CENTRE FOR EUROPEAN POLICY STUDIES

Thinking ahead for Europe since 1983

Adaptation to Climate Change in the European Union
Efficiency vs. Equity Considerations

CEPS Working Document No. 301/September 2008

Stine Aakre and Dirk T.G. Rübbelke

Abstract

EU climate policy is based on GHG emissions reduction (mitigation), coupled with measures aimed at responding efficiently to the unavoidable consequences of climate change (adaptation). However, as the European Commission recently stated in its Green Paper on adaptation in Europe, there is still a need to develop an overall EU adaptation strategy. Moreover, such a strategy should take into consideration both efficiency and equity concerns. This study proposes a framework for EU adaptation policy that addresses both concerns and enables a transparent decision-making process. In the proposed scheme, universal weightings of the individual policy objectives have to be agreed upon prior to actual decision-making.

Keywords: adaptation, climate change, cohesion, EU policies, public goods, weight factors

JEL classification: D30, D61, H40, H50, Q54

ISBN-13: 978-92-9079-816-3
Available for free downloading from the CEPS website (http://www.ceps.eu)

Contents

ADAPTATION TO CLIMATE CHANGE IN THE EUROPEAN UNION: EFFICIENCY VS. EQUITY CONSIDERATIONS

CEPS Working Document No. 301/September 2008

STINE AAKRE & DIRK T.G. RÜBBELKE[*]

1. Introduction

Climate change presents the European Union with a dual challenge, and an appropriate response requires a two-pronged approach. First, in order minimise the most crippling impacts of climate change, greenhouse gas concentrations have to be reduced. Accordingly, transition to a low-carbon economy through measures to mitigate emissions constitutes a central pillar of the EU's climate change policy (European Commission, 2007a). Second, since climate change is already occurring, a climate policy based on mitigation must be coupled with measures that are designed to effectively adapt to the unavoidable impacts of climate change (European Commission, 2007a; IPCC, 2007). The latter requirement motivated the European Commission's launch of a Green Paper on adaptation in 2007, which sought to initiate a debate on how to devise an efficient and coordinated adaptation strategy for Europe.

To concentrate EU adaptation activities, the Green Paper outlines a four-action approach, among which developing adaptation strategies "in order to identify optimal resource allocation and efficient resource use which will guide actions at EU level, through EU sectoral and other policies and the available Community Funds" constitutes one of the four priority areas (European Commission, 2007a, p. 13). First of all, the European Commission identifies a need to define an appropriate role for the EU centrally, the scope for a Community level policy strategy and how best to assist local, regional and national adaptation efforts. Since there are several policy areas that will be directly or indirectly affected by the impacts of climate change, and since the impacts will inevitably vary from region to region "depending on physical vulnerability, the degree of socio-economic development, natural and human adaptive capacity, health services and disaster surveillance mechanisms", the Commission recognises the need for a multilevel governance-approach: "Whilst a 'one-size-fits-all' approach to adaptation is clearly not appropriate, climate change will nevertheless impact everywhere and those impacts will not follow administrative boundaries. In many areas adaptation will require a cross-boundary approach" (European Commission, 2007a, pp. 11-12). Second, the social dimension of an EU adaptation strategy is underscored: "In order to ensure that the poorer and disadvantaged regions and those regions that will be hit hardest by climate change will be able to take the necessary measures" (European Commission, 2007a, p. 12). Accordingly, in addition to expressing a need to define an appropriate division of labour between the different levels of government, in the Green Paper the European Commission points to the need to consider how adaptation can be

---

[*] Center for International Climate and Environmental Research – Oslo (CICERO), Gaustadalléen 21, 0349 Oslo, Norway, email: s.y.aakre@cicero.uio.no and dirk.ruebbelke@cicero.uio.no.

Acknowledgements: The authors would like to thank Asbjørn Aaheim, Bettina Damm and Karen Pittel for helpful comments and acknowledge that any remaining errors are their own. The work devoted to this paper is funded under the project "Adaptation and Mitigation Strategies: supporting European climate policy" sponsored by the European Commission and partly executed at CICERO.

taken into account in EU spending programmes, such as the Structural and Cohesion spending programmes.

Along similar lines, the new Cohesion Policy (2007-2013) stresses the importance of climate change in EU cohesion policy (European Commission, 2007b).[1] The Structural and Cohesion spending programmes are concentrated on Lisbon (innovation, growth, jobs) and Gothenburg (sustainable development) goals. In the period 2007-2013, cohesion policy will amount to €308 billion, 62% of which should finance projects linked to the Lisbon objectives (Artim et al., 2008).

Against this backdrop, in this paper we assess the appropriate levels of adaptation policy measures. What should be the different roles of EU, national, regional and local authorities? What are the conditions under which an EU-wide approach is more appropriate? Second, we address the expressed desire to establish a link between an EU-level adaptation policy and the new Cohesion Policy, i.e. the dual EU policy aims of efficiency and equity, by exploring the interplay between allocative and distributive aspects of adaptation conducted or supported by a central government within a single framework. How might distributional aspects be incorporated into adaptation policy? We demonstrate that if we explicitly integrate distributional aspects, there may be a role for EU policy in the adaptation field, even when the adaptation effects are only on a local or national scale. Moreover, desired distributional effects of supporting adaptation can be regarded as co-benefits of EU adaptation support, and accordingly, adaptation and cohesion policy may fruitfully be considered jointly.

According to Feldstein (1974, p. 139), "if expenditure decisions are going to reflect distributional preferences [...], economists should help to see that this is done in a systematic and consistent way". In this paper, we provide a proposal for how this could be accomplished on a European level by developing a framework that allows for including policy-makers' preferences/weights explicitly.

The paper is organised as follows. In Section II, we explore the dimensions of climate policy and of public economic policy. We discuss possible reasons why government intervention might be required (or why market forces may be unlikely to attain an efficient adaptation) in detail. In Section III, we investigate how adaptation policy should be organised within the EU. First, we address the question of 'on which level governmental intervention should take place', given that adaptation measures are rather heterogeneous. Second, we address the question of 'how decisions on adaptation programmes/projects should be made'. We propose a framework for decision-making that adheres to the twin EU policy goals of efficiency and equity. This framework allows for a transparent governmental decision-making process, where the allocative and distributive components are highly visible and distinguishable. Finally, Section IV summarises and concludes.

2. Dimensions of Climate Policy and Public Economic Policy

There are two different groups of policies responding to the threat of climate change: 1) **mitigation** policies that intend to combat global warming itself and 2) **adaptation** policies that pursue the prevention of damage caused by global warming, but do not target the prevention of global warming itself. The approach to adaptation needs to be different from the way mitigation has been handled. While mitigation in response to climate change primarily represents activities

---

[1] The EU Cohesion Policy was enshrined in the Treaties with the adoption of the Single European Act, with the purpose to "promote an overall harmonious development and strengthen economic and social cohesion by reducing development disparities between the regions" (European Commission, 2006).

to *protect nature from society*, adaptation constitutes ways of *protecting society from nature* (Stehr and Storch 2005). The IPCC (2001, p. 881) defines more extensively:

> Adaptation is adjustment in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. This term refers to changes in processes, practices, or structures to moderate or offset potential damages or to take advantage of opportunities associated with changes in climate.

From a public-economic-policy point of view, two polar groups of adaptation activities can be distinguished: 1) **those activities which are not contrary to the different objectives of public economic policy** and 2) **those activities which require government intervention** (e.g., because of free-rider incentives concerning the financing of adaptation measures) in order to be provided in a way such that the different objectives of public economic policy are met or at least not counteracted.

According to Musgrave (1959),[2] three basic objectives of public economic policy can be distinguished:[3]

1) establishment of an efficient **allocation** of resources,
2) attainment of the desired/proper **distribution** of income and wealth,
3) economic **stabilisation** (secure price-level stability and full employment).

As Musgrave (1959, p. 21) explains, the latter objective should not be accomplished by means of modifying the level of public expenditures on goods and services, but rather by means of transfers (or taxes) that are proportional to the proper distribution of income (i.e. that are distribution neutral). Consequently, adaptation measures do not represent attractive options for stabilisation policy, although adaptation measures in turn may have a positive effect on economic stability. Hence, we focus our analysis mainly on the other two objectives of public economic policy: the allocation and distribution branches. In particular, the distribution branch may also contribute to stability, since, as Alesina and Perotti (1996) identify in their analysis, income inequality tends to have a negative influence on economic growth.

As Hansen, Kelley and Weisbrod (1970, p. 364) point out, "distributional issues are at the heart of economic efficiency studies" and therefore the idea of economic efficiency goes beyond the scope of allocative efficiency. In response to the tendency in the literature to focus only on allocative-efficiency considerations, Weisbrod (1968) introduces the concept of "grand efficiency", which subsumes both allocative and distributive aspects. As he contends (1968, p. 184), distributional considerations are relevant to political decision-makers; "Therefore, when economists disregard these distributional considerations, they should not be surprised to find that their advice is not necessarily fully heeded by decision-makers". In line with this way of reasoning, Adger et al. (2005, p. 82) argue that the success of adaptation depends "not only on its effectiveness in meeting defined goals, but also on issues of equity and perceived legitimacy of action." Moreover, as Weisbrod (1970, p. 119) suggests, since government activities designed to alter the allocation of resources have side effects on the distribution of income, they may be utilised deliberately for the purpose of income redistribution.

---

[2] Musgrave (1959, p. 5) analyses the objectives of budget policy for an imaginary state and points out that "[T]he responsibilities of the Fiscal Department in our imaginary state are derived from a multiplicity of objectives." He subsumes and classifies these objectives within three groups of objectives which three different branches (allocation, distribution, stabilisation branch) of the Fiscal Department have to pursue respectively.

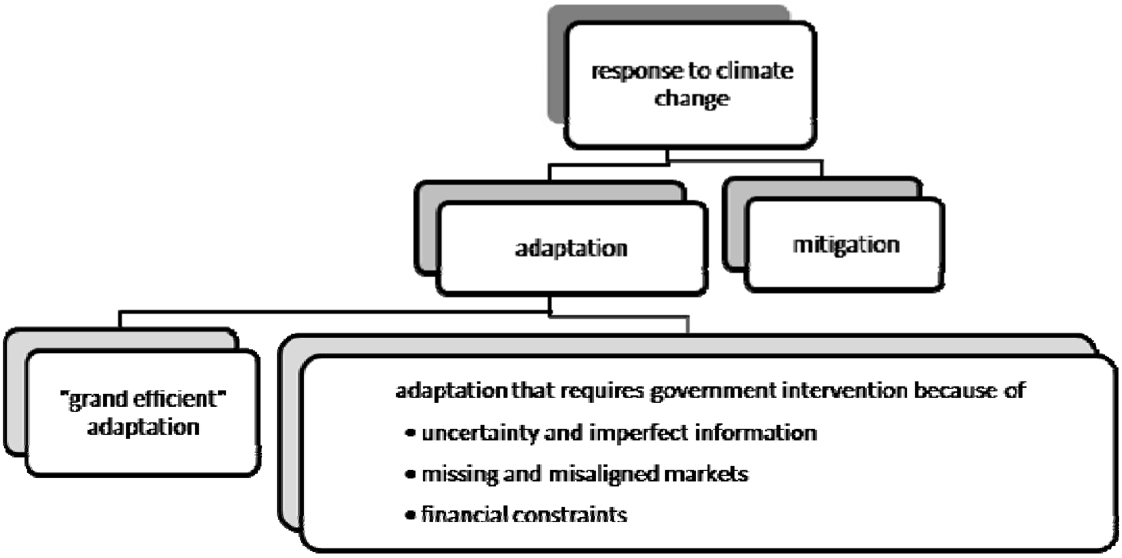
[3] Oates (1968) provides an analysis of allocation, distribution and stabilisation objectives and discusses the roles of different levels of government in the implementation of economic policy.

Consequently from a public-economic-policy point of view government intervention may sometimes be justified, even if allocation-efficient adaptation takes place autonomously or spontaneously (e.g., by market behaviour) or in the shape of planned adaptation measures by individuals (e.g. building a shelter for one person's car).[4] The reasons for governmental intervention concerning adaptation are discussed by Fankhauser, Smith and Tol (1999, pp. 68-69), who stress that successful adaptation depends to a large extent on 1) "timely recognition of the need to adapt", which in turn "requires access to reliable and detailed information, and the ability to process such information", 2) "an incentive to adapt", which in turn requires functioning markets or governmental regulation, and 3) "ability to adapt", which in turn may only be given if budget constraints are not too restrictive.

Stern (2007, p. 411) posits that in many cases the market forces are unlikely to generate efficient adaptation, broadly because of the following three reasons (see Figure 1):

1) uncertainty and imperfect information,
2) missing and misaligned markets (includes public goods issues), and
3) financial constraints.

Figure 1. Different Dimensions of Climate Policy



Referring to Musgrave's distinction of objectives, the first two reasons (uncertainty and imperfect information; missing and misaligned markets) specified by Stern mainly serve as a justification for government intervention due to missing allocative efficiency, while the third reason (financial constraints) mainly refers to the public-economic-policy objectives related to distribution (and stabilisation). However, beyond these three reasons, adaptation measures may also be implemented because they serve as a vehicle for redistribution in general. The central government may aim at a more equal distribution of income, for example, which may be achieved by supporting adaptation mainly in poorer regions. Consequently, beyond the aspect of financial constraints threatening the efficiency of adaptation and worsening the outcome for the poor, we regard the potential of adaptation measures to effectively redistribute welfare to the poor. Therefore, we follow Weisbrod's (1970, p. 119) advice to deliberately utilise reallocation for the purpose of income redistribution.

---

[4] Furthermore, such adaptation can be either reactive or anticipatory. For a distinction of adaptation types and forms see IPCC (2001, p. 883).

3. Government's Role in Adaptation to Climate Change

Regularly, analyses of adaptation policies are conducted in a piecemeal way. One of the few positive exceptions is Smit et al. (1999, 2000) who provide a systematic specification and differentiation of adaptation, based on three questions: 1) "adapt to what?" 2) "who or what adapts?"; and 3) "how does adaptation occur?". Furthermore, the question "how good is the adaptation?" could be added (Smit et al. 1999, p. 204; 2000, p. 230).

In contrast to this positive analysis (questions 1)-3)), the questions we will raise in our analysis are normative ones, in the sense that they suggest a framework for evaluating whether a given adaptation project is 'good'. These questions are however related to the positive questions 2) and 3) in Smit et al. (1999, 2000). More precisely, we develop a framework that allows decision-makers to address the following questions: "**which decision level** is adequate for EU adaptation efforts?" and "**how to decide** on a given selection of adaptation projects?" We argue that the extent to which a given adaptation project should be considered 'good' ultimately depends on the choice of decision level and the project selection procedure, and the extent to which such choices adhere to efficiency and equity concerns.

In this paper, our focus is exclusively on the governmental sphere. There exists a broad range of options for the government to respond to the threat of climate change by supporting adaptation. Among these, Fankhauser et al. (1999, p. 74) argue that perhaps the main role for government will be to provide the right legal, regulatory and socio-economic environment to support autonomous adaptation. However, sometimes it may be insufficient just to actuate autonomous adaptation. In particular, this is the case for public goods, i.e. goods characterised by being non-rival in consumption and having non-excludable benefits, such as large-scale coastal defence structures and river-basin management. The reason why governments may need to intervene in such cases is that such public good provision is often limited by free-rider incentives and is at risk of being underprovided.

According to Leary (1999, p. 309), "policies directed at adapting the provision of public goods to climate change and climate variability" are the most compelling cases where there is a rationale for not solely or heavily relying on autonomous adjustments of private agents, but for applying (additionally) public adaptation policy. In line with this reasoning, we will focus on the public goods aspects when we address policies to restore allocative efficiency in our analysis, i.e. we widely omit policies mitigating uncertainty and imperfect information.

There are different kinds of public adaptation goods. The heterogeneity of these goods is addressed in the subsequent section, where we describe the different geographical spheres affected by adaptation policies as well as the different technologies of public supply aggregation (TPSA).

3.1 Heterogeneity of public adaptation goods

Public adaptation goods are highly diverse, both with regard to their geographical coverage and the supply technologies. Adaptation policy has to carefully take into account the heterogeneity of the characteristics of individual adaptation options.

In order to illustrate the heterogeneity, first, we distinguish public adaptation goods concerning the geographic dimensions of their benefits, i.e. between local/regional/national, EU-wide/transboundary and global public goods. Second, we take a look at different technologies of public supply aggregation (TPSAs) associated with adaptation options. By employing examples of three different technologies we illustrate the respective heterogeneity of public adaptation goods, which is regularly ignored.

3.1.1 Geographical dimensions of public adaptation goods

There is a wide range of adaptation measures whose provision may be supported by governments because of their public good properties (see Table 1) and these measures may have effects on either sub-national or national (national public goods), EU-wide/transnational (EU-wide or transboundary public goods) or global (global public goods) levels.

Protection against landslides is a measure to protect the regional public good `infrastructure´, which may be subsumed under the concept of national public goods, i.e. public goods that do not exert effects that spill over across international boundaries.

Often river-basin management measures have transnational or EU-wide effects, and hence, constitute an example of what may be considered an EU-wide public good.

Support to poor countries in their efforts to adapt to climate change may prevent the international spread of illnesses or conflicts. The reasoning behind this is as follows: if developing countries are heavily affected by an extreme event like a flood, then there may not be enough capacity in these countries to prevent the induced spread of epidemic diseases on an international level. Furthermore, refugees leaving affected developing countries may lead to conflicts outside theses countries. Consequently, international adaptation support or cooperation helps to preserve international health as well as international security. International health (or prevention of the spread of illnesses) and security (prevention of violent attacks) exhibit properties of international or even of global public goods.

Table 1. Examples of adaptation measures and the geographical dimensions of their effects

National/Domestic Public Goods (Including Local and Regional Effects)	**EU-Wide/Transboundary Public Goods**	**Global Public Goods**
Protection against landslides by constructing an entrenchment	River-basin management	Support of adaptation in vulnerable developing countries → prevention of refugee disasters and armed conflicts
Protection against floods by constructing dikes	Provision of information about impacts of climate change and adaptation options (EU-focus)	Provision of information about impacts of climate change and adaptation options (in general)
Storage of drinking water	Implementation of a satellite-based fire detection system	Arrangement and maintenance of a coordination scheme for international assistance after extreme weather events (e.g. preventing the spread of epidemic diseases after flooding).

Furthermore, all countries could benefit from the dissemination of general information about climate change impacts and adaptation options. There is non-rivalry in consumption prevailing as well as – largely – non-excludability in the consumption of such information. Consequently, the provision of such information is a global public good.

3.1.2 Technologies of public supply aggregation

Different adaptation measures are associated with different technologies of public supply aggregation (TPSAs). TPSAs describe the relationship between an individual agent's contribution to a public good and the total quantity of the public good available for consumption (see Sandler 1998, p. 224).

Sandler and Arce M. (2002, pp. 207-208) explain that assessment of health risks and education of people about a disease are contributions to public goods whose TPSAs can be formulated as summation technologies. In a similar way we could argue that assessment of risks of climate change and education of people about climate change impacts and adaptation options contribute to public goods whose TPSAs can be represented by a summation technology. The total awareness and knowledge of climate change risks cumulates with overall educational actions, for example. Given the summation technology, the total amount of a public good (e.g., knowledge about climate change risks) is the sum of all individual contributions to this public good, i.e. individual provisions are added together in order to determine the aggregate level of the public good available to recipients.

In contrast, river-basin management that contributes to the prevention of overflows may be regarded as being associated with a weighted-sum technology. The international public good `prevention of overflows at the river Rhine´ may affect several European countries (Switzerland, Austria, Liechtenstein, France, Germany and the Netherlands) located along this river. Yet, the importance of contributions to this kind of European public good differs among the countries located at this river. Of course, the measures accomplished in an upstream country like Switzerland and which affect all downstream countries, tend to be more important than the ones in the downstream country the Netherlands. Consequently, the individual contributions to the public good should be weighted according to their effects on the total provision of the public good, before they are added together in order to find the aggregate level of the public good available to recipients.

Dike construction is an example of a public good associated with a weakest-link technology, as discussed by Hirshleifer (1983) in his seminal paper on the weakest-link concept. Here, the weakest-link in the defence structure of a dike determines the provision level of the public good ‘protection against the flood’.

3.2 Decisions about adaptation in the European Union

Before EU adaptation policy is conducted not only the nature of individual adaptation measures (which TPSA and which geographical influence?) but also the underlying decision rules should be determined, i.e. responsibilities should be assigned to individual government levels and adequate procedures for decision-making should be outlined.

In a first step, we analyse ***on which government level*** (national or EU level) decisions about producing public adaptation goods should be made. We confine the analysis to aspects of allocative efficiency, although distributive aspects are implicitly involved. Then, in a next step, we explicitly integrate distributional aspects into the analysis, which may provide some justification for EU intervention, even if local or national public adaptation goods are considered. We examine ***how decisions*** about local or national public adaptation goods should be accomplished on the EU level, when decision-makers’ preferences about income distribution have to be taken into account.

3.2.1 Which decision level?

Let us consider the standard public good case where the summation technology applies on an international level. The effects of an adaptation measure a_i are assumed to spill over to all considered countries and the total amount of adaptation (A) is the sum of one country i’s own provision (a_i) and the provision (A_{-i}) by all other countries. Yet, the provision of public adaptation activities has different impacts $\frac{\partial X_i}{\partial A}$ on the actual public good level enjoyed in the individual countries, where the public good $X_i(A)$ can be quite generally be assumed as "mitigation of climate change induced loss". In countries which are very vulnerable to climate change, an adaptation measure A in the shape of "generating information about adaptation options by means of research" will have a stronger effect $\frac{\delta X_i}{\partial A}$ than in countries which are not very vulnerable. The marginal utility of a country i stemming from adaptation can be expressed as follows:

$$\frac{\partial U_i}{\partial A} = \frac{\partial U_i}{\partial X_i}\frac{\partial X_i}{\partial A}. \quad (1)$$

Of the two partial derivatives on the right-hand side, the second is the marginal physical product of input A for country i, and the first is the valuation of the marginal product. The valuation $\frac{\partial U_i}{\partial X_i}$, i.e. the marginal utility damage reduction, may also differ among countries, e.g. it may differ between rich and poor countries.

With regard to the decision-making of individual countries we postulate Nash behaviour or zero-conjectures, i.e. each country i observes the current level of A_{-i} and conjectures that this provision level by the other countries will persist independently of any modification in its own provision level.

Let us regard a two-commodity world where the welfare of the individual countries depends positively on the extent X of becoming more adapted and on the level y of private good consumption. Each country i has an exogenously fixed initial endowment of I_i units of the private good. As the price of a unit of the private good is normalised to unity, one may think of I_i as country i's private income.

Country i's preferences over y and X can be expressed by the welfare function $U_i(y_i, X_i(A))$ which is assumed to be continuous, strictly increasing, strictly quasi-concave and everywhere twice differentiable with respect to its two arguments y_i and X_i. Country i maximises its utility derived from the consumption of the public good X and the private good y_i subject to its budget constraint $y_i + a_i c = I_i$:

$$\max_{y_i, a_i} U_i(y_i, X_i(A)) = U_i(y_i, X_i(a_i + A_{-i})) \quad (2)$$

$$\text{s.t.} \quad y_i + a_i c = I_i, \quad (3)$$

with $i = 1,..., n$. c stands for a constant uniform price, which the country has to pay for each unit of adaptation it provides. Maximising utility in (2) subject to the budget constraint (3) yields the first-order condition:

$$\frac{\frac{\partial U_i}{\partial X_i}\frac{\partial X_i}{\partial A}}{\frac{\partial U_i}{\partial y_i}} = c. \quad (4)$$

Hence, country i provides the public good up to the level where its marginal rate of substitution between public and private good $MRS = \frac{\frac{\partial U_i}{\partial X_i}\frac{\partial X_i}{\partial A}}{\frac{\partial U_i}{\partial y_i}}$ becomes equal to the price ratio c.

If we face the case that the adaptation measure is a European public good, i.e., a measure that generates transnational benefits exclusively in the European Union, the behaviour compatible with (4) is not Pareto efficient. For an outcome to be Pareto efficient, the EU consisting of 27 member states will have to agree upon a regulation that instructs each individual member state to produce that adaptation level which is consistent with the maximisation of the whole EU's welfare $U_{EU} = U_1(y_1, X_1(A)) + U_2(y_2, X_2(A)) + \cdots + U_{27}(y_{27}, X_{27}(A))$. Hence, the EU faces the following maximisation problem

$$max_{y_1,\ldots,y_{27},A}\, U_{EU}\left(U_1(y_1, X_1(A)) + U_2(y_2, X_2(A)) + \cdots + U_{27}(y_{27}, X_{27}(A))\right) \quad (5)$$

$$s.t. \qquad \textstyle\sum_{i=1}^{27} y_i + cA = \sum_{i=1}^{27} I_i. \quad (6)$$

Welfare maximisation yields the condition that requires the sum over all 27 countries' marginal rates of substitution between the public and the private good to be equal to the respective price ratio:

$$\sum_{i=1}^{27} \frac{\frac{\partial U_i}{\partial X_i}\frac{\partial X_i}{\partial A}}{\frac{\partial U_i}{\partial y_i}} = c. \quad (7)$$

Consequently, each country provides the public adaptation good up to a level where the sum of all EU-countries' marginal rates of substitution between public and private good $\sum_{i=1}^{27} MRS_i = \sum_{i=1}^{27} \frac{\frac{\partial U_i}{\partial X_i}\frac{\partial X_i}{\partial A}}{\frac{\partial U_i}{\partial y_i}}$ becomes equal to the price ratio *c*, i.e., transnational spillovers have to be taken into account. Yet, if there are no such spillovers, i.e., we face a local or national public good, then the utility function of country *i* would become $U_i(y_i, X_i(a_i))$ Consequently, condition (7) would reduce to condition (4). Therefore, from an allocative-efficiency point of view, the EU is required to intervene only in cases where transnational spillovers take place within the EU.

However, in case of transnational spillovers which are global, decision-makers also have to take into account spillover effects coming from and exerted on the rest of the world, i.e., it is not welfare maximising to rely just on condition (7). With respect to European welfare maximisation, free-rider incentives are important. If the EU raises its adaptation efforts in order to internalise EU-wide spillovers, for example, countries outside the EU may take a free (or easy) ride on the EU's increased adaptation efforts (e.g., in the case of fundamental research on adaptation) and may mitigate own efforts. The lowered adaptation level outside the EU would imply a lower level of positive adaptation effects spilling over to the EU.

3.2.2 How to decide?

If we explicitly integrate distributional aspects, there may be a role for EU policy in the adaptation field, even when the adaptation effects are only on a local or national scale. The EU could exploit the distributive consequences of providing adaptation. Desired distributional effects of supporting adaptation can be regarded as co-benefits of EU adaptation support.[5]

Weisbrod (1970, p. 129) points out that "[I]f the equity effects of a particular program are sufficiently favorable, it may be worthwhile to sacrifice some economic efficiency, but in any

---

[5] However, as Pearce (1997, p. 212) points out in his analysis addressing benefit-cost issues in the developed and developing world: "using projects to correct for fundamental inequalities in income distribution is the wrong way to deal with inequality."

event, account needs to be taken of both types of program consequences".[6] Sandmo (1998, p. 380) also stresses the importance of both efficiency and equity concerns: "Just as tax distortions represent the cost of redistribution, a more equal distribution is the gain from distortions. Both need to be taken into account in a balanced evaluation of the marginal cost of public funds."[7]

In this section we focus on the production of local or national public adaptation goods. Furthermore, we do not regard two different goods categories (private and adaptation good) as in the previous subsection, but instead consider one good category (adaptation good) exclusively by investigating the selection of different individual adaptation projects (like dike construction projects). Given a limited budget, the EU has to decide on which projects – which may differ by type and host region – to finance, since not all possible options can be funded. The choice should be – on the one hand – guided by the pursuit of allocative efficiency. On the other hand, in line with the policy goals of solidarity and cohesion, distributional aspects also have to be taken into account (European Commission, 2007a; b).

Let us consider the benefits W^i of a single adaptation option produced in a region i located within the EU. Similar to the representation by Eckstein (1958), we can define:

$$W^i = \lambda^i (pB^i - C^i), \qquad (8)$$

where λ^i is region i's marginal utility of money,[8] B^i are the physical benefits caused by the project in region i and p is the market price of B^i. C^i are the project costs. Based on Eckstein's concept we propose the following scheme:[9]

$$W^i_{mod} = \frac{\lambda^i (pB^i - C^i)}{C^i}. \qquad (8')$$

The higher the weighted net benefits per costs, W^i_{mod}, of a project, the more attractive it tends to be from the EU-decision-maker's point of view. Given a limited budget, the decision-maker will only select the most profitable projects and the remaining projects (with lower W^i_{mod}) will drop out. We divide the difference between weighted benefits and costs by the cost, because we suppose that the EU intends to maximise the net benefits and therefore, (8') tends to be a proper profitability indicator.[10]

Yet, we have to take account of the fact that the beneficial effects of adaptation may not have a market price and therefore p is subject to a non-market evaluation. As we can observe from the marginal benefit depiction $\frac{\frac{\partial U_i}{\partial X_i}\frac{\partial X_i}{\partial A}}{\frac{\partial U_i}{\partial y_i}}$ for public goods (in terms of marginal numeraire-good benefits) on the left-hand side of (4), there is the expression for the marginal physical benefit

[6] Johansson-Stenman (2005) shows that the use of distributional weights in the cost-benefit analysis regarding publicly provided goods does not necessarily imply inefficiency losses.

[7] Boskin and Sheshinski (1978) explore implications of partly dependency of individual welfare upon relative consumption for public policies that redistribute income via progressive income taxation.

[8] Brent (1984, p. 226) points out that redistribution in kind or using public projects is the basic justification for employing distributional weights in benefit-cost analyses.

[9] We disregard the fund-raising aspects here. Yet, we may assume that the EU-expenses for adaptation are covered in a lump-sum fashion by all individual regions.

[10] Otherwise, given the same λ^i for two projects, the project with $\lambda^i(pB^i - C) = \lambda^i(100 - 60)$ would be as attractive as the project with $\lambda^i(pB^i - C) = \lambda^i(70 - 30)$, although the latter project would generate a higher yield per monetary unit invested.

$\frac{\partial x_i}{\partial A}$ (mitigated damage loss) of adaptation included which in the one-good case - represented by equations (8) and (8') - has its counterpart in *B*.[11] Furthermore, there is also a valuation component $\frac{\partial U_i}{\partial x_i} / \frac{\partial U_i}{\partial y_i}$ included which can be interpreted as the marginal benefit of damage prevention (in terms of marginal numeraire-good benefits). The valuation component in (4) has its counterpart in value *p* in the one-good case. Were it the case that the utility function in (2) reflects welfare in utility units or 'utils' – instead of monetary units –, welfare effects in such utility units can be conveniently converted into monetary benefits by dividing the expression by the marginal utility of income.[12] Yet, the traditional school sets distributional weights equal to unity anyhow: "the competitive demand price for a given unit measures the value of that unit to the demander" and "when evaluating the net benefits or costs of a given action [...], the costs and benefits accruing to each member of the relevant group (e.g. nation) should normally be added without regard to the individual(s) to whom they accrue" (Harberger 1971, p. 785).[13] As long as there is no market price existing, the value of *p* may be approximated by means of willingness-to-pay (WTP) analyses. However, as Munda (1996, p. 164) points out: "WTP depends upon the *ability to pay*, thus projects which benefit higher income groups would generally be considered to be the best." Azar (1999, p. 249) refers to WTP in developing and industrialised countries and stresses that due to lower per-capita-income levels in poor countries, the WTP based estimates of damages in poor countries tend to be lower than in the industrialised world even if the impact is the same in human, physical or ecological terms. He suggests that one way to deal with this outcome "would be to introduce weight factors based on the different marginal value of money in the different regions of the world", i.e. he recommends assigning higher weights to poor regions (Azar, 1999, p. 249). Drèze (1998, p. 488) affirms this view: "In a world of resilient inequalities, it is hard to justify giving uniform weights to the benefits of a public project, irrespective of who enjoys them".

Yet, as Nash, Pearce and Stanley (1975, p. 127) remark, weights involving the income elasticity of the marginal utility of income cannot be measured. Therefore, rather than seeking to find the value of λ^i which precisely reflects the marginal utility of money, what we are interested in here is in λ^i as a political weighting factor that reflects the pursuit of political objectives.[14] These may however include the aim of more equal income distribution.[15]

In our analysis we presuppose that the valuation *p* of prevented damages has already been assessed, e.g., by means of the WTP concept. According to Fankhauser, Tol and Pearce (1997, p. 250): "There is nothing unfair *per se* in differentiated WTP/WTA values." Thus, we focus on the second part – the weighting factor λ^i – of the controversy which can be separated into two different issues:

---

[11] For a discussion of the compatibility of those approaches considering two goods (like equation (2)) with those considering only one good (like equations (8) and (8')), see Rübbelke (2002, p. 29).

[12] For the conversion of utils into monetary units given a social welfare function of the Bergson-Samuelson form, see Fankhauser, Tol and Pearce (1997, p. 254).

[13] The latter postulate is important for the design of the welfare function in (5). Harberger (1971, p. 785) adds a third postulate: "the competitive supply price for a given unit measures the value of that unit to the supplier". These three basic postulates provide the traditional framework for applied welfare economics.

[14] Johansson-Stenman (2000, p. 299) notes: "In practice, distributional weights are not very often applied in CBA, partly because the distributional consequences are often believed to be minor."

[15] Harberger (1978, p. 119) notes that low income by itself is not a sufficient index of social concern. He adds that we are, e.g., also concerned about the human suffering connected with unemployment.

> the valuation of environmental damages at an individual level, which is a matter of empirical analysis, and the comparison and aggregation of these effects, which is a political process involving ethical judgments on, among other things, the socially desirable distribution of income (Fankhauser et al., 1997, p. 250).

Put differently, we intend to impute to some individuals external benefits connected with the improvement in the circumstances of others and model a decision scheme that integrates these external benefits. To make the point more clear, we refer to Harberger's (1984) distinction between "distributional weights" and "basic needs" approaches.

The "distributional weights" approach takes account of the fact that the marginal utility of an extra dollar or euro to a rich person is lower than that of the same dollar or euro to a poor person.[16] In contrast, the 'basic needs' approach is based on the assumption that people receive a benefit from acts of supporting poor/disadvantaged people (e.g., healing the sick, feeding the hungry, etc.). Harberger (1984, p. 455) notes: "Similar motivations may also lie behind legislation in which societies have accepted a collective responsibility for meeting the medical, educational, nutritional and housing needs of their less fortunate citizens." Such legislation addressing collective responsibilities also exists on an EU level. By reference to the objectives of the EU cohesion policy we will explain how distributional aspects can be included in EU decision-making. Although we mainly pursue the 'basic needs' approach, we nevertheless employ weighting factors like in the 'distributional weights' approach.[17]

An alternative way of describing the employed approach is that of a management science approach, as discussed by Nash, Pearce and Stanley (1975, pp. 130-131). As Eckstein describes (1961, p. 445), "the economist must interpret the desires of the policy people whom he is serving and express them in an analytical form as an objective function." We seek to construct and maximise such an objective function given the empirical relations and institutional constraints in the EU.

The modelling of weights. The EU distinguishes three objectives of cohesion policy: 1) convergence, 2) regional competitiveness and employment, and 3) European territorial cooperation. The relevance of unemployment for EU policy has been also stressed in the Lisbon Strategy, which aims at making the EU the most competitive economy in the world and achieving more and better employment. Due to the multiplicity of objectives we have to apply a multiple indicator index (see Brent 1984, p. 223).

Next, we proceed on the assumption that, in general, EU projects located in countries and regions with low per capita income levels and high unemployment rates as well as interregional and transnational projects tend to be preferred to projects in more prosperous regions and those which do not require interregional/transnational cooperation. This is in line with what is generally perceived in the EU as a collective responsibility for the less fortunate regions. Moreover, it takes account of the fact that financial constraints to adaptation are most intensely perceived by the poor and that insufficient adaptation by the poor makes them more vulnerable than the rich.[18] Hence, they tend to be the main victims of climate change, which worsens their

---

[16] Another reason – in addition to the reason of utilities being concave in income – for applying distributional weights is that the social welfare function is concave or quasi-concave in utilities, so that a utility rise from a low level augments social welfare more than the same utility increase from a high level (see Johansson-Stenman, 2000, p. 301).

[17] Consider that the European Commission considers equity-weighted global marginal cost estimates for CO_2 in its cost-benefit analysis of domestic climate policies (European Commission, 2005: 20-21).

[18] "As an overall tendency, vulnerability may decrease as national income grows" (Fankhauser et al., 1999, p. 76).

financial situation. Therefore, the adverse distributional impacts consist of an exacerbation of existing inequalities. These adverse impacts can be addressed by EU policy intervention supporting adaptation in poor regions.

Consequently, the function λ^i takes the following shape:

$$\lambda^i = \lambda^i(E^i, Y^i, t^i), \qquad (9)$$

which is in fact an indicator that assigns the level of distributional adequacy to a project, where E^i reflects the country's or region's (un)employment (E^i is equal to 1 minus the unemployment rate in *i*), Y^i the per-capita income and t^i indicates to which extent the project is interregional (within a nation). t^i is the larger, the more the decision-maker assesses the project to have interregional/transnational character. λ^i could take the functional form derived and described in Appendix 2.1.

In line with McGuire and Garn (1969), we describe an index which takes on a set of values λ^i, with $i = 1, \dots, n$. This set gathers equity aspects, and the value of an individual λ^i is the higher, the poorer the respective region *i* performs (compared to the average). The different equity aspects included in the index have to be weighted. The weights reflect the subjective judgments of decision-makers.[19]

In a first step, we consider adaptation measures with national impacts, i.e. projects that constitute mainly a national public good, and therefore choose EU member state-level data – instead of smaller regional entities – as references. In a second step, we take a look at adaptation measures that have local effects only, i.e. at the level of smaller regional entities. We omit the interregional/transnational component t^i for the following two reasons: 1) We focus on adaptation activities which are purely regional or purely national public goods, i.e. there are no spillovers affecting areas outside the considered region/country; and 2) our main interest is in aspects of equity (regarding income and employment).

Nationally public adaptation. The average GDP per capita at current market prices in the EU-25 was $\bar{Y} =$ 23,400 Euro in 2005.[20] The rate $\bar{E}$ (= 1 – minus the average unemployment rate in the EU-25) in the EU-25 was 91.2. For λ^i, we can write:

$$\lambda^i = a\theta \left(\frac{91.2}{E^i}\right)^{\alpha} + b\left(\frac{23{,}400}{Y^i}\right)^{\beta}, \qquad (10)$$

where we set $a\theta, b = 1/2$ and furthermore, we assume that $\alpha, \beta, \gamma \geq 1$. For a derivation of the functional form of λ^i, see Appendix 2.2.

Taking a closer look at Spain (see Table 2 in Appendix 1) for instance, we face numbers for per-capita income and employment that are approximately equal to the EU-25 averages. Therefore, efficiency should be a stronger criterion regarding projects in Spain than regarding those in countries which perform worse (and where the distribution factor should play a more important role). Latvia constitutes one example of such a country. For Latvia we get a value for λ^i which is equal to $\frac{1}{2} + \frac{1}{2}2.13^{\beta}$, that means, the benefits pB^i of a project accomplished in Latvia get a

---

[19] Munda (1996, p. 162) stresses that "there is no escape from value judgements." He discusses possible approaches for getting distributional weights.

[20] Data are from Eurostat (2007a).

higher weight, because there is a need for redistribution due to a very low average per capita income. In contrast, the λ^i for Spain is only $\frac{1}{2}+\frac{1}{2}1.01^{\beta}$.

A priori, it is not so clear how a trade-off between employment and income should be assessed. Depending on the decision-makers' subjective judgments, the components can be weighted in different ways, which is reflected by the parameters α and β. They also determine the relative importance of distributional issues compared to the objective of efficiency.

Cyprus has a rather high employment level, while the average per-capita income level is quite low. Conversely, Germany has an employment level that is below the EU-25 average, but a high average per-capita income compared to the EU-25 average. Again, the decision-maker would need to subjectively weight the relative importance of unemployment compared to low income levels.

It seems reasonable (although in a way subjective) to claim that countries in which income and employment levels are above average should not be penalised, but concerning these countries the decision-maker should make his decisions solely on efficiency grounds, i.e. the relevant decision criterion is the level of $\frac{pB^i-C}{C}$. Therefore, if $\bar{Y} \leq Y^i$, we may set $\bar{Y} = Y^i$ in equation (10) and if $\bar{E} \leq E^i$, we may set $\bar{E} = E^i$ in equation (10). The respective results can be observed from Table 2 (see Appendix 1).

Regionally public adaptation. In this section we take a look at a selection of NUTS I regions that have a poor performance either with regard to employment or per-capita income. In contrast to the preceding section, we consider the EU-27 in 2005. The average EU-27 employment level (1 – unemployment rate) and per-capita income were 91.0 and 22.400 Euro, respectively. For λ^i in region *i*, we can write:

$$\lambda^i = \frac{1}{2}\left(\frac{91}{E^i}\right)^{\alpha} + \frac{1}{2}\left(\frac{22{,}400}{Y^i}\right)^{\beta}, \tag{11}$$

i.e., we set $a\theta, b = 1/2.$

As can be observed comfortably from the numbers in Table 3 (see Appendix 1), there is in many cases a trade-off between per-capita income levels and employment levels. So, given the same benefit pB^i and cost C^i levels of two projects – for instance the one located in the poor Romanian region of Macroregiunea Doi and the Belgian region of Bruxelles-Cap./Brussels Hfdst. which has a high unemployment level – which should be undertaken, if there is money available for only one of these projects?

For the Romanian region we get:

$$\lambda^R = 1/2 + 1/2(3.69)^{\beta}, \tag{12}$$

and for the Belgian region we obtain:

$$\lambda^B = 1/2 + 1/2(1.09)^{\alpha}. \tag{13}$$

As we can derive by equating (12) with (13), a decision-maker should be indifferent between both projects if:

$$\alpha = \beta\frac{\ln 3.69}{\ln 1.09}. \tag{14}$$

Yet, if the left-hand side is larger (smaller) than the right-hand side, then the EU should select the adaptation project in Belgium (Romania). Therefore, the decision about the right project depends on the weight the EU-decision-makers assign to employment vs. income.

Again, projects in regions that meet the EU-27 average numbers or even perform better should be assessed exclusively by efficiency criteria.

In order to illustrate how the weighting factor could be designed for project selection purposes, we select the following set of conditions (of course, the decision-maker may choose to rely on different conditions):

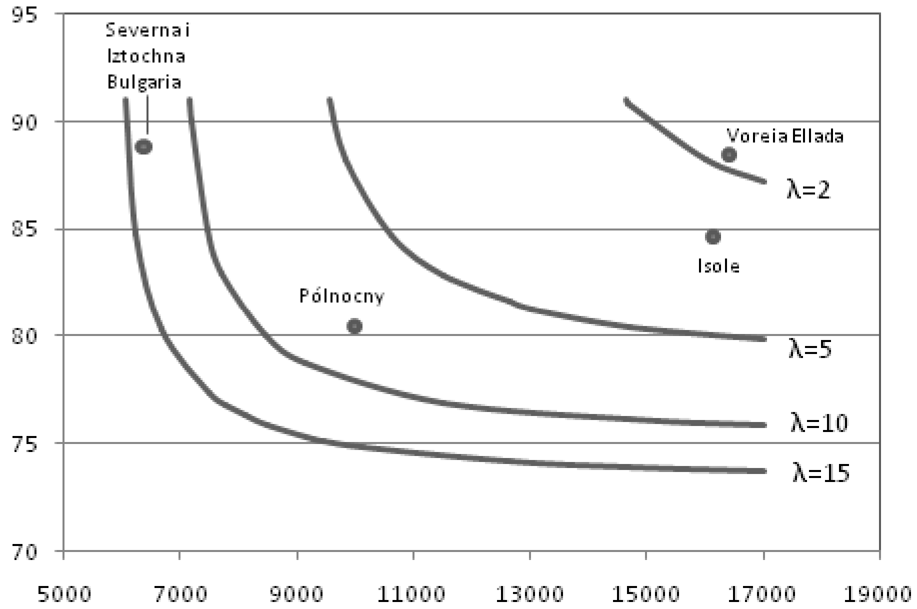
1) $\lambda = 1$, if $E \geq 91$ and $Y \geq 22{,}400$ (91% is the average employment rate and 22,400 the average per-capita income in the EU-27 in 2005).
2) If $E \geq 91$, then we set $E = 91$ and if $Y \geq 22{,}400$, then we set $Y = 22{,}400$.
3) In the worst performing areas we choose $\lambda = 15$. We choose Départements d'Outre-Mer (because it has the lowest employment rate of the regions gathered in Table 3) with $E = 73.9$ and $Y = 14{,}698$ and Macroregiunea Doi (because it exhibits the lowest per-capita income of the regions exposed in Table 3) with $E = 93.4$ and $Y = 6{,}074$.
4) $\theta = \frac{\Delta e}{\Delta y}$ and we assume that $\alpha = 0.5/\theta$.

Application of these conditions yields (calculations are displayed in Appendix 3):

$$\lambda^i = \frac{1}{2}\left(\frac{91}{E^i}\right)^{15.84} + \frac{1}{2}\left(\frac{22{,}400}{Y^i}\right)^{2.69} \qquad (15)$$

In Figure 2, the different weightings of regions are illustrated for four NUTS I regions (for weighting factors of selected NUTS I regions see Table 3 in Appendix 1).

Figure 2. Alternative levels of income and employment which have the same λ.



As can be easily observed, a lower weighting factor is assigned to Voreia Ellada than to Isole. Isole's projects should – in turn – be judged to a greater extent according to efficiency criteria than projects in Pólnocny. The lowest weighing factor of the four displayed regions is assigned to Severna i Iztochna Bulgaria. The regions Départements d'Outre-Mer and Macroregiunea Doi are not displayed but they are located on the curve reflecting the income and employment levels with $\lambda = 15$.

Our suggestion is to use such weights, in order to make sure that decisions on projects reflect the objectives of EU policy as well as their implicit distributional preferences in a consistent way. Politicians should agree on a reference weighting, evaluating trade-offs between objectives. Deviations from this consensus could be justified in individual cases, but they should be reported and explained by giving reference to the agreed reference weighting.

A structured analysis in the run-up of decision-making is especially important because of the heterogeneous patterns regarding vulnerability, employment and income levels in individual regions.

The figures in Appendix 4 illustrate the heterogeneity of NUTS I regions according to their vulnerability, per-capita-income and employment rates. Furthermore, the (degree of) trade-offs between these three decision criteria are dissimilar among individual regions. Yet, those regions most vulnerable to climate change - in the sense that they exhibit a high share of agriculture in the economic performance – tend to have a low per-capita income level. The relationship between share of agriculture in the economic performance and employment rate is however more ambiguous. These instances make decisions rather difficult: the more vulnerable regions, i.e. those where the highest benefit from adaptation (at given cost) can be expected, tend to have low per-capita-income levels and consequently seem to be attractive as recipients of EU support. However, from the employment levels we do not derive any strong advice regarding the eligibility of vulnerable regions (high share of agriculture) to become beneficiaries.

Like the agricultural sector, the tourism sector is vulnerable to climate change. Regions with higher tourism intensities (i.e. the number of tourist bed-places or number of tourist nights in a region compared with its population) tend to exhibit higher employment rates (see Eurostat, 2008a, pp. 6-7). Yet, the picture regarding per-capita-income levels is ambiguous (see Appendix 4).

4. Summary and Conclusions

By now, there is broad consensus that climate policy aimed at mitigation must be complemented by measures inducing adaptation to climate change. However, since adaptation may be conducted in inefficient ways, governmental intervention may sometimes be required. For the EU, which is a multi-level system consisting of heterogeneous member states and regions, this raises the question of what constitutes the right level of intervention (local, national or EU) and appropriate evaluation standards for adaptation projects. The necessity of addressing these questions is accentuated by the fact that – compared to mitigation – adaptation has been a largely disregarded policy field of climate policy until only recently, and research is still in an early stage (European Commission, 2007). However, much can be learnt from past research in other fields.

We started our analysis by making the traditional distinction between the public finance branches of allocation (efficiency), distribution (equity) and stabilisation and classifying the reasons for governmental intervention concerning adaptation by subsuming them under the individual branches. We proceeded by exploring what roles the government should play in order to improve the outcome of adaptation to climate change by considering two questions: 1) what constitutes the right level of decision-making within the EU for a given project, and 2) what constitutes adequate adaptation project selection?

One important field of action for EU adaptation policy is the provision of public goods. Public adaptation goods are heterogeneous, as we illustrated by describing different technologies of public supply aggregation associated with individual adaptation measures. Restricting our analysis to the standard case of a summation technology, we showed that decisions on EU-wide public adaptation goods should – from an allocative efficiency point of view – be made on the EU-level. In contrast, it is unclear whether decision-making on global public adaptation should be centralised to the EU-level, since spillover effects could cause a welfare reduction within the EU. Conversely, in order to get an efficient allocation in the case of national/domestic public adaptation goods, national government intervention in adaptation efforts may be justified, especially when taking into account that national governments may have information advantages on local/regional adaptation compared with decision-makers at the EU-level.

While the allocation branch does not identify any rationale for EU intervention in the case of national public adaptation, the distribution branch would under certain conditions suggest otherwise. This is because co-benefits can be generated by implementing adaptation projects, and these benefits may be higher in some EU regions than in others. The co-benefits are derived from pursuing adaptation and cohesion policies simultaneously. The EU could conduct an adaptation policy by allocating projects preferentially in regions where there is more need for support than in others, i.e. regions with low per-capita income and high unemployment rates, which are mainly intended to be supported by cohesion policies.

Motivated by the recently stated need to develop an EU adaptation policy that takes into consideration both efficiency and equity concerns, we propose a framework for selecting amongst different adaptation projects. The framework presented here enables a transparent decision-making process, since universal weightings of the individual objectives have to be agreed upon prior to the actual decision-making. Deviations from the predetermined weighting factors should be explained and justified. These weightings are no inflexible standards, but serve as reference for actual decision-making. Thereby inconsistencies and unsystematic ways of decision-making can be prevented.

Our analysis of adequate EU-decision-making on adaptation measures has its special appeal by also being applicable to projects in other policy fields in the EU.

References

Adger, W.N., N.W. Arnell and E.L. Tompkins (2005), "Successful Adaptation to Climate Change across Scales", *Global Environmental Change*, 15, pp. 77-86.

Alesina, A. and R. Perotti (1996), "Income Distribution, Political Instability, and Investment", *European Economic Review*, 40, pp. 1203-1228.

Artim, E., E. Baltzar, J. Fiedler, D. Sevic and R. Zhechkov (2008), *Investing in the Environment as a Way to Stimulate Economic Growth and Employment. How Environmental Projects Contribute to Achieving Lisbon Agenda Goals*, REC Grey Paper, The Regional Environmental Center, Szentendre.

Azar, C. (1999), "Weight Factors in Cost-Benefit Analysis of Climate Change", *Environmental and Resource Economics*, 13, pp. 249-268.

Boskin, M.J. and E. Sheshinski (1978), "Optimal Redistributive Taxation When Individual Welfare Depends Upon Relative Income", Quarterly Journal of Economics, 92, pp. 589-601.

Brent, R.J. (1984), "Use of Distributional Weights in Cost-Benefit Analysis: A Survey of Schools", Public Finance Quarterly, 12, pp. 213-230.

Drèze, J. (1998), "Distribution Matters in Cost-benefit analysis: Comment on K.A. Brekke", Journal of Public Economics, 70, pp. 485-488.

Eckstein, O. (1958), *Water Resource Development, The Economics of Project Evaluation*, Cambridge: Harvard University Press.

Eckstein, O. (1961), "A Survey of the Theory of Public Expenditure Criteria", in National Bureau Committee for Economic Research (ed.), *Public Finances: Needs, Sources, and Utilization: a Conference of the Universities*, Princeton: Princeton University Press.

European Commission (2005), *Winning the Battle against Global Climate Change - Background Paper*, The Commission of the European Communities, Brussels.

European Commission (2006), *A Reformed Cohesion Policy for a Changing Europe. Regions, Cities and Border Areas for Growth and Jobs*, The Commission of the European Communities, Brussels.

European Commission (2007a), *Adapting to climate change in Europe – options for EU action*, Green Paper, The Commission of the European Communities, Brussels.

European Commission (2007b), *Growing Regions, Growing Europe. Fourth Report on Economic and Social Cohesion*, The Commission of the European Communities, Brussels.

Eurostat (2007a), *Europe in Figures: Eurostat Yearbook 2006-07*, Luxembourg.

Eurostat (2007b), "New Member States Contribute to Reducing Unemployment in Europe", *Statistics in Focus*, 124/2007, Luxembourg.

Eurostat (2008a), "Are Recent Evolutions in Tourism Compatible with Sustainable Development?", *Statistics in Focus*, 1/2008, Luxembourg.

Eurostat (2008b), "GDP per Inhabitant in 2005 Ranged from 24% of the EU27 Average in Nord-Est in Romania to 303% in Inner London", *Eurostat News Release*, 19/2008, Luxembourg.

Fankhauser, S., J.B. Smith and R.S.J. Tol (1999), "Weathering Climate Change: Some Simple Rules to Guide Adaptation Decisions", *Ecological Economics*, 30, pp. 67-78.

Fankhauser, S., R.S.J. Tol and D.W. Pearce (1997), "The Aggregation of Climate Change Damages: A Welfare Theoretic Approach", *Environmental and Resource Econonomics*, 10, pp. 249-266.

Feldstein, M.S. (1974), "Distributional Preferences in Public Expenditure Analysis", in H.M. Hochman and G.E. Peterson (eds), *Redistribution through Public Choice*, New York: Columbia University Press.

Hansen, W.L., A.C. Kelley and B.A. Weisbrod (1970), "Economic Efficiency and the Distribution of Benefits from College Instruction", American Economic Review, 60, pp. 364-369.

Harberger, A.C. (1971), "Three Basic Postulates for Applied Welfare Economics: An Interpretive Essay", Journal of Economic Literature, 9, pp. 785-797.

Harberger, A.C. (1984), "Basic Needs versus Distributional Weights in Social Cost-Benefit Analysis", *Economic Development and Cultural Change*, 32, pp. 455-474.

Hirshleifer, J. (1983), "From Weakest-link to Best-shot: The Voluntary Provision of Public Goods", Public Choice, 41, pp. 371-386.

IPCC (2001), *Climate Change 2001: Impacts, Adaptation, and Vulnerability*, Cambridge: Cambridge University Press.

IPCC (2007), "Climate Change 2007: Synthesis Report. An Assessment of the Intergovernmental Panel on Climate Change", Intergovernmental Panel on Climate Change (available at http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf).

Johansson-Stenman, O. (2000), "On the Value of Life in Rich and Poor Countries and Distributional Weights Beyond Utilitarism", *Environmental and Resource Econonomics*, 17, pp. 299-310.

Johansson-Stenman, O. (2005), "Distributional Weights in Cost-Benefit Analysis – Should We Forget about Them?", Land Economics, 81, pp. 337-352.

Leary, N.A. (1999), "A Framework for Benefit-Cost Analysis of Adaptation to Climate Change and Climate Variability", *Mitigation and Adaptation Strategies for Global Change*, 4, pp. 307-318.

McGuire, M.C. and H.A. Garn (1969), "The Integration of Equity and Efficiency Criteria in Public Project Selection", Economic Journal, 79, pp. 882-893.

Munda, G. (1996), "Cost-benefit Analysis in Integrated Environmental Assessment: Some Methodological Issues", Ecological Economics, 19, pp. 157-168.

Musgrave, R.A. (1959), *The Theory of Public Finance*, New York: McGraw Hill.

Nash, C., D.W. Pearce and J. Stanley (1975), "An Evaluation of Cost-benefit Analysis Criteria", *Scottish Journal of Political Economy*, 22, pp. 121-134.

Oates, W.E. (1968), "The Theory of Public Finance in a Federal System", *Canadian Journal of Economics*, 1, pp. 37-54.

Pearce, D.W. (1997), "Benefit-cost Analysis, Environment, and Health in the Developed and Developing World", *Environment and Development Economics*, 2, pp. 210-214.

Rübbelke, D.T.G. (2002), *International Climate Policy to Combat Global Warming – An Analysis of the Ancillary Benefits of Reducing Carbon Emissions*, Cheltenham, Northampton: Edward Elgar.

Sandler, T. (1998), "Global and Regional Public Goods: A Prognosis for Collective Action", *Fiscal Studies*, 19, pp. 221-247.

Sandler, T. and M.D.G. Arce (2002), "A Conceptual Framework for Understanding Global and Transnational Public Goods for Health", Fiscal Studies, 23, pp. 195-222.

Sandmo, A. (1998), "Redistribution and the Marginal Cost of Public Funds", Journal of Public Economics, 70, pp. 365-382.

Smit, B., I. Burton, R.J.T. Klein and R. Street (1999), "The Science of Adaptation: A Framework for Assessment", *Mitigation and Adaptation Strategies for Global Change*, 4, pp. 199-213.

Smit, B., I. Burton, R.J.T. Klein and J. Wandel (2000), "An Anatomy of Adaptation to Climate Change and Vulnerability", *Climate Change*, 45, pp. 223-251.

Stehr, N. and H. Storch (2005), "Introduction to Papers on Mitigation and Adaptation Strategies for Climate Change: Protecting Nature from Society or Protecting Society from Nature?", Environmental Science and Policy, 8, pp. 537-540.

Stern, N. (2007), *The Economics of Climate Change – The Stern Review*, Cambridge: Cambridge University Press.

Weisbrod, B.A. (1968), "Income Redistribution Effects and Benefit-Cost Analysis of Government Expenditure Programs", in S.B. Chase Jr (ed.), *Problems in Public Expenditure Analysis*, The Brookings Institution, Washington, D.C.

Weisbrod, B.A. (1970), "Collective Action and the Distribution of Income: A Conceptual Approach", in R.H. Haveman and J. Margolis (eds), *Public Expenditures and Policy Analysis*, Chicago: Markham Publishing Company.

Appendix

Appendix 1: Overviews of Data for European Countries and Regions

Table 2. Employment and income data (EU-25, in 2005)

Country	E^i **(= 1 - unemployment rate in** ***i*****)**	Y^i **(= GDP per capita, in PPS)**	λ^i
Belgium	91.6	27,600	1
Czech Republic	92.1	17,100	$1/2+1/2(1.37)^{\beta}$
Denmark	95.2	29,100	1
Germany	90.5	25,700	$1/2+1/2(1.01)^{\alpha}$
Estonia	92.1	13,400	$1/2+1/2(1.75)^{\beta}$
Greece	90.2	19,200	$1/2+1/2(1.01^{\alpha} + 1.22^{\beta})$
Spain	90.8	23,100	$1/2+1/2(1.01)^{\beta}$
France	90.3	25,500	$1/2+1/2(1.01)^{\alpha}$
Ireland	95.7	32,100	1
Italy	92.3	24,100	1
Cyprus	94.7	19,500	$1/2+1/2(1.2)^{\beta}$
Latvia	91.1	11,000	$1/2+1/2(2.13)^{\beta}$
Lithuania	91.7	12,200	$1/2+1/2(1.92)^{\beta}$
Luxembourg	95.5	58,000	1
Hungary	92.8	14,300	$1/2+1/2(1.64)^{\beta}$
Malta	92.7	16,200	$1/2+1/2(1.44)^{\beta}$
Netherlands	95.3	28,900	1
Austria	94.8	28,700	1
Poland	82.3	11,700	$1/2+1/2(1.09^{\alpha} + 2^{\beta})$
Portugal	92.4	16,700	$1/2+1/2(1.4)^{\beta}$
Slovenia	93.5	18,700	$1/2+1/2(1.25)^{\beta}$
Slovakia	83.7	12,900	$1/2+1/2(1.09^{\alpha} + 1.81^{\beta})$
Finland	91.6	25,200	1
Sweden	92.2	26,900	1
UK	95.3	27,300	1
EU-25	**91.2**	**23,400**	

Source: Eurostat (2007a) and own calculations.

Table 3. Employment and Income Data (selected NUTS I regions in the EU-27, in 2005)

Region	E^i (= 1 – unemployment rate in *i*)	Y^i (= GDP per capita, in PPS)	λ^i(for $\alpha = 15.84$ and $\beta = 2.58$)
Bruxelles-Cap./Brussels Hfdst	83.7	53,876	2.46
Région Wallonne	88.2	19,592	1.53
Severna i Iztochna Bulgaria	88.8	6,663	12.15
Yugozapadna i Yuzhna tsentralna	91.0	9,289	5.35
Berlin	80.8	22,075	3.81
Brandenburg	81.9	17,800	3.56
Bremen	83.5	35,184	2.45
Hamburg	89.6	45,271	1.14
Mecklenburg-Vorpommern	78.7	17,547	5.93
Niedersachsen	89.6	22,704	1.14
Nordrhein-Westfalen	89.6	25,597	1.14
Saarland	89.2	24,698	1.19
Sachsen	81.3	18,863	3.76
Sachsen-Anhalt	79.7	18,441	4.91
Schleswig-Holstein	89.8	22,983	1.12
Thüringen	82.9	18,010	3.07
Voreia Ellada	88.6	16,699	1.83
Kentriki Ellada	89.9	17,442	1.56
Nisia Aigaiou, Kriti	91.8	18,488	1.32
Noroeste	90.2	19,663	1.28
Centro (ES)	89.8	19,340	1.35
Sur	87.0	18,285	1.86
Canarias	88.3	20,982	1.40
Île de France	90.5	38,666	1.04
Bassin Parisien	91.3	21,911	1.03

Nord- Pas-de-Calais	86.8	19,847	1.74
Est	91.4	21,934	1.03
Ouest	92.3	22,315	1.01
Sud-ouest	92.3	22,384	1.00
Méditerranée	88.5	22,304	1.28
Départements d'Outre-Mer	73.9	14,698	15,00
Sud	86.2	15,583	2.46
Isole	84.7	15,806	2.79
Dunántúl	93.1	12,651	2.68
Alföld es Észak	90.8	9,450	5.15
Centralny	84.3	15,634	2.94
Poludniowy	82.6	11,325	5.22
Wschodni	84.1	8,126	8.59
Pólnocno-Zachodni	81.1	11,507	5.89
Poludniowo-Zachodni	78.6	11,237	8.05
Pólnocny	80.3	10,139	7.49
Continente	92.2	16,832	1.55
Madeira	95.5	21,255	1.07
Macroregiunea Unu	92.9	7,794	8.12
Macroregiunea Doi	93.4	6,074	15.00
Macroregiunea Trei	91.7	10,612	3.94
Macroregiunea Patru	93.4	7,489	8.95
North East	93.9	21,598	1.05
Wales	95.5	20,643	1.12
Northern Ireland	95.3	21,726	1.04
EU-27	**91.0**	**22,400**	

Source: Eurostat (2007b, 2008b) and own calculations.

Appendix 2: Derivation of Functional Forms for λ^i

Appendix 2.1

Let us express the welfare of a country/region *i* as a function of employment level, per capita income and interregional/international integration:

$$U = Lf(E) + Ng(Y) + h(ty),$$

where

L =	size of labour force,
E = E/L =	employment rate in the considered country/region,
e =	employment in the considered country/region,
N =	number of inhabitants in the considered country/region,
Y = y/N =	average per-capita income,
y =	total income in the considered country/region.

It holds that

$$\Delta U = L\frac{\partial f(E)}{\partial E}\Delta E + N\frac{\partial g(Y)}{\partial Y}\Delta Y + \frac{\partial h(ty)}{\partial y}\Delta y = \frac{\partial f(E)}{\partial E}\Delta e + \left(\frac{\partial g(Y)}{\partial Y} + \frac{\partial h(ty)}{\partial y}\right)\Delta y\,.$$

We define:

$$f(E) = K_1 - \frac{Ea}{\alpha-1}\left(\frac{E}{E}\right)^{\alpha-1},$$

$$g(Y) = K_2 - \frac{Yb}{\beta-1}\left(\frac{Y}{Y}\right)^{\beta-1},$$

$$h(ty) = ct^Y y.$$

Hence, we get:

$$\frac{\partial f(E)}{\partial E} = f_E = a\left(\frac{E}{E}\right)^{\alpha},$$

$$\frac{\partial g(Y)}{\delta Y} = g_Y = b\left(\frac{Y}{Y}\right)^{\beta},$$

$$\frac{\partial h(ty)}{\partial y} = h_y = ct^Y.$$

We interpret additional benefits (expressed in monetary terms) received from a project as additional income. Such a project-induced income change has the following effect on welfare:

$$\Delta U = a\left(\frac{E}{E}\right)^{\alpha}\frac{\Delta e}{\Delta y}\Delta y + b\left(\frac{Y}{Y}\right)^{\beta}\Delta y + ct^Y\Delta y = \left(a\theta\left(\frac{E}{E}\right)^{\alpha} + b\left(\frac{Y}{Y}\right)^{\beta} + ct^Y\right)\Delta y,$$

with $\theta = \frac{\Delta e}{\Delta y}$.

Finally, we get:

$$\lambda = a\theta\left(\frac{E}{E}\right)^{\alpha} + b\left(\frac{Y}{Y}\right)^{\beta} + ct^Y.$$

Appendix 2.2

Let us express the welfare of a country/region *i* as a function of employment level and per capita income:

$$U = Lf(E) + Ng(Y).$$

It holds that

$$\Delta U = \frac{\partial f(E)}{\partial E}\Delta e + \frac{\partial g(Y)}{\partial Y}\Delta y.$$

We define:

$$f(E) = K_1 - \frac{\bar{E}a}{\alpha-1}\left(\frac{\bar{E}}{E}\right)^{\alpha-1},$$

$$g(Y) = K_2 - \frac{\bar{Y}b}{\beta-1}\left(\frac{\bar{Y}}{Y}\right)^{\beta-1}.$$

Hence, we get:

$$\frac{\partial f(E)}{\partial E} = f_E = a\left(\frac{\bar{E}}{E}\right)^{\alpha},$$

$$\frac{\partial g(Y)}{\partial Y} = g_Y = b\left(\frac{\bar{Y}}{Y}\right)^{\beta}.$$

We interpret additional benefits (expressed in monetary terms) received from a project as additional income. Such a project-induced income change has the following effect on welfare:

$$\Delta U = \left(a\theta\left(\frac{\bar{E}}{E}\right)^{\alpha} + b\left(\frac{\bar{Y}}{Y}\right)^{\beta}\right)\Delta y,$$

with $\theta = \frac{\Delta e}{\Delta y}$.

Finally, we get:

$$\lambda = a\theta\left(\frac{\bar{E}}{E}\right)^{\alpha} + b\left(\frac{\bar{Y}}{Y}\right)^{\beta}.$$

Appendix 3: Determination of *α* and *β*

Due to the four conditions we set up, it must hold that:

$$15 = 0.5\left(\frac{91}{934}\right)^{\alpha} + 0.5\left(\frac{22{,}400}{6{,}074}\right)^{\beta} \qquad (*)$$

as well as

$$15 = 0.5\left(\frac{91}{73.8}\right)^{\alpha} + 0.5\left(\frac{22{,}400}{14{,}698}\right)^{\beta}. \qquad (**)$$

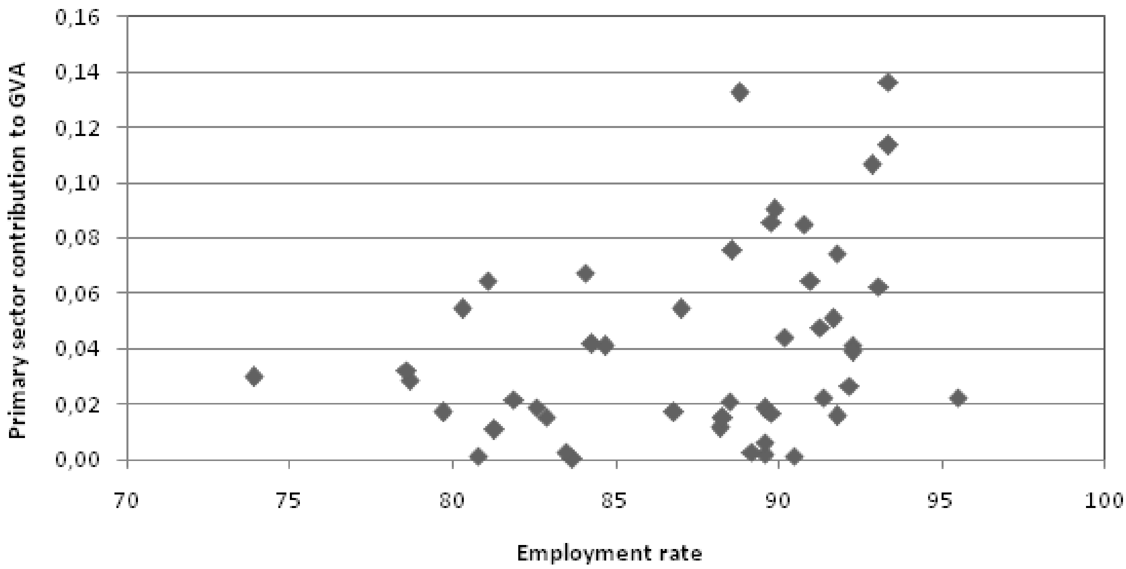
Due to condition 2), equation (*) becomes:

$$15 = 0.5 + 0.5\left(\frac{22{,}400}{6{,}074}\right)^{\beta} \qquad (*')$$

Solving (*') for β yields $\beta = 2.58$. By insertion of $\beta = 2.58$ into (**) and solving for α we obtain $\alpha = 15.84$.

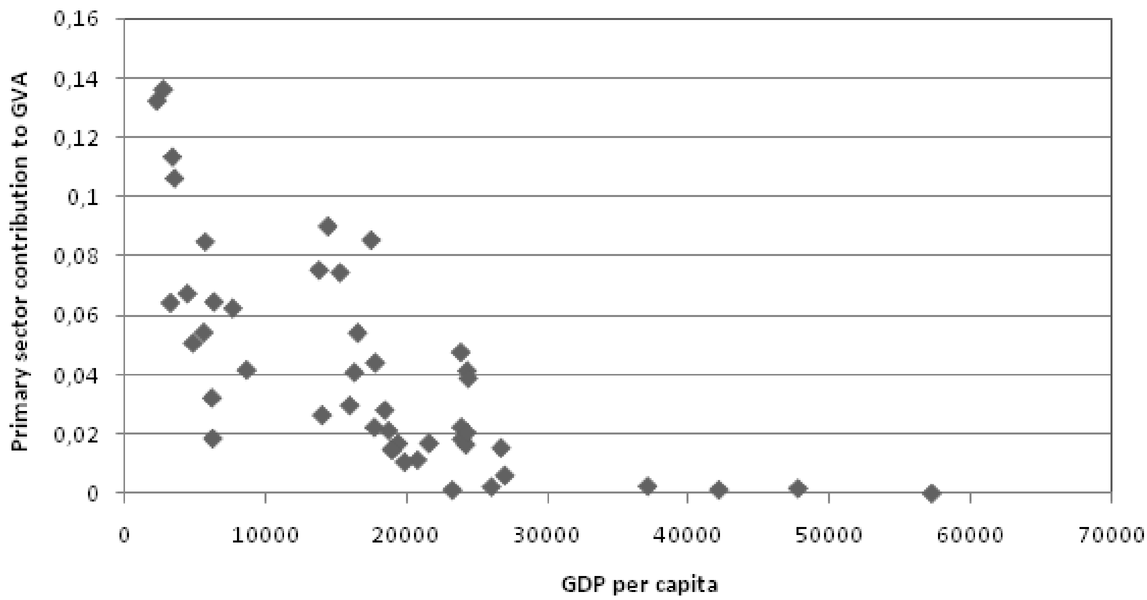
Appendix 4: Heterogeneity of NUTS I Regions According to Vulnerability, Per-Capita-Income and Employment Rates

Figure 3. Importance of Agriculture, Forestry and Fisheries vs. Employment. Selected NUTS I Regions 2005



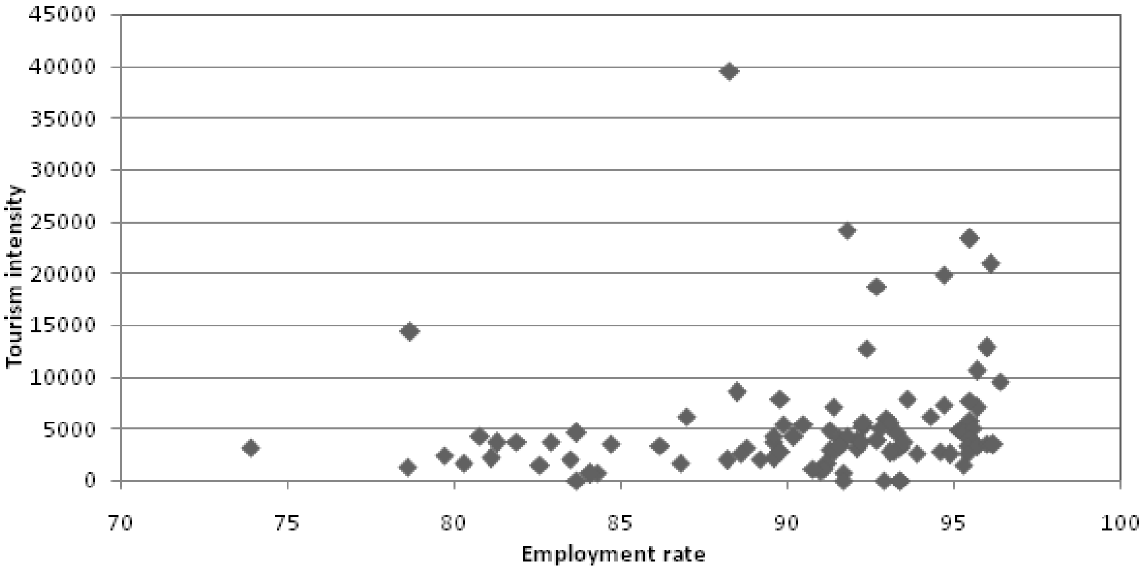
Source: Eurostat and own calculations.

Figure 4. Importance of Agriculture, Forestry and Fisheries vs. GDP per capita. Selected NUTS I Regions 2005



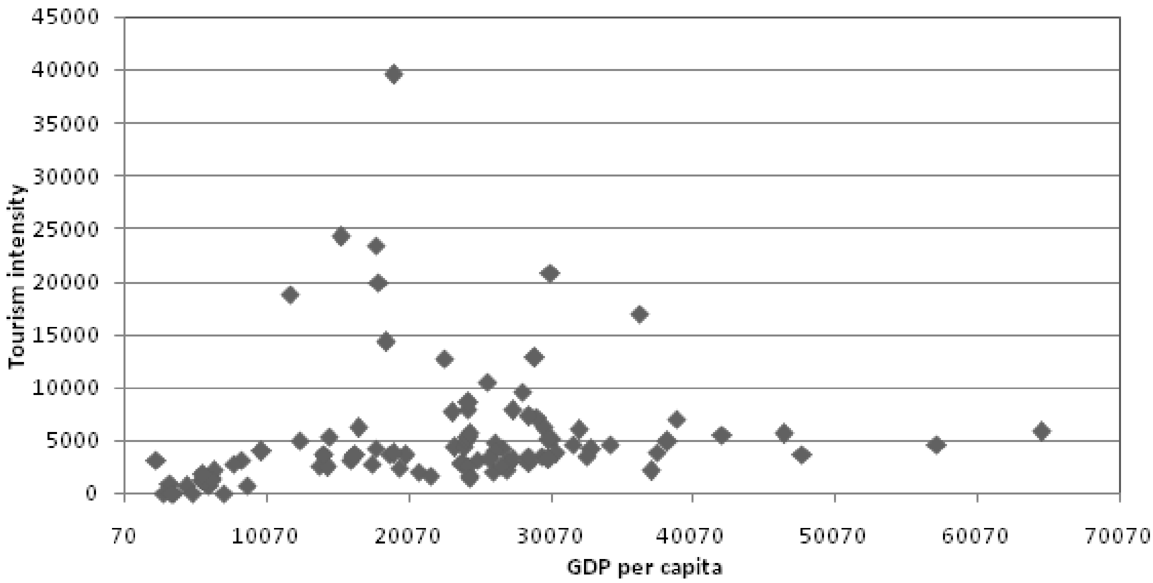
Source: Eurostat and own calculations.

Figure 5. Tourism Intensity vs. Employment. NUTS I Regions 2005



Source: Eurostat and own calculations.

Figure 6. Tourism Intensity vs. GDP per capita. NUTS I Regions 2005



Source: Eurostat and own calculations.