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Interactions between Sustainable Development Goals – Focus on Goal 7: Affordable Clean Energy

Discussion paper

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Abstract

There is a recurring concern about how, and to what degree, the United Nation's 17 distinct sustainable development goals (SDGs), and associated 169 targets, interact with each other. These interactions can have important consequences for the effectiveness of policies implemented under Agenda 2030. The complexity of the problem facing policymakers, but also industry and civil society actors, is daunting enough without considering the interactions between SDGs. Introducing the interactions is not only critically necessary but also augments this complexity significantly. In this note, we draw on lessons learned from welfare economics and the theory of the second best1 to help simplify the mapping of trade-offs between SDGs. These lessons are then used to frame some brief comments on the Swedish Energy Agency's proposed strategy to support solar power use (related to SDG 7 - Affordable and Clean Energy). There are two key messages: the first is that the complexity of interactions between SDGs can be simplified because interactions with SDGs that are achieved are likely to be weak; and the second is that support for solar power is best achieved using a mix of policies to mitigate "bad" interactions.

Introduction

It is the Swedish Government's ambition to be a leader in the implementation of the United Nation's Agenda 2030 and the 17 Sustainable Development Goals (SDGs). According to assessments Sweden has already achieved or will soon achieve a significant number of targets. Even so, the SDGs imply a transformation of Swedish society in critical economic, social and environmental aspects towards a sustainable welfare state. Despite Sweden's relatively well-developed policies, the challenge facing Swedish policymakers, but also industry and civilians is daunting, and the challenges are even greater for less developed countries.

A recurring issue is the potential interactions between goals. Moving ahead with efforts to support a goal can have an impact on efforts undertaken to support other goals. Policy impacts can spill over and help, or hinder, progress on other goals. The SDGs comprise 17 distinct goals, each of which includes several targets. There is a total of 169 targets[2] and related indicators. Interactions between goals and targets vastly increase the complexity of the SDG undertaking.

The purpose of this *promemoria* is to help provide guidance that can simplify the mapping of trade-offs between SDGs, drawing on lessons learned from welfare economics and policy design in a second-best setting. We then apply the guidance to the trade-offs associated with "SDG 7. Ensure

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[1] An economic principle that says that if policies in one area inadequately address a problem, implementing policy in another area can have detrimental overall, societal effects. The most efficient overall solution for achieving two or more goals may be one that does not include optimal solutions for each of the individual goals.

[2] A final tally of all these goals and targets is available at https://sustainabledevelopment.un.org/content/documents/11803Official-List-of-Proposed-SDG-Indicators.pdf

access to affordable, reliable and modern energy for all" and the Swedish Energy Agency's 2016 "Proposal for a strategy to increase solar electricity use". The focus is on domestic Swedish actions and interactions with other goals that are relevant to the domestic context, recognizing of course that much of the focus of the SDGs is supporting developing countries, and international collaboration and participation.

While there is a literature that studies different aspects of the interactions between SDGs there are no studies that explicitly link to the lessons learned from second-best welfare economics. This is surprising since the interaction of policies is a key issue in economics, and is relevant to understanding how to deal with SDG interactions. In recent work, Nilsson et al. (2016) rate seven possible types of interactions between SDGs, from the most positive (+3) to the most negative (-3). In their guide to practitioners, Griggs et al. (2017) apply this scoring system to a selection of the SDGs on a global scale. On "SDG7 - Ensure access to affordable, reliable, sustainable and modern energy for all" for example, they propose an interaction of +2 between SDG 7.1 (universal access to energy)[3] and 1.4 (energy as a basic service)[4], therefore universal energy access reinforces the achievement of poverty reduction goals. On the other hand, the interaction between SDG 7.2 (increase renewable energy)[5] and SDG 1.4 (energy as a basic service) is given a score of 0/-1: there is potential for increased share of renewable energy and increased energy efficiency to increase energy prices, which can work against poverty reduction efforts. In other related work, Weitz et al. (2018) and Le Blanc (2015) study SDG interactions using a network like approach to capture the complexity and interconnections between SDG goals and targets to help support more effective SDG policies. Boas et al. (2016) also study the relationship between SDGs and argue that ignoring interactions, across goals and across sectors, can lead to detrimental outcome from well-meaning policies and that policy interventions should therefore target multiple aspects.

Mapping the interactions between SDGs: complications and simplifications

The complexity of the SDG challenge

To illustrate the complexity of the challenge, and to highlight the importance of simplifying the trade-offs between SDGs, suppose Sweden's welfare W can be expressed as a function of the SDG targets, denoted Gi.j and a single policy that is implemented to reach each SDG target, which we denote $t_{i.j}$, where i=(1,..,17) denotes the SDG and j=(1,..,19) corresponding targets. Of course, policymakers will probably deploy several policies to reach each SDG target, but we will abstract from that issue for the moment to simplify an already impossibly complex challenge. If each SDG target is a function of all policies, then Sweden's welfare can be written as

$$W(G_{1.1}(\boldsymbol{T}), \dots, G_{17.19}(\boldsymbol{T})) \tag{1}$$

where $\mathbf{T} = t_{1.1}, \dots, t_{17.19}$ is a vector of all SDG policies. There are a total of 17 SDGs covering 169 targets and 169 policies. For the sake of simplifying the exposition, the welfare function is assumed to have the usual well-behaved properties, although relaxing this assumption would increase the complexity of this challenge.[6] The policymaker's challenge is to set each SDG policy to fulfill the SDGs: Sweden's welfare is maximized when the goals are achieved. In a world without any constraints facing the policymaker, all policies could be set at their optimum and we would find ourselves in a first-best world. The policymaker needs to choose each policy to solve

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[3] By 2030, ensure universal access to affordable, reliable and modern energy services

[4] By 2030 ensure that all men and women, particularly the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership, and control over land and other forms of property, inheritance, natural resources, appropriate new technology, and financial services including microfinance.

[5] Increase substantially the share of renewable energy in the global energy mix by 2030.

[6] Differentiable, concave in its arguments, with a unique global maximum.

$$\max_{t_{i.j}} W\big(G_{1.1}(\boldsymbol{T}), \dots, G_{17.19}(\boldsymbol{T})\big). \quad (2)$$

There is potential of 169 such problems facing the SDG policymakers: one policy challenge for each target. Each policy $t_{i.j}$ is chosen to satisfy the first-order-condition

$$\frac{\partial W(G_{1.1})}{\partial G_{1.1}} \frac{\partial G_{1.1}}{\partial t_{i.j}} + \cdots + \frac{\partial W(G_{17.19})}{\partial G_{17.19}} \frac{\partial G_{17.19}}{\partial t_{i.j}} = 0 \quad (3)$$

The solution to this first-order-condition is the policy that optimizes Swedish welfare, which is denoted $t^*_{i.j}$, where the * superscript denotes a policy that fulfills the SDG (e.g. "optimal" policy). When the optimal policy is implemented, then it follows that

$$\frac{\partial W(G_{i.j})}{\partial G_{i.j}(t^*_{i.j})} = 0 \quad (4)$$

For each policy, there are a potential 168 interactions with other SDG targets (and one direct effect). Hence there is a maximum total of 169 X 168 interactions that need to be considered by the policymaker. The matrix and network representations of the interactions across SDG targets in Griggs et al. (2017) and Le Blanc (2015) illustrate the potential complexity of the SDG challenge.

If the policymaker somehow manages to set all policies to be optimal, such that all SDG's are achieved, then Sweden's welfare function is at its maximum, and

$$\nabla W\big(G_{1.1}(\boldsymbol{T}^*), \dots, G_{17.19}(\boldsymbol{T}^*)\big) = 0 \quad (5)$$

where each $\mathbf{T}^*$ denotes the vector of all optimal policies $\{t^*_{1.1}, \dots, t^*_{17.19}\}$ that achieves the SDGs. This is a set of first-best policies: all policies completely target all the goals and all externalities are internalized. Of course, the first-best world is an abstract idea, and it is probably safe to say that this is not the kind of world in which we live and in which the SDGs will be implemented. However, policies are often advocated under the assumption that first-best policy options are fully available. For policymakers, this is of little help since it is often clear that many desirable policy options are infeasible because of political constraints, incomplete information or prohibitive transaction and compliance costs.

Suppose we (reasonably) assume that the policymaker is working in this second-best world on a way to achieve SDG 7.2 - to increase the share of renewable energy in total final energy consumption. If all SDGs are interconnected, which according to Weitz et al. (2018) and Le Blanc (2015) they probably are to varying degrees, then each SDG is a function of all the SDG policies. With full interactions between all the SDGs, the solution to the policymaker's problem needs to satisfy

$$\frac{\partial W}{\partial t_{7.2}} = \frac{\partial W(G_{1.1})}{\partial G_{1.1}} \frac{\partial G_{1.1}}{\partial t_{7.2}} + \cdots + \frac{\partial W(G_{17.19})}{\partial G_{17.19}} \frac{\partial G_{17.19}}{\partial t_{7.2}} = 0 \quad (6)$$

The interactions between SDG 7.2 and all the other SDGs increase the complexity of the policymakers problem. The indirect effect of $t_{7.2}$ on all the other goals and targets, captured by the $G_{i.j}/\partial t_{7.2}$ terms, needs to be considered by the policymaker working to achieve $G_{7.2}$ by implementing $t_{7.2}$. In the most general case, meeting SDG 7.2 requires the policymaker to consider the interactions between SDG 7.2 and all other SDGs and corresponding 168 targets!

This discussion links to an economic principle that says that if policies in one area inadequately address a problem, implementing policy in another area can have detrimental overall, societal effects.[7] The issue of interactions between SDGs is an example of this economic principle. Ignoring interactions could undo benefits of well-meaning SDG policies. One key lesson from this literature

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[7] This is the theory of the second best studied by Lipsey and Lancaster (1956) and is still an active research topic, see Jacobs and De Mooji (2015).

is that implementing the first-best policy, when policies in other areas are second-best, can be detrimental to welfare, precisely because of the interactions.

What then is the best alternative when first-best options are not available? The second-best alternative it turns out consists of a "package" of multiple policies, that seek to balance the benefits and losses across different policy objectives. This is a critical principle to guide the design of policies to support the SDGs, and has been studied and discussed by a number of scholars. Getting the correct mix of policies is not straightforward either. This difficulty in matching and mixing renewable energy policies is examined by Kalkuhl et al. (2013). Fankhauser et al. (2010) show how complementary renewable energy policies can interact in ways that undermine their effectiveness: for example a carbon tax is shown to be undermined when it is complemented by a cap-and-trade policy like the EU ETS. Hubler et al. (2015) study the complementarity of policies that support learning-by-doing, research and development of renewable energy and investments in energy efficiency. They suggest that feed-in tariffs are a good substitute for learning-by-doing but not for research and development and energy efficiency subsidies. An important lesson from this literature is that the degree to which SDG areas interact depends on the specifics of the policies being implemented.

In sum, the take-away points from the discussion are: the interactions between policies and SDG targets need to be taken into consideration because interaction effects can undo the benefits of well-meaning policies; taking the interactions into consideration can vastly increase the complexity of SDG challenge; the "best" real world approach is to design a package or mix of policies that target the direct and spill-over impacts; getting the mix of policies right is also difficult and context specific. These points are as relevant for renewable energy as they are for all policy exercises.

Simplifying the SDG challenge: a case example of solar energy

A rule that can significantly reduce the difficulty of this challenge is that all interactions with SDGs that are achieved, or nearly achieved, is likely to be weak. If an SDG is achieved, or nearly achieved, then by definition the first order condition for that particular SDG is equal to zero, as with equation 4. So for example, "SDG1 - No Poverty", is largely fulfilled in Sweden, which would mean that

$$\frac{\partial W\left(G_{1.1}(t_{1.1}^{*})\right)}{\partial G_{1.1}}=0 \qquad (7)$$

which means in turn that the first term of equation 6 drops out.[8] Fortunately for Sweden, significant number SDGs are almost, or totally, achieved, and this means this first rule alone greatly simplifies Sweden's SDG challenge. For an extreme example, if Sweden had achieved all its SDGs, except SDG7, then equation 6 would simplify to

$$\frac{\partial W}{\partial t_{7.2}} = \frac{\partial W(G_{7.2})}{\partial G_{7.2}}\frac{\partial G_{7.2}}{\partial t_{7.2}}=0 \qquad (8)$$

All other terms are zero in optimum because we require optimal policies to yield $\partial W/\partial G_{i,j}(t^{*}_{i,j})=0$. There would be no interactions to take into account. The challenge described in equation 8 is significantly simpler than the challenge described in equation 6.

Statistics Sweden's 2017 report[9] written at the request of the Swedish Government, statistically assesses Sweden's implementation of Agenda 2030 for sustainable development, e.g. the fulfilment of the suggested SDG indicators[10]. The targets and corresponding indicators for SDG7 are:

- Target 7.1 By 2030, ensure universal access to affordable, reliable and modern energy services
  Indicators:

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[8] This outcome is a straightforward application of the envelope theorem and is applicable when policy reforms are modest.

[9] Statistical follow-up of the 2030 Agenda for Sustainable development, 2017, ISSN 1654-0743.

[10] All SDG targets have one or more corresponding indicators to measure progress

  - 7.1.1 Proportion of the population with access to electricity;
  - 7.1.2 Proportion of the population with primary reliance on clean fuels and technology;
- Target 7.2 By 2030, increase substantially the share of renewable energy in the global energy mix
  Indicator:
  - 7.2.1 Renewable energy share in total final energy consumption;
- Target 7.3 By 2030, double the global rate of improvement in energy efficiency
  Indicator:
  - 7.3.1 Energy intensity of the Swedish economy in terms of the ratio of primary energy to GDP;
- Target 7.A By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology
  Indicator:
  - 7.A.1 Financial contributions to enhance international cooperation on clean energy research and development;
- Target 7.B By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programmes of support
  Indicator:
  - 7.B.1 Investments in energy efficiency in developing countries.

Target 7.1 is largely achieved, and 7.A and 7.B focus on international coordination. Hence, it is essentially targets 7.2 and 7.3 that are relevant for this discussion because they focused on domestic actions and have not yet been achieved. Achieving these goals will require considering the interactions across all the other SDGs. To what degree should the other SDGs be considered when setting renewable energy policy and how much simplification can be achieved by recognizing that Sweden is a relatively well governed society?

As a case in point, the Swedish Energy Agency's proposal for a strategy for increased use of solar energy summarizes the multiple policy instruments that are being deployed in the sector.[11] Their approach is characteristic of policies that are deployed to support solar energy in that it offers a package of multiple instruments that seek to not only provide direct support to increase solar energy use, but also solve different spill-over impacts. The document outlines initiatives that target a broad set of issues, or "interactions" with other policy spheres.

The Energy Agency's proposal includes short-term interventions that target solar power investment directly:

- Reduce waiting times for subsidies for solar power investments;
- Reduce transactions costs for obtaining subsidies for solar power by reducing the number of government agencies involved;
- A number of tax reforms that strengthen incentives to invest in solar.

The Energy Agency's proposal also includes a number of actions that target indirect, or spill-over, effects from increased solar power use:

- Gathering data/statistics to help manage potential, and diverse, effects of increasing solar power usage;
- Assessing and improving electricity distribution capacity and electricity storage technology;
- Educating private consumers and investors in solar power;
- Harmonize building permit rules for solar facility construction across Sweden;

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[11] See the report "Förslag till strategi för ökad användning av solel" accessible online at: http://www.energimyndigheten.se

- Ensure that increasing solar energy capacity increases employment;
- Adapt waste management of solar cells.

Much of the Energy Agency's focus in their strategy is devoted to managing the indirect effects of solar power support policies, which is the way to approach second-best policy design. The strategy packages complementary policies that deal with indirect effects, or spill-overs, with areas such as: information and education (SDG 4), building permits (SDG 16), and employment (SDG 8).

An example where a trade-off with another policy is likely to be weak (because the objectives in the other policy area are achieved) is in the waste management of solar energy equipment. The Energy Agency points out that Swedish efforts to implement the Waste Electrical & Electronic Equipment-Directive (also known as the WEEE-Directive) largely manage the issue. The interaction with waste management (closely related to SDG 12 - Responsible consumption and production) is thus considered to be weak and no additional policy response is required.

A number of other SDGs are not mentioned, likely because the Energy Agency deem the spill-over effects from their solar strategy to be negligible, or positive (why do you need to intervene when the spill-over is a good thing?). For example, in some contexts, implementing solar power could: reduce air pollution and thereby improve health outcomes (SDG 3 - Good health and well-being); free up time for women to gain work and thereby improve gender equality (SDG 5 - Gender equality); power rural pumps and sewerage facilities (SDG 6). However, these interaction are legitimately considered to be a non-issue, or at least of lesser importance in the Swedish context. They are therefore legitimately not considered by policymakers working to support increases in solar energy use. In many developing countries, however, these trade-offs, and more, need to be considered and are more likely to have important impacts.

Concluding remarks

The interaction across SDGs is a complex challenge that can be simplified in some dimensions. This short note clarifies two key principles for designing renewable energy policies, and other SDG policies as well: first that interactions with SDGs that are nearly, or completely achieved, are likely to be weak; and that interventions should apply a mix of policies that manage any negative spill-over effects. Unfortunately, there is no general rule that can be used to characterize the trade-offs across SDGs, rather the interaction between SDGs depends on the details of the policies implemented, and the specific context in which they are implemented.

With these principles in mind, we look at the strategy recommended by Sweden's Energy Agency to support solar power use. Their strategy identifies interactions that are likely weak in areas that are adequately managed in Sweden and proposes several policies targeting potential negative interactions with other policy spheres. In the strategy, multiple policies are packaged to complement each other, and minimize negative trade-offs, which is the best approach to take when setting second-best policy.

Going forward, there is a clear need to deepen our understanding of the interactions between SDGs and for energy related issues given the scale of proposed changes to the energy sector. This note provides preliminary guidance for how to approach the design of these policies and interactions across policy objectives. A promising area for future research is to bring theory to practice to map out how Sweden's energy policies interact with other SDG policy goals, and how the interactions can be managed to ensure policy effectiveness. Another research area is to analyze how the SDG indicators could be used to define sustainability indicators for the energy system.

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