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Adaptation in first- and second-best worlds

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Mitigation policies have traditionally been evaluated from the perspective of first-best worlds that have perfect foresight and full and immediate policy implementation. Adaptation assessments typically consider second-best worlds that incorporate the realities of market imperfections, institutional and informational constraints, delayed policy implementation, and other issues. As mitigation analyses increasingly consider the potential effectiveness of policies implemented under second-best world assumptions, it strikes us that their use of first-best and second-best benchmarks is becoming increasingly valuable. It also strikes us that adding the perspective of first-best worlds to adaptation analyses would do the same by providing comparable baselines for national and international assessments integrating the costs and benefits of adaptation and mitigation policies. In addition, adaptation analyses under first-best world assumptions could provide valuable information to policymakers on what *could* be achieved under ideal conditions. It would be very informative for science and policy to understand the benefits, trade-offs, human and financial resource requirements, and residual damages under first-best and second-best assumptions about the rate, extent, and timing of implementation of climate policies.

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Introduction

Global and national estimates of the extent to which adaptation and mitigation polices could reduce current and projected climate change impacts, the trade-offs between adaptation and mitigation, and the potential costs and benefits of these policies often start from different underlying assumptions. Many models evaluating policies designed to reduce greenhouse gas emissions, particularly integrated assessment models, commonly assume perfect foresight and full and immediate policy implementation. These are 'first-best world' analyses assuming a hypothetical situation where a policy works essentially perfectly; that is, such analyses do not take account of the realities of constraints to policy formulation (such as possible consequences or environmental considerations), market imperfections, institutional and informational constraints, delayed policy implementation, social preferences, and other issues [1••,2•].

Evaluations of adaptation policies, by way of contrast, typically have not explicitly explored their possible effectiveness under ideal conditions. Instead, most analyses of adaptation projects and programs (whether autonomous or planned) start from existing constraints to their formulation and implementation, including the realities not included in first-best world analyses. That is, they work in what economists term a 'second-best' world where progress is often slow, erratic, and the result of hindsight (e.g., impacts experienced), with considerable imperfections in information, institutions, political will, and adaptive management [1••,2•]. These imperfections are part of the constraints and barriers to adaptation.

These mismatches in assumptions and direction of analyses have consequences for national and international assessments of the extent to which mitigation and adaptation can be mutually reinforcing in preparing for and managing the risks of climate change. Evaluating trade-offs between mitigation and adaptation becomes difficult, if not misleading, or even impossible, when research results are based on different and perhaps incompatible assumptions. It follows that comparisons of effectiveness, human and financial resource requirements, and the rate, extent, and timing of implementation may provide misleading or irrelevant information for policy action.

1st vs. 2nd best worlds

Creating first-best benchmarks has a long history in economic thought. Economists continue to conduct positive analyses of this policy or that in economic environments *first* under the assumption of perfectly competitive product and input markets — even though perfectly competitive markets are few and very far between. The critical insight is that these analyses produce solid intuitions of what might happen and why. This is why analyses conducted under different second-best environments come second — to see if the results would be different from a world of perfect efficiency, and to use the underlying intuition to explain, without resorting to equations or high-level analytics, why this result could actually make sense and why it might be correct. Whether it is interesting or important is another matter. Results of analyses of the effectiveness of a particular policy or program in reducing the severity or likelihood of an impact can be quite different in first-best or alternative second-best worlds. But the questions are — by how much and why?

In mitigation, there is growing interest in exploring climate policies under second-best conditions that evaluate policies under constraints on the availability of needed technologies, the timing and efficacy of mitigation policies, the degree of countries' participation in international mitigation agreements, and the degree to which adaptation at any temporal and/or spatial scale can reduce the consequences of residual impacts. These studies typically indicate that market imperfections can have a pronounced effect on the costs of mitigation [3•,4–6] and their net values in terms of currency or simply reduced risk. Because there is never a unique second-best policy mix, however, these studies spend little time comparing themselves to each other, instead comparing themselves to first-best benchmarks. This allows the authors to begin to explore the relative costs of the modeled imperfections *and* the economic values of even partial amelioration of these imperfections, including using metrics that account for uncertainty and attitudes toward risk (e.g., [7,8]).

An adaptation first-best world is one with perfect conditions for designing and implementing a policy; that is, there are no weaknesses in the underlying determinants of adaptive capacity that constrain design, implementation, effectiveness, or monitoring (e.g., no economic, social, institutional, or technological conditions and no lack of political constrain development or deployment of adaptation).

The value of the perspective of 1st and 2nd best worlds

There is significant potential value in providing policymakers with analyses evaluating the costs and benefits of adaptation and mitigation in internally consistent first-best and second-best worlds, including:

- More realistic assessments of the success of mitigation policies in second-best worlds. Such assessments would further understanding of the severity of possible impacts of climate change (e.g., what will need to be adapted to);
- Joint analyses of adaptation and mitigation, including highlighting the possibility that investment in one may make the other more productive (i.e., they complement one another in the strict economic sense). Such analyses should be based on the commonality of many factors that characterize second-best adaptation and mitigation worlds; and
- Adaptation baselines for future analyses based on descriptions of adaptation first-best worlds. These baselines can provide decision-makers with information on what adaptation could achieve under ideal situations, help prioritize which constraints and limits may be more important to address, and provide additional information on the full range of options achievable with particular policies.

More realistic assessments of the success of mitigation policies in second-best worlds are needed to further understanding of the severity of impacts to which future societies will need to prepare for, respond to, and recover from. If the assumptions underlying analyses of climate policy through integrated assessment models are unrealistic (in their portrayal of implementation efficacies), they can lead to overly optimistic projections of the magnitude and extent of reduction of greenhouse gases. In these cases, current generations will underinvest in adaptation *and* future generations will pick up the bill because they will have to do more.

Factors that define second-best environments for adaptation and mitigation show considerable overlap, including limited knowledge of what polices and measures are needed where and when (which includes understanding not just climate change projections, but also how development will interact with climate change risks), the unavailability of necessary human and financial resources (i.e., imperfect capital markets and government process that do not appropriately discount for projects and programs that complement private investment), the unavailability of appropriate technologies, and limited political will to implement policies. These factors can also interact: benefits and costs of adaptation options (expressed as reduced risk, simple benefit-cost ratios, etc.) depend on mitigation trajectories and the magnitude and extent of climate change. At the same time, the application of adaptive potential affects the benefits and costs of mitigation policies. It follows, as noted above, that adaptation and mitigation can complement one another in the sense of more investment in one makes the other more productive, especially in a policy world that recognizes the need to iterate as we learn and not one that uses uncertainty as an obstacle to do nothing. These and other overlaps indicate that joint evaluations are possible and extremely valuable, but only if these evaluations work with and through common sets of assumptions, comparing themselves with other integrated evaluations as well as against the relative first-best benchmarks.

Taking existing inefficiencies and constraints as the starting points for adaptation assessments limits the information provided to decision-makers and policy-makers about the full range of options that could achieve particular policy goals. Explicit descriptions of adaptation first-best worlds from the perspectives of different sectors and regions would be a helpful baseline for future analyses, providing information on the magnitude and extent to which adaptation policies could reduce impacts in a world without constraints and barriers from path dependencies created by choices such as the location of infrastructure, or continued lack of access to energy, safe water, and improved sanitation in underserved populations in low-income and middle-income countries.

First-best and second-best adaptation analyses would also provide valuable insight into real-world interactions of constraints and limits, highlighting which may be more important to address. For example, a first-best world might assume farmers have perfect foresight, planting the cereal and cash crops best suited to a particular climate. An analysis based on a second-best world would need to take into consideration not just the productivity of different cultivars under particular temperature and precipitation projections, but also local and perhaps even global food preferences, the efficiency of the seed sector, access to storage and markets and so on. These analyses would provide input to policy choices, not just in climate change, but also in other areas such as investments in research and development to reduce food insecurity or improve market integration, whose implementation would increase resilience to climate change.

Further, comparable obstacles to adaptation exist in many places, affecting the efficiency of different types of adaptations designed to ameliorate many different climate risks; it follows that understanding how these obstacles might be overcome (at least partially) in one context could pay enormous dividends across a broader range of applications — but here, of course, difficulty in transmitting the information from one context to another itself becomes yet another obstacle.

Comparisons of first-best and second-best worlds help researchers and practitioners identify research and technology gaps, as well as needed institutional and governance changes that would make those technologies more effective and more widely applicable. Policy-makers may benefit from understanding options just out of reach, where additional research and/or technology development could fill knowledge gaps, and options requiring greater investments. The goal is to increase the range of future adaptation options so that policy-makers have options available when they are needed.

Joint 1st-best adaptation and mitigation worlds

Evaluation of adaptation policies usually focuses on a particular sector and region, often in the very near term (second-best or even third-best words). Mitigation first-best worlds generally take larger geographic and longer temporal perspectives. An example of visioning common first-best and second-best adaptation and mitigation worlds is the Shared Socio-economic Pathways (SSP) being developed as part of the new scenario process [9•,10•,11•,12•]. Researchers from the integrated assessment modeling and the vulnerability, impacts, and adaptation communities are collaboratively developing the SSPs, to be used within a scenario matrix approach to identify the landscape within with a particular scenario can be located. The SSPs define the state of human societies and ecological systems at a macro scale over the 21st century, along the axes of increasing challenges to adaptation and to mitigation, where challenges to adaptation increase the risks associated with any level of climate change by making adaptation more difficult, and challenges to mitigation include factors that increase the generation of high reference emissions and that determine the social capacity for mitigation. There are five SSPs; one describes is a world with low challenges to both, or an approximate first-best world. This is a world making relatively good progress toward sustainability, with sustained efforts to achieve development goals, while reducing resource intensity and fossil fuel dependency. The other four SSPs describe variations of second-best worlds. Use of these SSP in analyses of the possible effectiveness of adaptation and mitigation policies will provide common assumptions to facilitate comparison of the severity of climate change impacts, costs and benefits, and residual damages under different scenarios.

1st and 2nd best adaptation worlds in practice

Building on the work of White [13], Ebi and Burton [14••] developed guidance for identifying and prioritizing health adaptation options at local and regional levels that takes a first-best and second-best perspective.

The first step in the process is to develop, in collaboration with stakeholders, a comprehensive list of all theoretically possible adaptation options, without consideration of technical feasibility, cost, or other limiting criteria. The list should include all available measures, new or untried measures, and measures identified from a canvass of current practice and experience, from a search for measures used in other locations, and from discussions with scientists, practitioners, and potentially affected stakeholders. This list could be the basis for first-best analyses, under the assumptions that the options are completely effective now and in the future; are simultaneously implemented everywhere needed; and do not create future adaptation challenges or path dependencies.

The second step in the process is to screen the options to identify measures that would be practical for implementation in a particular sector and region (i.e., moving from a first-best to second-best analysis). Screening factors can include technical viability; degree of effectiveness; environmental acceptability; human and financial resource capacity; and social and legal acceptability, including compatibility with current policies. Limits to full deployment describe second-best worlds. Such lists provide policy-makers with information on not only which measures could be implemented, but also which choices are constrained because of a lack of technology, information, or resources, or because of other policy choices. This process explicitly acknowledges that policy objects can be achieved through many pathways, so provides information on path dependencies that could affect the range of future options.

One example of the use of this approach is the adaptation assessment conducted by the state of Alaska to manage climate change risks to human health and culture [15]. Based on discussions with a wide range of stakeholders, the first step generated over 100 possible adaptation options, under assumptions of no constraints to implementation. The stakeholders prioritized the options and identified a few options of high importance to recommend for immediate implementation. The process highlighted to policy-makers not just priority options for implementation, but also where investments in research and technology development presented opportunities for a broader range of future adaptation options, creating flexibility for future adaptation.

The experience is New York City (NYC) highlights using mitigation assumptions to frame first-best and second-best adaptation options. The Mayor created a scientific advisory committee (the New York Panel on Climate Change — NPCC) and an Adaptation Task Force [16••]. The NPCC presented a risk-based framework reflecting the likelihood of various climate futures that could influence the vulnerability of public and private investments in infrastructure; its framing influenced not only the City's decision-making structure, but also the National Research Council in its conceptual contribution on adaptation to 'America's Climate Choices' [17•]. The Adaptation Task Force worked alongside the NPCC to calibrate adaption options in terms of likelihood, consequence, and timing in a variety of futures that were, to a large degree, determined by mitigation in NYC, North America, and abroad. None of the participating agencies and private companies expected their adaptation investments would eliminate risk or reduce consequences to zero (in the near-term or even long-term); they worked from a second-best perspective. Superstorm Sandy confirmed that reality, but experiences from the earlier hurricane named Irene show the value of learning. To be more precise, extensive negotiation across government agencies and private sector representatives resulted in significant investments (billions of dollars for a cash-strapped city and a business sector facing a recession) that appear to have diminished damage as 2012 moved into 2013. Damage from Sandy and the subsequent fairly routine Nor'easter was significant, but was smaller than it would have otherwise without the lessons from Irene. The process of prioritizing and cataloguing limitations in a planning and implementation process saved lives and highlighted both obstacles and opportunities. The next iteration of the NPCC will move forward from there; an issue is the degree to which risk-based adaptive decisions can keep pace with the ramifications of climate change in futures that are driven by alternative emission pathways — especially those generated by changes in the intensity and frequency of extreme weather and climate events.

Conclusions

Employing the perspective of first-best and second-best worlds in analyses of the effectiveness and efficiency of adaptation policies would provide not only useful information for adaptation policy-makers, but also an appropriate basis for national and international assessments of the extent to which adaptation and mitigation could reduce the risks of climate change, highlighting opportunities for addressing common constraints and limits that would benefit both, and providing more realistic evaluations of trade-offs, costs, benefits, and residual damages. The fundamental idea is that adaptation and mitigation are not substitutes in a second-best world; they are complements — but only if decision-makers work in the 'same world'.

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