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**Fiscal implications of climate change impacts and adaptation policies in EU
Mediterranean countries: An application to sea level rise**

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Fiscal implications of climate change impacts and adaptation policies in EU Mediterranean countries: An application to sea level rise

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Long Abstract

Introduction

Public policy making faces diverse challenges and pursues a variety of aims. Its objectives can range from fostering economic development and reduce poverty to mitigating the negative environmental externalities, as well as providing a social welfare system. Given the diversity of objectives, there are also plenty of instruments that can be used to pursue a specific policy target, which should also be evaluated prior to its implementation since it will affect the public budget, and therefore its sustainability. Moreover, in the policy evaluation process the time dimension is also very important, in particular because of the transitional dynamics. Very often decisions are taken considering only short-run implications of policies that were designed and intended for the long-run. In this regard, the evaluation should consider both short- and long-run indicators to provide a proper assessment. This is true in particular for climate policies that address a long-run phenomenon such as climate change, but are subject to political considerations where short-run results also matter. This paper focuses on climate change impacts and the likely public adaptation expenditures which should be taken in order to deal with unavoidable impacts, but considering as well short-run indicators on the public sector. The focus is in on five countries of the Mediterranean area (France, Italy, Spain, Portugal, Greece) which show high public debt or experience troubles in keeping a balanced public budget.

In the current situation, where public budgets are overstretched due to economic crisis, there is an increasing pressure to understand the implications of climate policies as well as climate change impacts and adaptation strategies on the fiscal side. In a background of a financial crisis along with high levels of indebtedness for many countries adaptation policies are not regarded as an urgent issue, and they are often postponed in the political agenda. This perspective is crucial in the European Union, where a group of countries (mainly in the Mediterranean area) experienced growing levels of deficit and debt in the last decades. In this context, cuts in public expenses to reduce the gap between revenues and expenditures appear to be the winning strategy. In addition, because of their long- run outcomes, adaptation expenditures may not be among governments' priorities.

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Although adaptation has been less prominent than mitigation in the public, scientific, and economic debate for many years, this perception has recently changed. There are at least two main reasons for this. Firstly, climate change is already observable and given the inertia of the climate system it will inevitably intensify (EEA, 2008; IPCC, 2013a). In other words, even if the world does not warm more than 2°C above preindustrial temperatures, a target proposed by the EU (EU Council, 2004), adaptation is necessary. Secondly, the prospects for a binding agreement restricting the world's emissions sufficiently to halt climate change are at least uncertain (Helm, 2008). As for a definition of adaptation, we follow the IPCC (2013b) who defines adaptation as the "Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities". The new emphasis on adaptation, however, also raises difficult questions: What is the role of the public sector in supporting adaptation? Given the fundamental role of national governments to design effective national adaptation strategies, what would be the effects of those expenditures on the public budget? Is there any trade-off between spending for adaptation and spending for other purposes? Since the damages of climate change are likely to be sector- and region-specific, how does one allocate resources in the presence of budget constraints?

Climate change impact assessment in the literature

Traditionally, CGE models have been used to assess economic issues related to trade policy or tax reforms. However, recently they have been also applied to the study of the economic consequences of climate change impacts (a review of several CGE models recently applied to environmental issues is available in Bergmann, 2005). An important feature is that CGE models are able to explain to what extent and by which economic channels the climate shocks propagate to sectors and regions outside the impacted area. Therefore, CGE models measure the high order economic effects or indirect effects generated by the climate impacts in the economic system. They are usually combined with bottom-up approaches, such as Hydrological, Agro and Energy models, Global Circulation Models (GCMs), Geographic Information System (GIS), econometric estimations, and also tailored tools such as DIVA, and Global Vulnerability Assessment (GVA) for SLR (Hinkel and Klein, 2009; Hoozemans *et al.*, 1993) or MIASMA (Marten *et al.*, 1997) for climate change impacts on health.

The basic idea is to translate the output of the bottom-up models into inputs feeding the CGE models. This implies two tasks to be achieved. First, matching the two very different spatial scales. In fact CGE models are usually specified at the country level while bottom up approaches are much more geographical resolved. In general, the output of the bottom-up are re-aggregated at the country level in order to feed the CGE. Second, it is necessary to choose which variables in the CGE model will be shocked using the information stemming from the bottom up analysis.

The literature has been growing rapidly over the last decade and several applications can be found. The climate physical impact is usually the change in temperature or precipitation, the frequency of extreme events and SLR. This information stems from the bottom up approach, whatever it is. Then, the data are converted in a shock for the CGE model. The shock can be implemented by a reduction of available land, capital or labor for a certain sector following the change in the mean temperature and precipitation or the rise of sea level. Nonetheless, both sectoral demand for consumption and crop productivity yields can be affected as well.

Compared to the Integrated Assessment Models (IAMs), the CGE models have the advantage to consider a higher number of economic sectors. For this reason, they are used not only to assess the indirect economic effects in terms of GDP changes but also the indirect economic outcomes for a specific sector. Economic assessments have been carried out for agriculture, fishing, infrastructure, transport, mining, energy sector but also manufactures, services, health and tourism.

While CGE models are widely used to assess the fiscal implication of public policies, there are few examples of CGE that combine both aspects (climate change impacts and/or climate policies and fiscal implications). Olmos *et al.* (2011) use a CGE model to assess the fiscal direct effects of a transition to a low carbon economy in EU member states considering the public budget position as well. Reducing carbon emissions via a Carbon tax may have beneficial effects on the fiscal position due to the increase in public revenues (namely revenues from carbon pricing), although other policies increasing public expenses, such as increasing direct investments (to promote low-carbon technology development) or transfer payments, may worsen the fiscal position. These are fiscal direct effects which mostly affect the public budget, but there are other notable indirect effects, such as changes in state revenues and expenditures due to impacts of climate policy on economic activities. Burniaux and Chateau (2011) study how phasing-out fossil fuel subsidies could reduce fossil fuel consumption and emissions, and these action will also have effects on public budget. McKibbin (2012) focuses on the potential positive effects of carbon pricing on the government budget and other options of tax recycling in the USA. Most of the CGE models assessing the effects climate change impacts of on public budget are single country models (i.e. Arndt *et al.*, 2012; Arndt *et al.*, 2010a,b).

Including fiscal implications in a General Equilibrium framework

1. The model

Fiscal implications of sea level rise (SLR) are studied using a modified version of the core ICES model (Parrado and De Cian, 2012; Eboli *et al.* 2010). This extended version has an extended Government module following Delpiazzi and Standardi (forthcoming) to consider in a specific way the effects of climate change impacts and climate policies on the public budget. In the standard ICES model, the government was not considered as a single institution with its own budget constraint. Similarly to Hertel (1997), government consumption was one of the final uses in each country. This means that regional income was devoted to private and public consumption and private savings according to a Cobb-Douglas function. In this extension, instead, the representative household and the government have two different behaviors and two different budget constraints. The government receives income from tax revenues ($TTAX_r$), inter-regional and intra-regional transfers. Inter-regional transfers consider grants and aid paid and received by governments ($NETAID_r$), while intra-regional transfers includes social transfers from central government to households ($TRNG_r$). Moreover, interest payments (INT_r) are taken into account both respect residents and non-residents. Formally, the new government budget constraint becomes:

$$YG_r = TTAX_r + NETAID_r + INT_r + TRNG_r \quad (1)$$

Then, total income is devoted to savings ($GSAVE_r$) and expenditures ($GEXP_r$) according to a Cobb-Douglas function.

$$YG_r = GEXP_r^\alpha \cdot GSAVE_r^{(1-\alpha)} \quad (2)$$

and the total government expenditure is the summation of each commodity consumption ($g0_{j,r}$):

$$GEXP_r = \sum_j g0_{j,r} \quad (3)$$

In this framework, we can analyze how changes in expenditures affect the government savings. Similarly to what happens in EU public finance statistics we can derive a “deficit/GDP ratio”, although some caveats are required. Our deficit/GDP ratio is defined as:

$$\frac{DEFICIT_r}{GDP_r} = \frac{GEXP_r - YG_r}{GDP_r} \quad (4)$$

In $GEXP_r$ we consider only recurrent expenditures while EU-statistics consider both investment and recurrent expenditures (EU Commission, 2007). Although our definition of government income is very extended compared to the standard CGE models, it does not cover all the income sources of the government financial statistics. However, this measure is significant to analyze short-run effects of adaptation combining economic growth (the variable GDP_r) and fiscal implications ($DEFICIT_r$). The best way to assess the burden of government deficit in the country is the use of the deficit/GDP ratio since it clearly evaluates how much of the national GDP should be used to repay the government yearly deficit.

In addition, we consider a simple adaptation module. Assuming that there is a rationale to support a public action in adaptation to climate change, we model adaptation expenditures as a government recurrent expenditure. There is no evidence on the nature of adaptation expenditures (i.e. investment expenditures or recurrent expenditures), thus in this exercise we suppose they are an increase in a specific sector recurrent expenditure. Adaptation to SLR consists of increasing protective infrastructure, such as dikes, therefore we model adaptation as an increase in government expenditures in the “construction” sector. However, given the budget constraint, the government cannot increase its expenditures without any limit. We suppose a compensating mechanism inside the government total expenditure level, such that if it decides to increase expenditures in one sector it automatically lowers the expenditures in some other sectors. Formally, we state, that given the budget constraint and the rule to assign income to expenditure and saving, the allocation of expenditures among commodities and services varies according to a shifting parameter from non-construction commodities to the construction sector.

Thus, recalling equation 3 where we could take as given the total expenditure $GEXP_r$, we can re-write the equation as following:

$$\overline{GEXP_r} = \sum_i g_{i,r} * (1 - b_r) + g_{Cons,r} + \Delta g_{Cons,r} \quad (5)$$

Where $g_{i,r}$ represents expenditures in all sectors but construction, $g_{Cons,r}$ represent expenditures on construction and $\Delta g_{Cons,r}$ are the additional adaptation expenditures in the construction sector to build sea barriers. Since $\Delta g_{Cons,r}$ is the SLR adaptation policy, expenditures on the rest of the sectors $g_{i,r}$ should decrease proportionally to respect the budget constraint. This proportional reduction is represented by the shifting parameter b_r which is equal to:

$$b_r = \frac{\Delta g_{Cons,r}}{GEXP_r - g_{Cons,r}} \quad (6)$$

In the benchmark $\Delta g_{Cons,r}$ is equal to 0, therefore b_r is also equal to 0 and equation 5 collapses to equation 3.

2. The input data

ICES is calibrated on release 8 of the GTAP database (Narayanan, 2012). However, to perform this analysis we require input data on the impacts of sea level rise in the countries taken into account. These data are provided by the DIVA (Dynamic Interactive Vulnerability Assessment) model (Dinas Coast consortium, 2004). We consider two scenarios. In the first one we assume there is no adaptation to SLR, therefore coastal zone are more prone to increased flood risk and storm damage, loss of low-lying land and coastal wetlands, increased erosion, and intrusion of salt water into coastal freshwater resources. This is called “no action” scenario. In the second case we assume there is a full strategy to adapt to climate change. This means a wide range of instruments are implemented to protect the coastal zones. These comprehend dikes, beach, wetland and tidal basin nourishment. We refer to this case as the “full adaptation” scenario. They are two extremes of a range of alternatives. The “no action” scenario assumes the highest impact level and zero adaptation expenditures. Conversely, the “full adaptation” scenario supposes the highest adaptation expenditures to null SRL impacts. Between these two extremes there are many other combinations that partially reduce impacts at a lower expenditure level. For instance, SLR effects are mainly two, erosion and submergence, and supposing only to adapt to one of them, such as submergence, there is a reduction in the total impact (now due only to erosion) and a lower expenditure level (because adaptation does not consider dikes construction).

The impacts of SLR is dually considered. On one hand, there is an immediate loss of coastal land, thus the stock of this factor of production is negatively affected. On the other hand, there is a contemporaneous reduction in capital stock, which lies on the impacted land. Since we cannot say exactly how much capital is installed in each unit of loss land, we assume a 1 to 1 relation between the loss of land stock and the loss of productive capital stock.

3. Results

Our assessment focuses on both real side, as most of the CGE impact analysis, considering GDP changes after the SLR shock, the increasing adaptation expenditures, and the government public finance. With respect to this, we can quantify the changes in the government income (mainly composed of tax revenues) and the changes in government savings (surplus or deficits). In the model there are 6 different tax instruments. There are both direct and indirect taxes. In the “no action” scenario total tax revenue is higher than in the “full adaptation” scenario. This trend is evident in all countries but Greece where the situation is reversed. The drop in tax revenues is mainly led by a reduction in indirect taxes while income tax changes are smaller or close to zero.

This effect depends on the values of the initial impacts. Our SLR shock are very low, and they slightly affect the total factor endowment of the representative household, therefore there is a little erosion of the income tax base. In the indirect tax case, changes are more evident. Taxes on production and factor uses are more complex and they depend on the substitution of factors and level of production. Moreover, to clarify the reduction in tax revenue, we recall that they are in nominal terms and their lower level is due to a reduction in commodity price that is more evident in the “full adaptation” scenario than in the “no action” scenario.

Although the presence of other items in the government income definition, total tax revenue drives the total public income level. Government expenditure reduces both in the “no action” and the “full adaptation” scenario but for different reasons. In the first case, the reduction is mainly led by two forces: i) the reduction in production and ii) the reduction in income level for the government. In the second case, the mechanism is slightly different. There is once again the effect of the lower level of income but there is also a substitution effect among the demanded commodities. In fact, government now has to spend more in construction to adapt to SLR but, according to our modelization, this means a contemporaneous expenditure reduction in other commodities and aggregate expenditures decline.

As a residual, we calculate the deficit or the surplus of the government as the difference between the total expenditure and the total income of the government. In the “no action” scenario, the reduction in total tax revenue is higher than the reduction in expenditures. The same trend is in the “full adaptation” scenario but the reduction in tax is higher as well as the reduction in expenditures. Finally, the two scenarios show higher level of deficits.

The last stage is to consider the deficit/GDP ratio to evaluate the two scenarios. In the “no action” scenario the numerator of this ratio, the government deficit, worsens respect to a baseline scenario where no impact is assumed. But, at the same time, the denominator, GDP, declines as well. The reduction in GDP is more evident so that the ratio worsens. In the “full adaptation” scenario, government deficit increases but GDP increases as well. Finally, the ratio is better than in the “no action” scenario. The GDP increase is higher than the increase in government deficit. This means that although the government worsens its fiscal position with higher deficit, the country has a higher GDP.

Conclusions

This presentation focuses on the fiscal implications of climate change impacts and adaptation expenditures. In a general equilibrium framework, we analyze the effects on the fiscal position of a government because of the impact of sea level rise. Moreover, we assess how the implementation of an adaptation strategy changes the fiscal situation and which is the direction of the change. Applying an extended version of the ICES model with a government module, we can show an interesting interaction among climate change, deficit and economic growth.

This research is a work in progress. After the definition of these relations, further research will include the assessment of the same interactions in a recursive dynamic framework, to evaluate not only the deficit/ GDP ratio changes but also the debt/GDP ratio. Moreover, new strands of

research will focus on the fiscal effects of climate change and adaptation when more constraints, such a 3% deficit/GDP fiscal policy, are in place.

References

Arndt C., Chinowsky P., Strzepek K. and J. Thurlow (2012). Climate Change, Growth and Infrastructure Investment: The Case of Mozambique. *Review of Development Economics*, Vol. 16, pp.463–75

Arndt, C., Benfica, R., Tarp, F, Thurlow, J. and Uaiene, R. (2010a). Biofuels, Growth and Poverty: A Computable General Equilibrium Analysis for Mozambique. *Environment and Development Economics*, Vol. 15 (1), pp. 81–105.

Arndt, C., Pauw, K. and Thurlow, J. (2010b). *Biofuels and Economic Development: A Computable General Equilibrium Analysis for Tanzania*. Discussion Paper 966. Washington, DC: International Food Policy Research Institute.

Bergmann L. (2005). CGE modelling of environmental policy and resource management. In *Handbook of Environmental Economics*. Amsterdam: Elsevier, pp. 1274-1297

Burniaux, J. and J. Chateau (2011), *Mitigation Potential of Removing Fossil Fuel Subsidies: A General Equilibrium Assessment*, OECD Economics Department Working Papers, No. 853, OECD Publishing. DOI: 10.1787/5kgdx1jr2plp-en

Delpiazzi and Standardi (forthcoming). *Introducing an explicit Government institution in ICES model*. CMCC Working Paper.

DINAS-COAST Consortium (2004). *DIVA 1.0*. Potsdam Institute for Climate Impact Research, Potsdam, Germany, CD-ROM.

Eboli F., R. Parrado and R. Roson (2010). Climate Change Feedback on Economic Growth: Explorations with a Dynamic General Equilibrium Model. *Environment and Development Economics*, Vol. 15 (5), pp. 515 -533.

EEA (2008). *Impacts of Europe's changing climate- 2008 indicator-based assessment*. European Environment Agency No 4/2008, JRC Reference Report No JRC47756.

EU Commission (2007). *General Government Data. General Government Revenue, Expenditure, Balance and Gross Debt*. ECFIN/REP/52680/2007-EN. Directorate General ECFIN, Economic and Financial Affairs

EU Council (2004). *2632nd council meeting*. 20 December, Council of the European Union, Brussels.

Helm D. (2008). Climate-change policy: why has so little been achieved?. *Oxford Review of Economic Policy*, Vol. 24, pp. 211-238.

Hertel, T.W. (Ed.). (1997). *Global trade analysis: Modeling and applications*. Cambridge and New York: Cambridge University Press.

Hinkel J. and R.J.T. Klein (2009). Integrating knowledge to assess coastal vulnerability to sea-level rise. *Global Environmental Change*, Vol. 19, pp. 384-395.

Hoozemans F.M.J., M. Marchand, and H.A. Pennekamp (1993). *A global vulnerability analysis: vulnerability assessment for population, coastal wetlands and rice production and a global scale*. 2nd edn. Delft Hydraulics, Delft.

IPCC (2013a). *Climate Change 2013: The Physical Science Basis*. Contribution of working group I to the fourth assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.

IPCC (2013b). *Climate Change 2014: Impacts, Adaptation and Vulnerability*. Contribution of working group II to the fourth assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.

Martens W.J.M., T.H. Jetten *et al.* (1997). Sensitivity of malaria, schistosomiasis, and dengue to global warming. *Climatic Change*, Vol. 35, pp. 145-156.

McKibbin W., Morris A., Wilcoxon P. and Y. Cai (2012). *The potential role of a carbon tax in U.S. fiscal reform*. Climate and Energy Economics Discussion Paper. The Brookings Institution, July.

Narayanan B., Aguiar A. and R. McDougall (Eds). (2012). *Global Trade, Assistance, and Production: The GTAP 8 Data Base*. Center for Global Trade Analysis, Purdue University. Available online at: http://www.gtap.agecon.purdue.edu/databases/v8/v8_doco.asp

Olmos, L., Ranci, P., Pazienza, M. G., Ruester, S., Sartori, M., Galeotti, M., and Glachant J.M. (2011), *The Impact of Climate and Energy Policies on the Public Budget of EU Member States*, Final report for Topic 4 of the EU's FP7 funded project THINK, European University Institute, 2011.

Parrado R. and E. De Cian (2012). *Technology Spillovers Embodied in International Trade: Intertemporal, regional and sectoral effects in a global CGE*. FEEM Note di lavoro 2012.02.