tax cut critically enough to be effectively cheaper than foreign rivals? If companies do not see more demand, a tax cut will not motivate to hire more workers. Bossier & Bréchet (1995) warned for the risk of uncertainty and the necessity for simulation before policy actions. For example the E3ME (energy-environment-economy model of EU) by Barker (1998) was an econometric attempt to simulate effect of carbon tax on emission, GDP, competitiveness and employment.

There is a good practice on green tax reform combined with employment objectives in Germany. The *Gesetz zum Einstieg in die ökologische Steuerreform* (Act on entry into the ecological tax reform) got into power in 1999. Green tax was levied on primary energy consumption, parallel with it, the employers labour-related tax was cut. (Bach et al. 2002) Kohlhaas (2005) created *ex post* and *ex ante* model to estimate the GDP and employment effect of German green tax reform. Table 1 shows the results. The German green employment shows effective characteristics, as during the global crisis and recession the German unemployment could have decreased from 10% to 6%.

Figure 7. Scale of emission (left axis, 1000 tons/year) and employment (right axis, 1000 persons) in Germany, France, United Kingdom.



Source: Eurostat

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

Change in	1999	2000	2001	2002	2003	2004	2005	2010f
CO2 emission	-0.55	-1.33	-1.75	-1.95	-2.39	-2.47	-2.61	-3.1
Employment	0.64	0.76	0.67	0.41	0.76	0.63	0.52	0.46
GDP	0.39	0.47	0.44	0.29	0.45	0.38	0.3	0.13

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

## 7. Conclusions

It can be established, that climate change has introduced a new aspect into the structure of public finances both in expenditure and in revenue side. The exact fiscal impact in a given country is very uncertain since neither the exact regional natural impact is unsure, nor the unilateral national/regional mitigation could be enough and efficient without global cooperation. The fiscal impacts can be mapped by calculating with direct spending related to damages caused by climate change, and with indirect impacts in revenues and new expenditure themes caused through climate impacts on the economic growth, health condition, social relations and energy demand.

It is clear, that the multi-year fiscal stimuli to anticipate the global crisis started in 2008 created unfavourable fiscal rigidity for new types of spending, like climate change related mitigation and adaptation. It is not an easy task to enforce the political decision makers to prefer a 50-100 year-long problem to their short term interest related to political cycles, either. However, there are good practices how to build-in automatism into the budget by funding, how to keep the balanced budget by restructuring of spending and tax systems, how to involve the private (autonomous) financial resources through insurance and funding. The government must find the optimum distribution of adaptation cost between public (planned) and private (autonomous) adapting actors and the adequate structure of incentives to motivate the private individuals for cooperation and participation in mitigation and adaptation to climate change.

The efficient policy should treat with the factors or drivers of climate change cost, just like the degree of exposure to gradual and extreme climate events, the level of existing protection, the state's liability for damages, the potential and impacts of autonomous adaptation, the cross-border effects, and the fiscal capacity.

The public budget must be the reserve for mitigation with complex structure. Either infrastructural or social or health or industrial or employment etc. aspects can connect to the climate problem. It is not simple to introduce any fiscal item or action for mitigation and adaptation since fiscal crowding-out and multiplier effects must be simulated on savings, investments, carbon emission, economic growth, competitiveness, external balance and employment. The simulation in the same time means testing the policy risk, namely the potential failure of green budget reform, and the political risk, namely losing the next elections because unwanted side effects.

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.

As climate change is global problem, international/global cooperation is likely to be the most efficient also in fiscal aspect. International cooperation can give solution for risk distribution, low income insolvency, credible funding with private investors, technological cooperation and access to knowledge, efficiency of early warning and reserving sustainable national budgets, all together.

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