Are Climate Policies in the Nordic Countries Cost-Effective?*

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Abstract

This paper argues that Nordic climate policy can become more cost-efficient. To support our empirical analysis, we develop a general equilibrium framework to analyse the benefits and costs of environmental (and climate) policy. We demonstrate that the usual partial equilibrium intuition is quite robust, provided that the policy changes are "small enough". This result simplifies empirical analysis considerably. Significant possibilities for cost reductions are available within current EU policy packages, especially regarding the non-trading sector. There are also some gains to be had from policy co-ordination. Ample within-country opportunities exists, such as the removal of ineffective subsidies/overlapping regulations. Finally, the significant forest endowment in Finland, Norway and Sweden, may also play a useful role in shaping a more effective climate policy.

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1 Introduction

Along with the EU, the Nordic countries aim to achieve a reduction of greenhouse gases by at least 40% compared to 1990 by 2030. Briefly, Denmark aims at a complete decarbonization of energy supply, Finland envisions a reduction of 80% in 2050 within a larger international effort, Iceland targets a $50 - 75$ % cut (on net); Norway and Sweden both aim at zero net emissions by 2050 and 2045, respectively. Overall, these reductions go beyond internationally agreed goals and demonstrate a commitment among the Nordic countries to maintain a relatively ambitious climate policy (Kjellèn (2007) documents the long history of having an ambitious environmental policy in the case of Sweden)). At the same time, the contribution to the overall problem is small on a global scale, which leaves the Nordic countries with a familiar dilemma. What can a small country, or a group of small countries, then do? This question has been discussed at great length in the environmental economics literature, a useful summary of the arguments involved is in Hoel (2012). Dimensions of this discussion involves carbon leakage, technological spill-overs, first-mover advantages, demonstration effects (”others might follow”), exempting competitive sectors, and much more, including our moral obligations as rich countries. While we touch upon some of these arguments, our main focus in this paper is on marginal cost disparities and how to reduce them in a Nordic perspective within existing policy agreements. In particular, a starting point is the fact that the Nordic countries faces two prices on carbon.

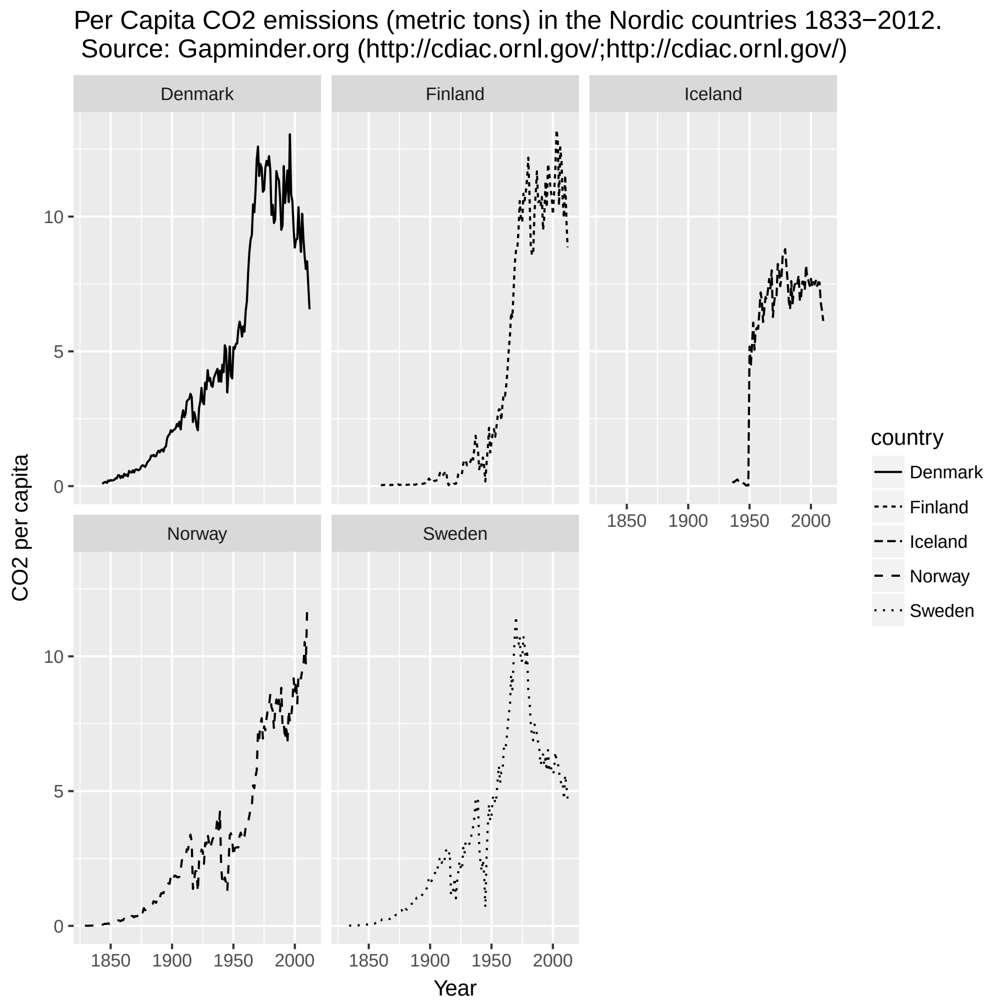
Thus, while the particulars of the domestic carbon policies differ (see section 3 for details), there is an important similarity, that we may call the dual carbon economy. This is because of the EU(+ Iceland, Norway and Switzerland)-wide international carbon market (EU-ETS), which comprise a certain subset of economic activity in the EU(+)economies. The non-trading sector, most importantly the transportation sector, does not face this carbon price and therefore may not face the same marginal cost. Consequently, there may be within country and in-between country marginal cost differences between the Nordic countries, as well as between the Nordic and other countries. Exploiting such differences means that we can have more for less, i.e. climate policy can be made more efficient. We spell this out in a general equilibrium framework that helps unravelling the key issues involved. We then try to identify areas where we think the Nordic countries can make progress on climate policy. Essentially, by utilizing existing flexibility mechanisms within the EU, remove certain in-between tax disparities and discard several inefficient subsidy schemes, and more, our ”athmospheric footprint” can be reduced substantially, without allocating more resources to climate policy than we currently do. The significant forest endowment should also be considered in the policy mix.

To set the stage, we begin by considering how carbon emissions have developed over time, using a long time series, in section 2. Section 3 explains our framework and discusses a number of simplifying assumptions that we make. The rest of the paper turns to empirical issues. We explain relevant parts of existing policy frameworks in section 4. Section 5 has provides a glimpse of climate policy analysis undertaken in the Nordic countries, with a few examples. We also provide a simple analysis that backs up our main proposal. Section 6 brings together the theory and the empirics in terms of policy implications. Section 7 concludes.

2 Carbon emissions 1833-2012 in the Nordic countries

To set the stage for our discussion, it is useful to take a look out how carbon emissions have developed, using a long time series. Figure 1 display CO2 emissions per capita for the countries of interest in this paper.

Figure 1



Whether or not growth is decoupled from carbon emissions is hard to say from these plots, although it is tempting to assert an "environmental Kuznets curve" for all countries except Norway. Thus, with the exception of Norway, the CO2-emissions per capita tend to increase up to a certain point, after which they turn back, while economic development continues. Iceland, Norway and Sweden has for some time now essentially not used fossile fuels in electricity generation. Denmark and Finland have an energy system that uses more fossile fuels than the others. It would require detailed econometric analysis to disentangle how (climate) policy has affected the development. There is ample evidence (not reviewed) that e.g. incentive-based instruments are effective in curbing emissions. For country-specific reviews of environmental policy, we refer to the OECD country reports and sections 4 and 5 below. The webpage of the Nordic Council `www.norden.org` contains a wealth of information about Nordic co-operation in environmental policy. More on this in section 6.

With this preamble, we now turn to the conceptual model. The objective is not to develop a model that would "explain" the development pictured abovet, rather to understands some basic mechanisms of an efficient policy.

3 A framework

Our objective is to derive general equilibrium cost-benefit rules for a small perturbation of an existing equilibrium. This perturbation can be interpreted as a small change in environmental policy and will include all the repercussion it will have on all markets. In a way, it is a "non-parametric" computable general equilibrium model (CGE), in the sense that we make no particular parametric assumptions about the supply and demand curves (which one will have to do in a in a CGE-model). Our framework handles non-market values and their interaction with the economy, see Smith & Zhia (2016) for an example of how to integrate externalities in a comprehensive way in a typical computable general equilibrium (CGE)-model. The key insight from this exercise is that the standard partial equilibrium analysis, on which much intuition and policy recommendation is based, is quite robust (provided that the perturbation of the economy is small enough). The key result shows the welfare consequences, in general equilibrium, of marginal cost disparities (and the gains of reducing them); it also gives a very simple way of measuring them.

We consider the following setting. A region (the world can be one region) includes $k \geq 1$ countries, each with a two sector "perfect" market economy with two economic instruments used in environmental policy, a permit market and a tax. The permit market is used in sector 1 where the representative firm competes on the regional competitive market, while a tax is used in domestic sector 2 that does not export its production. Where relevant, we will set the exchange rate to 1 and abstract from any terms-of-trade issues (they are unlikely to be important in our setting, given our focus on small changes). Note that the policy options means that emissions are exogenously given in the case of a permit market, but endogenous if we use a tax. In the latter case, emissions will vary with changes of the economy.

The tax revenue is returned to a representative household as a lump-sum, and in the background the quasi-rent from the permits are also returned lump-sum (implicitly, there could be an auction of permits with the revenues given back to the single household). There is a rule for distributing the permits between the countries of the region, but it will be not be important for the perturbations we study here (this is a version of the Coase-"theorem", that we will discuss further below). While it is well-known that carbon policies are, overall, regressive, we treat distributional issues in a very simple way. Furthermore, while heterogeneity among firms can be important in some analyses, we use a representative firm. We return to the distributional issues below.

In the first case under study, we assume that the environmental problems are strictly domestic. The permit market in each country targets one type of emissions (z_1) and the tax another type (z_2), where we skip country-indices to save on notation. In the second case, we consider climate policy; there is a single type of emission that affects the region as a whole, the uniformly mixed case. Several other variations are possible, such as having one perfectly mixed type of emission and one that affects only each country (or some further variation such as upstream-downstream issues and so on). On the modelling side, we could introduce a whole spectrum of different types of game theoretical models. All of these and other extensions have been studied in detail in the extant literature.

3.1 Assumptions

We will use a static model, even though the underlying problem is inherently dynamic. We do not make explicit the assumptions needed for a general equilibrium to exist and to be unique; because we have externalities in our model, the typical convexity assumptions need not hold. See Mäler (1974) for a detailed analysis of the assumptions needed in general equilibrium models models that cover the environment.

A static model is not ideally suited to study dynamic issues such as the so-called "Green Paradox", which is a kind of intertemporal carbon leakage (intratemporal leakage can be defined as a case when activities move to countries with less stringent environmental policy). Proponents of the Green Paradox argue that an announcement of a gradually stricter climate policy induces oil producer to "start selling, when the selling is good". Paradoxically, announcing an upcoming sharpening of climate policy may therefore increase emissions "today", emissions that otherwise would have come later. An early contribution along this line is Sinclair (1994); the literature today on this topic is substantial, see Van der Ploeg & Withagen (2015) for a survey. How important the "Green Paradox" really is remains a research topic. It has increasingly been realized that there are several counterbalancing forces, in some cases proving the usefulness of a general equilbrium view. For example, in a general equilibrium all assets must give the same rate of return. A intertemporal reallocation of oil production towards the present may decrease interest rates via increasing global savings, which according to the standard model (the Hotelling model) tends to slow down extraction.

Although we will not explicitly deal with intratemporal leakage, our framework can be used to think of these issues; one of our main points is that the Nordic energy taxation is relatively well harmonized (at least in the transportation sector), see section 4. If there were significant leakage with the region, it is perhaps surprising that the literature on intratemporal leakage does not give an immediate suggestion about the impact, since the estimates vary by a wide margin (from negative to positive). See Boehringer et al (2017) for a recent assessment. They also discuss another topic of climate policy that we do not consider here, namely border tax adjustment to mitigate carbon price differences between trading countries. It is not a topical issue in the discussion about Nordic climate policy, so we skip it here.

A further simplification we impose relates to technical progress. To some extent, this is related to the discussion about how much an individual country should do on its own when the underlying problem is supranational; is there a "first-mover" advantage? Such effects tend to be directly or indirectly related to innovations that would, it is argued, not have materialized without an aggressive climate policy. We return to this issue when we discuss the impact of technological progress within the model below.

Furthermore, we restrict attention to small changes. While the standard partial equilibrium approach is quite robust if we study marginal changes, meaning that it well approximates the general equilibrium case, the non-marginal case is significantly more challenging. Briefly, we need to cater for consumer and producer surplus changes in many markets (the marginal case is a limiting case when these surpluses goes to zero). Without making strong assumptions, the net welfare effects will not be invariant to the choice of path from the initial to the final equilibrium. This path-dependency problem can be addressed in various ways. We could solve it here by using another welfare measure (compensating (CV) or equivalent variation (EV)), but this will introduce other issues, not the least of measurement. If we want to deal with the path-dependency problem in practice, we use a computable equilibrium model and simply compute CV (EV), a computation that is necessarily based on a number of assumptions; as noted, our results are in a certain sense "non-parametric". It is a straightforward exercise to extend the framework here to the non-marginal case but in the interest of space, we skip this extension.

The simplicity of the welfare measure we derive is essentally due to our assumptions of equilibrating markets. There will be quantity adjustments, in principle in all of the economy's market, but the assumption of perfect markets thus means that we do not have to consider those changes explicitly in our welfare measure. This assumption, of course, is of considerable help when trying to assess changes of environmental policy. If we have markets imperfections, such as unemployment and imperfect input markets, our main result will have to be modified. We submit, but do not prove here, that the result will still be quite amendable to empirical application, See Johansson & Kriström (2016) for such extensions and the discussion below on welfare measurement inside the production boundary. It would be of merit to make this extension when discussing the issue of "green jobs", a rather popular idea in policy circles (as a quote below will illustrate). This is because "green jobs" are almost invariable discussed in a partial equilibrium sense. The general equilibrium approach reminds us that the resources must come from somewhere, quite possibly from another sector in the economy.

Finally, uncertainty and not the least time and dynamics are important contextual issues that is not included formally in the framework. To handle forests (more generally the LULUCF issue that will be explained in section 4.2.3 below), a dynamic framework would be especially useful. There is also a certain intertemporal flexibility in the EU-ETS not easily handled in a static framework. In short, a dynamic framework is appealing in context.

Despite the caveeats touched upon above, we still believe that our simple framework can be useful in thinking about some of the most pertinent issues in climate policy and we now turn to the details of our model.

3.2 The model

Because we are first considering the case when the environmental issues are isolated in the regions, it is sufficient to describe one of the regions, since we assume that the structure of the problem is similar in all countries. Thus, consider a two-sector competitive economy, where for concreteness one can think of sector 1 as the tradables sector and sector 2 supplying the domestic market. We abstract from inputs, because adding input markets is not going to change the basic result materially (in a second-best world with many taxes, it will). The first-order conditions hold, so that the value of the marginal product will be equal to the price of the input, and this is true for all inputs. This means that the marginal benefit is equal to the marginal cost for a small perturbation and that these changes net out. The permit and taxes will of course affect the cost of buying an input if it causes an externality covered by policy instruments.

The firm in each sector produces a good $x_i, i = 1, 2$ at a given price p_i. Both types of firms emits an externality $z_i, i = 1, 2$ with an emissions technology, so $z_i = g^i(x_i, \alpha_i)$, where the technology is smooth, increasing in x_i and decreasing in α_i. For simplicity, we assume for now that the emission technology is linear, i.e. $z_i = \alpha_i \cdot x_i, \alpha_i > 0$.

Firm 1 must buy emission permits for its operation, each permit can be bought at price p on a perfect market, the number of permits is $\overline{A}$ (this number can thus vary between countries). We will assume that the price of permits is positive, so that the emission constraint is always binding. Firm 2 pays a per-unit emission tax t on its emissions. We use t as a scalar here, although it can be thought of as a vector (in the Nordic countries, energy taxation invariably means that a number of per-unit taxes are levied on e.g. a fossile fuel, see tables 1, 3 and 2 below for details).

The tax revenues are, as noted, returned lump-sum to the consumer. If we add more structure to the model, e.g. an explicit labor market and a tax system, we could allow revenue-neutral tax swaps in the set of policies to be analyzed. This case has been extensively analyzed, e.g. in Commissions in several Scandinavian countries. These analysis tend to show that the "double-dividends" are not that easy to be found.

The profit functions are written as

$$\pi_1 = p_1 \cdot x_1 - p \cdot \alpha_1 \cdot x_1$$
$$\pi_2 = p_2 \cdot x_2 - t \cdot \alpha_2 \cdot x_2$$

In each country, there is a representative household equipped with a standard indirect utility V function with the usual smoothness and convexity properties (here decreasing in prices and emissions, and increasing in income),

$$V = V(p_1, p_2, Y, z_1, z_2) \tag{3.1}$$

where income is $Y = \pi_1 + \pi_2 + t \cdot z_2 + p\overline{A}$, so that we have given the permits to the households directly. We suppress the numeraire good. Thus, we can take the view that the firm buys permits directly for the household, with a perfect market of permits operating in the background and not detailed here. The utility function also represent the social welfare function when there is only one country in the region. Finally, we will use $\lambda = \frac{\partial V}{\partial Y}$ frequently below to convert from the utility metric into "money". In the next section we present our main results.

3.2.1 Analysis

First-order conditions entail that $\frac{\partial \pi_i}{\partial x_i} = 0$. Hotellings lemma provides the demand and supply function for x_i (and all markets that are suppressed in the model). We assume, as noted, that the price of permits is positive and that this market is in equilibrium. Note that the equilibrium depends on the (implicit) endowments of capital, labor and other resources as well as the exogenously given tax and the given number of permits.

We perturb the equilibrium in each country separately now and consider a small change of the economy as it moves from one equilibrium to another (given the labour, capital and other endownments not related to permits). Observe that the emissions in both sectors are given by the choice of $\overline{A}$ and t, that may or may not be optimally set in the initial equilibrium.

We summarize the general result in a proposition, in which we explicitly disallow for technological change. It summarizes the welfare change, converted into money, by a small perturbation of one economy. To avoid complications at this stage, we consider just one country .

Proposition 3.1 *Assume that the region consist of one country. Let $d\alpha_i = 0, i = 1, 2$ so that there is no exogenous technological progress. The general equilibrium welfare change in monetary terms due to a small perturbation is*

$$\frac{dV}{\lambda} = (p + \frac{V_{z_1}}{\lambda})dz_1 + (t + \frac{V_{z_2}}{\lambda})dz_2 \tag{3.1}$$

First of all, note that the prices of permits and taxes (the former determined via $\overline{A}$) in optimum should be such they are equal to marginal willingness to pay to reduce each type of emissions. Thus, in an optimum, $p = -\frac{V_{z_1}}{\lambda}$ and $t = -\frac{V_{z_2}}{\lambda}$, where V_z denotes partial derivative. This is a familiar result from textbooks. Here we interpret it as a *general equilibrium* cost-benefit rule in the sense that we catered for all market repercussions in this economy. A very robust general result in the welfare economics literature is that we only need to look at the "markets" where the exogenous change is made. The result corresponds to the cost-benefit analysis approach of computing the benefits and costs "in the project", which is typically correct for marginal projects.

Since p and t are given from the point of view of the firm, the firms are minimizing costs in the background, although $\overline{A}$ and t, to repeat, are not necessarily optimally set in the status quo ante. If set correctly, the welfare change will be zero by definition of an optimal instrument.

There is at least one possible policy implication from this result. For example, it indicates that we need to be vary of double-counting when considering so called "co-benefits" of environmental policy. For example, fossile combustion results in a vector of emissions, so that when we target one of the emissions with, say, an incentive-based policy instruments we necessarily also affect the whole vector of emissions. An instrument targeting carbon emission indirectly affects sulphur emissions to air, with ensuing health benefits. On the other hand, there could be a fertilization effect of global warming (not the least in the Nordic countries), which would then be lost if carbon was curbed. How are these and a myriad of other "co-benefits" to be added? The result above suggests that if we have "solved" one of the issues via an appropriately set tax (or number of permits), we must be vary of counting the co-benefits, since there is a risk for double-counting. If we switch to cars not using fossile fuels, then assuming that there already exists a correctly set tax on sulphur emissions, we have to take into account that the co-benefits of "climate policy" might already be internalized. This, of course, is also true if the policy is using non-incentive based regulations that are correctly set. Thus, when looking at co-benefits we must take a comprehensive view and think about the all the emissions covered by environmental policy. This point, albeit looking at the case with insufficient "direct policies", seems to be touched upon, in a OECD review of studies of co-benefits:

> However the magnitude of the incentives depends on several issues that have not been fully addressed by the existing literature. In particular, the incentives provided by co-benefits depend on the avoided cost of achieving the same co-benefits by direct policies, which represents an opportunity benefit. Bollen et al (2009, p.6)

We now specialize the emissions to be only of one type and we look at the perfectly mixed type, e.g. greenhouse gases, where Z is the sum of all emissions generated. For simplicity, the general result above abstracted from distributional issues, but to interpret the perturbation from the point of view of the region (which might be the whole world), we need to discuss distributional issues in some more detail. First of all, it is well-known that the impact of climate change is very asymmetric; the are winners and losers. Indeed, a recent Nature paper displays a remarkable difference of the social cost of carbon across the world. It is in the order of -(1-10) USD per ton in the Nordic countries, but up to 100 USD per ton in India. Thus, to emit a ton of carbon (ceteris paribus) actually results in a welfare gain for the "north", but entails a significant welfare loss for the "south". This pattern is fairly robust, when looking at the literature as a whole.

Whatever a globally optimal carbon policy is supposed to mean, it needs to discuss the social welfare function. The physical impact is one side of the coin, how we distribute the costs for reaching any particular goal is another. How to deal with distributional issues in welfare economics is a long-standing issue, with no consensus. Here we will use a standard, if very simple, utilitarian approach.

For concreteness, we now think of two countries (or groups of countries) that makes up the region. We need to do some book-keeping and therefore write out the regional indices, $j = 1, 2$.

$$V^j = V^j(p_1, p_{2^j}, Y^j, Z) \tag{3.2}$$

The case to have in mind is a carbon tax and a permit market for carbon, operating in tandem, much as it does in many European countries. The countries are now connected explicitly by a choice of a policy parameter, i.e. the number of permits allocated. There is also an implicit burden sharing agreement, determining the share $\beta_1 + \beta_2 = 1, \beta_j > 0$ grandfathered to each country. We could also interpreted the share parameters as a way of distributing the quasi-rent from an implicit auction. The allocation rule is not going to affect the result of the small perturbation (this is similar to the Coase theorem, where the equilibrium is independent of the initial allocation of property rights, which is generally true if the utility functions are homothetic). We do not explicitly include a (CSS)-technology, in which carbon is removed and stored in the ground. In addition, there is, as indicated above, no explicit "forest" sector, which would require a dynamic model where carbon is assimilated in proportion to net growth of the forest stock.

As indicated above, to derive the welfare consequences of a perturbation of these two economies, we need to be explicit about what the objective is. In this case, it is a function of the welfare in the two countries, that then needs to be added together in some fashion. The standard utilitarian framework entails that we simply sum the utilities. Alternatively, since we are looking at small changes, we may assume that we are close to a welfare optimum when look at the change. We follow a bulk of the literature when we take $W = \sum V^j$. In addition, we suppose that $\lambda^j = \overline{\lambda}$, i.e. income has been distributed such that the marginal utility of money is equal in the two regions. We then obtain

Proposition 3.2 *If $W = \sum V^j$, the emissions are perfectly mixed, Z is the total emissions, there is no technological progress and $\lambda^j = \overline{\lambda}$, then one way of writing the general equilibrium welfare change in monetary terms due to a small perturbation is*

$$\frac{dW}{\overline{\lambda}} = (p + \sum \frac{V_z^j}{\overline{\lambda}})dZ + (t^1 - p)dz_2^1 + (t^2 - p)dz_2^2 \tag{3.3}$$

The first part of the right hand-side is a Samuelson type of condition. This part looks non-intuitive at first, whence p is related to the sum of all emissions in the permit market which covers only a part of the total emissions. However, in the second two parts of the expression we deduct the terms pdz_2^j, which then nets out to the value of the change of the total emissions in the trading sector. To this we add the emissions in the non-trading sector, valued at the prevailing tax, so that the book-keeping of the emission change is correct.

To check our partial equilibrium intuition, suppose that the emissions are only changing in the non-trading sector of country 1, e.g.$dz_2^1 \neq 0$. The welfare change is then $\sum \frac{V_z^j}{\overline{\lambda}} dZ + t^1 dz_2^1$, the standard Samuelson condition; the welfare change is zero if the tax is set to the sum of the marginal willingness to pay for a reduction. A reduction of the emissions in 1 has a positive spillover effect on the inhabitants in country 2. This is the standard textbook result and a Lindahl equilibrium in the sense that each individual pays a private price for a public good.

The next two terms are not directly part of the standard textbook results. They can be interpreted as describing an efficiency loss, when we do not exploit marginal cost differences. To see this more clearly, let us pin down the optimum conditions first, i.e. $dW = 0$. For this to be the case, we must have that $p = t^1 = t^2$, which is just a condition of an equalization of marginal costs across sectors and regions. Currently, the countries of the world is far away from such an ideal situation, even after a long string of climate summits. There are, however, arguments in favor of differentiating carbon taxes on distributional grounds.

Chichilnisky & Heal (1994) thus argued that there is a case for having a lower carbon tax in the poorer part of the world, if there are constraints on international transfers. They argue that we need to consider "a Lindahl equilibrium rather than a Walrasian equilibrium" (op. cit, p. 443), which means that each country would, in principle, be paying a private price for the public good. Dautume et al (2016) extended the Chichilnisky & Heal (1994) analysis to a richer set of pollution types, so that combustion of fossile fuels also inflicts a local externality. They study a second-best world, in which the government uses distortionary taxes to finance its activities. They show that the carbon price should be equal in all countries also in this case, although this depends on the possibility of international transfers; if these are not available, then different carbon prices can be motivated by distributional concerns.

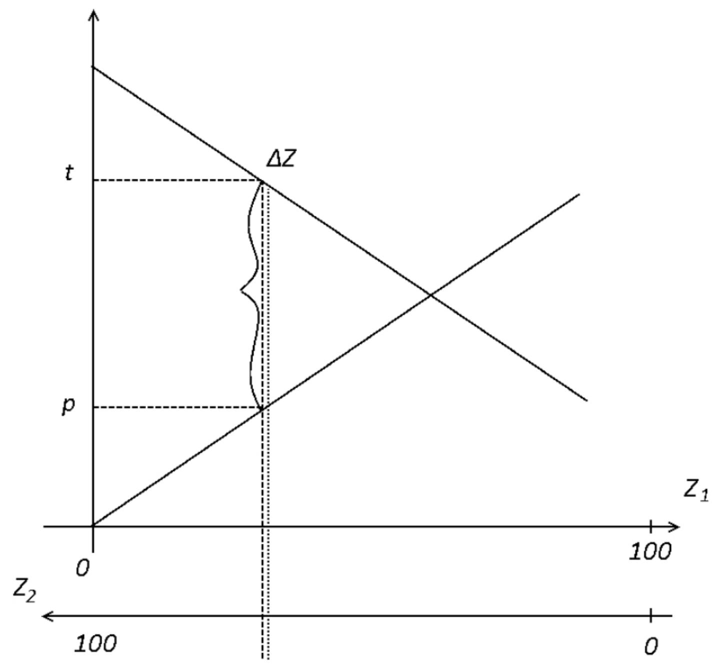
Suppose that the tax is higher than the permit price, a case which, as noted at some points already, has substantial empirical support in the case of the Nordic countries. A reduction of carbon emissions in the non-trading sector of country one, $dz_2^1 < 0$, then implies some welfare loss, even though it does give a direct utility gain to individuals in both countries, because there is a cheaper way of achieving the same result. In monetary terms, this efficiency loss computes to $(t^1 - p)dz_2^1 < 0$, since by assumption $t^1 > p$. This welfare loss can in this set-up thus be measured by simply multiplying the reduction times the tax-price disparity. It is of some interest to note that this, again, is a general equilibrium result. Alternatively, suppose instead that we look at this case in the opposite, i.e. an increase of the emissions in the non-trading sector in country 1, say. We then increase emissions where the marginal cost of reducing them is highest, for at net of $(t^1 - p)dz_2^1$, which would counteract to some extent the utility loss inflicted.

Given our objectives it is natural to explore marginal cost disparities. Let us focus this case with a diagrammatic analysis, in which we fix the emissions to a certain level and only look at the situation in one of the countries. In figure 2 the marginal cost or reducing emissions are plotted from the perspective of sector 1 on the z_1 axis, the higher the emissions, the lower the marginal cost of reducing them. Since the emissions in total are fixed, reducing emissions in sector 1, means that we increase them in sector 2, so the sector 2 marginal cost curve therefore has the opposite slope. Efficiency dictates that the marginal costs are equal, we illustrate a case when t¿p. The figure illustrates a part of proposition 2; the welfare change of a small change of z_1. The key idea is that we can, even in a general equilibrium context, obtain welfare measures that are amendable to empirical analysis. It is, at any rate, one of the conceptual ideas that we will explore in the empirical section of the paper.

3.2.2 Technological change

Let us now focus on the effect of exogenously changing α_i, the parameter representing exogenous technological change. It would be possible to amend our model with a mechanism that supports technological progress at some opportunity cost, but then our results will depend on how we model endogenous technical change. While there is a substantial number of such efforts in the

Figure 2 Marginal cost differences between the trading and non-trading sectors



literature, the work of Paul Romer not the least, here we need to confront the fact that we can subsidize innovation in any sector of the economy, not only for environmental improvements. This would require a substantial extension of the framework and we do not pursue it here.

It is not difficult to show how to include exogenous technological progress in the welfare measure; after all, since it is a costless improvement, it will increase welfare. Note, however, that technological progress in this simple framework also has a public finance effect in sector 2. If, for example, there is a significant switch to electric cars, which certainly is in the cards, this might have significant effect on the public sector revenues from carbon taxes on fossile fuels. It would be an interesting exercise to amend the model with a detailed tax-system. This analysis would then also have to include the fact that electricity might be subject to substantial taxes.

In passing, we may note that our general framework would alert us to the fact that there are externalities associated with electric cars that are not necessarily internalized. In public debate, there is much focus on carbon emissions, but not even electric cars comes as a free lunch in terms of its externalities. For example, the heavier a car, the higher is its wear and tear on roads. There is a substantial effort in the Nordic countries on estimating the externalities from road traffic that can be brought to bear on the vector of externalities involved.

Let us finally touch basis with Nordic policy, as detailed in a position paper from the Nordic Council (Bird (2017)).

> The Nordic countries have resolved to promote the spread of climate-friendly best available techniques. Their governments aim to support green technologies by encouraging public sector purchasers to serve as role models and help to build markets by favouring low-carbon options in areas such as transport, buildings and catering. Bird (2017, p.9))

A motivation for "favoring low-carbon options" in the public sector could be informational failures, but such failures are hardly unique to environmental issues. The basic function of a price on carbon is, indeed, to favor low-carbon options, so it is not clear why this particular effort is needed.

The discussion about the role of technological change in environmental policy has come to circle around the Porter argument and competitiveness and we next consider this in context of our framework.

3.2.3 The Porter and competitiveness arguments

In a well-known, very short, paper Michael Porter (1991) introduced what has become known in the environmental economics literature as the "Porter-argument". A more refined and longer version of the argument is in Porter & Van der Linde (1995). The gist of the argument is that stricter environmental regulations are associated with much lower costs than traditionally assumed, in fact, the costs could be negative. A very significant effort to estimate the marginal cost of carbon reductions has been undertaken by McKinsey. These analysis do tend to suggest that there are measures with negative marginal costs, e.g. in case of buildings, where the owner-renter split-incentives could be an explanation. In our framework, the marginal cost must necessarily be positive, since there is a price or tax on the emissions.

The Porter argument rests on the idea that the regulation itself may improve efficiency and support innovation that otherwise would not have been made. It is quite a popular argument and seems to have some support on the Nordic Minister level;

> Nordic national policies have actively promoted R&D investments related to clean energy sources and energy-saving technologies. Building up local markets for green technologies helps new businesses to create new, green jobs and build up a base for exports that can be expected to boom as other regions seek ways to respond to the global climate challenge. Bird(2017, p.9)

Assessments tend not to give strong evidence for the hypothesis, see e.g. Palmer et al (1995). A critical assessment for Swedish data and a comprehensive literature survey is in Brännlund (2007). A more positive review of the evidence is in Ambec & Lanoie (2008). The gist of the Porter- argument is technological efficiency and endogenous technological improvements, on which our approach is silent. If we are inside the production boundary due to constraints that prevents the economy from reaching all of its potential, we are generally speaking in a second-best world. The general result from the theory of second best is that a policy that moves the economy from the production frontier to somewhere inside it, can be welfare improving, and vice versa. Our linear welfare index is sign-preserving inside the production boundary for a marginal change. As indicated above, we can introduce unemployment and market imperfections in this kind of framework (the general disequilibrium case is treated in Johansson (1982)). Whether or not this comes close to representing the Porter-argument is unclear. There have been some attempts to develop a kind of behavorial economics CBA, where assumptions about maximizing behavior is relaxed, see Bernheim & Rangel (2009). A critical analysis of this proposal is in Smith & Moore (2009). The basic argument of Smith & Moore (2009) is that seemingly inconsistent and irrational choices by households and firms can be thought of as the result of unobserved constraints.

A somewhat related argument, which in some cases is interpreted as the Porter argument, holds that "moving first" in environmental policy translates to gains of competitiveness. The quote above does not mention first-mover advantages explicitly, but it seems plausible to interpret it in this way (since it foreshadows new export markets when other countries follow suit). Of course, "competitiveness" has little or no meaning in our framework, given the assumptions made. In the long run, the exchange rate will equilibriate the current account, so that competitiveness really has no definite meaning here. We can still ask if a more stringent environmental policy has been observed to improve our comparative advantages. There is some evidence of how a more stringent environmental policy in the Swedish pulp & paper industry on chlorine emissions led to the development of a new bleaching technology (oxygen delignification). In turn, this gave the Swedish industry an edge. Finland did not immediately follow suit regarding bleaching regulations. It is quite an interesting case of Nordic environmental policy, whence Sweden's proposal to limit the emissions were rejected at a Nordic Minister meeting in November 1988 (according to Auer (1996)). Whether or not this example supports Porter's ideas can, thus, be debated.

The Porter argument may also be taken to motivate subsidies; the traditional motive in trade policy has been the "infant industry" case, although the political arguments for carrots rather than sticks are probably useful to understand the widespread use of subsidies. The Danish subsidy to windpower and the Norwegian to electric cars are widely known. There is a plethora of other subsidies, not the least in the Nordic countries. A brief review of the Nordic subsidies related to climate policy is in section 4.

Suffice it to mention here that there are several estimates of the costs of climate subsidies, see section 5 for a brief overview. Whether or not the substantial investments in CSS in Norway will pay off is another matter of debate that we do not pursue here. Whatever the motives for subsidies, the case of Germany is of interest in this context, given the scale of the program. While the subsidies in the Energiwende has been scaled down in recent years, it remains exceptional even at a global scale. Germany invested heavily in photovoltaics, only to be outcompeted by China later on. This case also shed some light on the difficulty of harnessing learning effects and keep their benefits in a given country within a global economy.

A strong case for subsidizing technological progress, the "energy technology R&D budget" has been advanced (in the context of a small open economy, specifically Sweden), by Alfsen & Eskeland (2007). Rather than embarking on expensive domestic emission cuts, they argue that it might be better to support technological development that in the end gives a demonstration effect. It is difficult to evaluate this argument empirically, but one of the merits of the proposal is that it does not point to subsidizing any particular technology.

To sum up, it is difficult within this framework to come to grips with Porter-style arguments, because we assume that firms maximize profits, households maximize utility and there are no informational failures. While Porter-style arguments figure prominently in support of policies that are inefficient from a standard economics perspective, strong empirical support is currently not available. But there is no need for a debate about the validity of the Porter-argument, since there are ample opportunities to "do more for less" by utilizing flexibility options in existing policy frameworks, not the least for the Nordic countries. The remaining part of the paper is an attempt to back up this assertion, by detailing pertinent part of existing frameworks and exploring some empirical evidence.

4 The climate policy landscape

The threat of large and rapid climate changes is a global public bad. International co-ordination is thus needed. Here we give a brief description of the policy response, starting at the global level and working via the EU down to the national level of the Nordic countries.

4.1 International agreeements

The United Nations Framework Convention on Climate Change (UN 1992) constitutes the foundation for global climate policy. The Convention states that the objective for the global communitys policy response is to

> achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentra-tions in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sus-tainable manner

The first attempt to operationalize an international climate treaty the Kyoto Protocol set a cap for the industrialized countries' total emissions of greenhouse gases for the period 2008-12[1] and assigned national tradable emission quotas to the participating countries[2]. The idea was

[1]The cap amounted to five times of 94.8 percent of the industrialized countries' emissions in 1990.

[2]The Protocol also defined three different forms of emissions trading; International emissions trading (IET), Joint implementation (JI) and the Clean Development Mechanism (CDM).

that the developing countries would join later and that the overall cap would shrink over time. However, the developing countries didnt come along. A second set of emission quotas for the rich countries for the period 2013-2020 were negotiated, but it was clear that the world had to look for another way of global cooperation.

In 2015 the Paris Agreement was negotiated. The goal for the Agreement is to keep the global mean temperature increase well below 2 degrees C (relative pre-industrial level) and an ambition to stop the increase at 1.5 degrees C. Under the Agreement, each participating country announces how much it plan to reduce its greenhouse-gas emissions, the so-called Nationally Determined Contribution (NDC). Over time, the countries are supposed to announce new, more ambitious NDCs. The idea is that peer review and political pressure will produce such a development. Itmay be argued that the agreement has succeed where the Protocol failed, namely to attract also developing countries. About 180 countries have ratified the agreement. However, it remains to be seen how effective the Paris agreement will be.

The Paris agreement defines two flexible mechanisms ITMOS (Internationally Transferred Mitigation Outcomes, para 6.2) and a project-based mechanism (para 6.4) akin to the CDM of the Kyoto Protocol. It should be noted, however, that a setting where countries determine their own "emission quotas" is not well suited for international emissions trading since both seller and buyer countries then have incentives to increase their target levels (cf. Helm, 2003).

4.2 EU

As a party to the Paris agreement, the EU has announced (EC, 2014) that it will reduce its domestic emissions with at least 40 percent to the year 2030 (relative 1990). The unions long-term target is to reduce its emissions by 80-95 percent to 2050.

The EUs climate policy is divided in three sectors; the EU ETS (EU Emission Trading System), the ESR (Effort Sharing Regulation) and the so-called LULUCF (Land-use-and-land-use-changes). Of these, the permit trading system is particularly important, given our framework.

4.2.1 ETS

The EU ETS covers emissions of carbon dioxide and certain other greenhouse gases from energy intensive industries and energy industries in the EEA (the EU plus Iceland, Liechtenstein and Norway) and carbon dioxide emissions from aviation within the EES area[3]. The roots of the system is to be found in a failure of The European Commission to introduce EU-wide carbon taxes in the 1990s. After some initial resistance (e.g. in discussions of whether permit trading should be a part of the Kyoto Protocol), EC issued a 1998 paper that proposed a EU-wide permit market in 2005. Under the Kyoto protocol, EU had to reduce by 8% below 1990 for 2008-2012. When the system started in 2005, it covered about half of EU CO_2 emissions from 11,500 installations. There are four trading phases (2005-2007, 2008-2012, 2013-2020, 2021-2030), where the first was exploratory. Emission permits are distributed to the participating firms (either by auctioning or grandfathering) which may trade permits with each other. Firms that emit more than the number of permits they surrender to the regulator have to pay a penalty amounting to 100 per ton carbon dioxide. The number of permits added annually to the system is planned to be reduced by an amount corresponding to 2.4 percent of the 2005 allotment, implying that no

[3]Special emission permits are issued to the aviation industry. While flight companies may buy and use ordinary EU ETS permits, other firms cannot buy and use aviation permits.

Figure 3 The (futures) price of carbon on EU-ETS 2008-2018, EUR/ton.

Notes: Historical Futures Prices: ECX EUA Futures, Continuous Contract #1. Non-adjusted price based on spot-month continuous contract calculations). Source: sandbag.org.uk

more permits will be added to the system around 2055. For long, the permit price hovered at a low level, a level deemed too low to be consistent with the EUs long-term objectives. The system has therefore been reformed, a reform that is expected to subtract about 2.5–3 billion permits from the system during the 2020s[4]. This is one important reason as to why the permit price has quadrupled since last summer. Figure 3 displays the market price (a futures price) from April 2008 to October 2018.

The minimum price recorded using this data is about 3 EUR per ton and the maximum 30.5. On average, the price has been about 10 EUR.

[4]The two major elements of the reform are (i) the market stability reserve and (ii) the automatic annulment mechanism. In brief, the system works as follows. When the private banking of permits exceeds 833 million, less permits that are auctioned, permits are transferred to the market stability reserve. From the year 2023, the amount in the reserve is compared to the auction volume, and if being larger the difference is annulled (see NIER, 2018). If the future demand for emissions drops then we may see further reductions.

4.2.2 ESR

The ESR covers greenhouse gas emissions from non-energy intensive industries, households and services and domestic transportation (non-EU ETS). The ESR-directive states that the emissions from non-EU ETS in 2030 shall be 30 percent lower than 2005. Through negotiations between the member states, national emission reductions obligations are distributed. These negotiations gave an outcome related to the member states GDP per capita. For the period 2021-2030, Sweden and Luxembourg are obliged to reduce their yearly emissions in a linear fashion to a target level in 2030 that is 40 percent lower than in 2005. The corresponding targets for Denmark and Finland are 39 percent. Poorer countries, such as Bulgaria and Rumania, are given emission quotas that are just slightly below or equal to their 2005 levels. It is up to the member states to design policies that leads to compliance. A member state that fails to meet its obligation will see its emission reductions obligation for the next year in-creased with an amount equal to the shortfall multiplied with a factor 1.08[5]

4.2.3 LULUCF

The LULUCF-sector covers greenhouse gas emissions and changes in carbon stored in land and forests. Under this regulation member states must ensure that greenhouse gas emissions from the LULUCF-sector are offset by at least an equivalent removal of carbon dioxide from the atmosphere during 2021-2030. Member states that do not comply have to cover their deficits by surrendering ESR-credits to the EU. Carbon dioxide emissions from combustion of biomass in ETS and ESR are not counted in these but as reductions of the volume carbon stored in the LULUCF-sector. There is some controversy regarding the allocation of carbon credits attributable to forest sinks, e.g. when Finland protested in 2017 its allocation (allowed 4.5 MtCO2e, while estimated was 20-30 MtoCO2e).

4.2.4 Flexibility options for the Nordic countries in the EU

The EU ETS gives an EU-wide permit price and allows for optimal allocation of abatement efforts over time (although restrictions on banking behavior have been implemented). However, for the ESR-sector country specific prices/tax rates will materialize that are likely to vary substantially across both countries and time, should the countries follow their linear emission reductions obligations. To increase the cost-effectiveness of its climate policy the EU has established several flexibility mechanisms. The most prominent ones are listed below.

- A member state may borrow ESR emission quota units from the next allocation period (up to five percent of succeeding five years allotment) and may save un-used emission quota units to future allocation periods.
- Some member states (including all Nordic member states) may use EU ETS emis-sion permits (up to a limit) to comply with the ESR.

[5] The national policies must be designed given other EU Directives. Relevant directives include the Energy taxations directive, State aid directive, Energy efficiency directive (at least 27 percent increase in energy efficiency by 2030) and the Renewable energy directive (minimum 27 percent renewable energy in total energy consumption by 2030).

- A member state may transfer up to five percent of its yearly ESR-allocation to other member states. A member state that over-comply may transfer part of or all unused emission quota units to other member states.

- A member state may up to a limit use so-called LULUCF-credits to comply with the ESR.

- A member state that fail to meet its LULUCF-obligation must cover the deficit with units from its ESR-sector or buy LULUCF-credits from other member states. Any surplus may be banked.

Thus, there exists mechanisms that may be used to reduce marginal-abatement costs differences across member states ESR-sectors, much the same way that EU ETS does across energy intensive firms. What seems to be missing are mechanisms that allows for transfers of abatement efforts between the EU ETS and the ESR[6] It should be noted that the convention of counting carbon emission from combustion of biomass and biofuels within the EU ETS and ESR as zero and instead letting these emissions show as negative posts in the member states LULUCF accounts in effect transfers emission reduction obligation from the ESR and the EU ETS to the LULUCF-sector. We comment on this issue in section 6, when we discuss forests as a climate policy option.

As mentioned above, the EU plan to meet its 2030 target of 40 percent reduction of its domestic emissions (relative 1990) by the ETS reducing its emissions by 43 percent and ESR with 30 per-cent (relative 2005). Since these targets are formulated in terms of domestic emission, the EU cannot use the paragraph 6.2 or 6.4 of the Paris agreement to reduce or eliminate any cost differences visa vi the rest of the world.

4.3 Nordic countries: policy objectives

Energy intensive activities in all Nordic countries are, as noted, covered by the EU ETS. The main task for the national governments is therefore to control emissions from their non-EU ETS sectors. Norway and Iceland are not covered by the ESR. However, both countries have announced intentions of conducting their future domestic climate policies jointly with the EU. We will assume that this intention will be fulfilled when we discuss policy implications in section 6.

Table 1, below, display the mid- and long-term climate policy objectives of the Nordic countries. All countries have ambitious long-term targets to be a low carbon society by 2050[7]. When it comes to mid-term objectives some differences can be observed. While Denmark and Finland stick to their ESR-commitments and state that they may use flexible mechanism to comply with the ESR, Norway and Sweden have more ambitious national targets. Norway aims at being climate neutral by 2030 (by buying emission credits from abroad) while Sweden has stated a national emissions target substantially below its ESR obligation (59 percent reduction relative to 2005 instead of 40 percent). Eight percentage points may be attained complementary measures (LULUCF-credits or flexible mechanisms).

[6] Article 24 and article 24a are insufficient in our view.

[7] Defined as having reduced domestic greenhouse-gas emissions by at least 80 percent.

Table 1 The Nordic countries' national emission reduction targets.Bold figures are relative to 1990. Others are relative 2005.

	2030	*2040*	*2050**
Denmark	39	–	**80-95**
Finland	39	–	**80-95**
Iceland	39**	–	climate neutral
Norway	climate neutral(40)**	–	**80-95**
Sweden	59(40)	**75***	**85*****
EU mean ESR	30	60****	**80-95**

Notes: * = Targets regard the ETS-sector plus the ESR/ESD-sector. ** = Assumed ESR-targets. Nor-way expects a target of about 40 percent . For Iceland one might expect an emissions reductions target around 39 percent since it in terms of GDP per capita lies between Finland and Denmark. *** = The Swedish long-term target amounts to zero net-emission in 2045, thereafter negative net-emissions. **** = According to `https://ec.europa.eu/clima/policies/strategies/2050_en`.

As mentioned, Denmark, Finland and Sweden may transfer emission permits to their ESR-sector corresponding to 2 percent of their ESR emissions in 2005[8]. Given this and the fact that they can buy emission quota units from other member states, it becomes evident that Denmark, Finland and Sweden have significant flexibility. If Iceland and Norway join the ESR, they would also enjoy these opportunities. Whether and to what extent flexible mechanism will be used is a political question. Some countries also include sector targets, to be discussed further in section 6. For instance, Sweden has set an emission target for domestic transportation (excluding aviation) by 2030 this sectors emissions shall be 70 per-cent below the level in 2010. Finland has a set up a target of phasing out coal from its energy system by 2030.

4.4 Nordic countries: policy instruments

Since emissions from energy intensive industries and EES-internal aviation are covered by EU ETS, the main task for the national climate policies is to control emissions from the ESR-sector. Despite this, as we will see below, a large portion of the domestic policies are aimed at directly or indirectly reduce emissions covered by the EU ETS. This is, of course, an example of overlapping regulations that are inefficient.

Below we give a short description of the climate polices of the Nordic countries. All Nordic countries energy taxation consists of two components a carbon dioxide component and an energy component. All countries promote the use of renewable energy with price incentives or quotas. All countries differentiate their vehicle taxation with respect to specific carbon emissions. These general instruments are complemented with various support schemes.

4.4.1 Denmark

The Danish carbon tax equals .17 DDK per kg carbon dioxide. The tax is levied on fossil fuels, thereby supporting the competitiveness of biofuels. The use of renewable energy is fur-her promoted by lower energy tax rates and production subsidies. Denmark has a biofuel quota for

[8] In addition, they may use LULUCF-credits for complying with the ESR. The limits for this is Mton CO2 for Denmark, 4.5 for Finland and 4.9 for Sweden.

transportation fuels (5.75 percent). The registration tax on vehicles is differentiated with respect energy efficiency. Electric vehicles are granted further reductions. In addition, vehicle taxation is differentiated with respect to energy efficiency. A national green fund has been established. The fund supports initiatives that promote the green transition, including initiatives that contributes to the fulfillment of the Danish ESR-target. The total budget amounts to DDK 375 million (2017-2020). Several support schemes exists for biogas, e.g. on the use of biogas (e.g., in electricity and heat production) and to investments in biogas plants.

Denmark also have a set of instruments that focus on emissions that are covered by the EU ETS. For instance, a green tariff is levied on households electricity bills (11 percent). The revenues are used to finance renewable energy developments, e.g., wind and solar power plants. The green tariff will be replaced with tendering of green electricity. Moreover, power plants are required to use a certain volume of straw and wood. In addition, Denmark has several energy savings programs.

4.4.2 Finland

The Finnish carbon tax component is reduced (50-100 percent) for biofuels that meet the EUs sustainability criteria. The energy tax is levied on both fossil and bio fuels (except solid biofuels). Higher rates apply on fuels for transportation. Lower rates apply for agriculture. In total, the energy tax system tends support the use of biofuels. Finland has a quota for biofuels for transportation and a biofuel quota (10 per-cent) for heating of buildings and use of light fuel oil for machinery. The registrations and vehicle taxation is differentiated with respect to the specific carbon emissions of the vehicles.

Like Denmark, Finland has several policy measures aimed at emissions covered by EU ETS. There is a feed-in tariff system for electricity produced using renewable energy sources (wind, solar and for-est chips). Fossil fuels used in combined heat and power plants are levied an amount equal to half the ordinary carbon dioxide tax. Waste and bio mass in heat production and process use are not taxed. Finland also have a target of phase out coal by 2030.

4.4.3 Iceland

The Icelandic carbon amounts to 4.7 ISK per kg carbon dioxide. The tax is levied on fossil fuels. Since heat and power production almost exclusively relies on renewables and since industrial emissions mainly are covered by the EU ETS, the focus of Icelands climate policy is mobile emitters. Carbon neutral fuels are exempted from energy tax. There is a biofuel quota (5.75 percent in 2015) for transportations fuels. Iceland has an ambition to increase the use of biofuels in fishery including electrification of the fish-meal industry. Excises on road vehicles are differentiated with respect to the vehicles specific carbon diox-ide emissions. The biannual fee on vehicles is also differentiated, with respect to emissions and weight. No VAT on zero emission vehicles (capped) and methane vehicles face reduced excise and biannual taxes. In addition, low-emission vehicles receive parking benefits. Furthermore, there is a scheme for public procurement of low-carbon and fuelefficient vehicles.

4.4.4 Norway

The Norwegian carbon tax is levied on fossil fuels and amounts to 500 NOK per tonne. The taxation is rather uniform although some users such as fishery pays a lower tax rate. The carbon tax covers about 60 percent of total domestic emissions. Norway has a bio-fuel quota obligation for transportation fuels (10 percent). Biofuels used to fulfill this quota are subject to usual energy taxes (inclusive road usage tax). Biofuel sales over the quota obligation (from 2018 10 percent) are exempted from energy taxes. Investment grants are given to investments in biogas projects and small scaled bioenergy pro-jects based on forest biomass. From 2020 there will be a ban on the use of mineral oil for heating in buildings. Electric vehicles are exempted from vehicle registrations tax and road usage tax (since elec-tricity tax does not include such a component). Such vehicles also pay a reduced annual vehi-cle tax. EV are furthermore exempted from VAT. The user of a EV often get access to bus lanes, free toll passages and access to public parking. There also exist support schemes for building charging stations. The share of Electric vehicles, plug-in hybrids and other hybrids in sales of new cars has increased from about 10 percent in 2012 to around 50 percent.

Enova is a state-owned company (?) with the objective to support the transition to low emission society. Enova gives grants to i.a. projects that reduce greenhouse-gas emissions. Enovas budget has increased from 435 million NOK in 2002 to 2.8 billion in 2018. Enova has contributed to more than 7 000 projects. In addition, there is a program called Klimatsats which support climate investments at the local level. The budget amounts to 100 millions (2016) and 150 millions (2017).

Norway also use several instruments that aims at emissions covered by the EU ETS. The largest one is perhaps the program of developing carbon-capture-and storage technologies. Furthermore, the petroleum sector pays carbon tax and domestic aviation pays a carbon dioxide tax. There is also a so-called base tax on mineral oils to prevent fuel switching in the heating market due to a higher electricity tax. Norway and Sweden have a joint green electricity certificate system supporting electricity produced from renewable resources, e.g., wind power, biofuels and solar.

4.4.5 Sweden

The Swedish carbon dioxide tax amounts to 1.15 SEK per kg carbon dioxide. In general, emitters covered by the EU ETS do not pay any carbon tax. The main exception is heat producers which pay a reduced tax rate. A tax reform 2017 eliminated at set of tax reductions for indus-try outside EU ETS, whereby Sweden now has a rather uniform carbon dioxide tax. The carbon tax on fuels for transportation increases (in real terms) by 2 percent per year to account for the normal GDP growth.

The Swedish carbon tax is only levied on fossil fuels, thereby lowering the relative prices on biofuels. In addition, users of biofuels pay no energy tax or reduced tax rates. Some of these tax exemptions have been deemed be in conflict with EUs state aid rules. Therefore, as of June 2018 an obligation for oil companies to blend in biofuels in diesel (19.3 percent biodiesel) and gasoline (2.6 percent ethanol) is mandated[9]. Blended fuels for transportation pay both carbon tax and energy tax. Pure biofuels are still exempted from energy tax, both liquid and solid. In addition, investment support is given to investments in biogas production[10]

In 2018 Sweden established a bonus/malus system for new cars. A bonus (up to 60 000 SEK) is given to buyers of low-emitting vehicles. Vehicle with higher specific emission face a higher vehicle tax for three years.

[9]The plan is to increase the requirements so that they in total corresponds to a share of 40 percent by 2030

[10]Among others, 390 MSEK in 2014-2023 involving gas from fertilizers.

Klimatklivet supports investments that reduce greenhouse-gas emissions at the local and the regional level. Support is given to the projects that are deemed to yield the largest emission reduction per investment. Between 2015 and June 2017 the Swedish EPA had granted support to over 1 000 projects, totalling 1.2 billlion SEK. Focus is on the non-ETS sector and during recent years, the building of public charging stations for electrical vehicles. Previous evaluations of similar initiatives have shown quite clearly that the cost of reducing carbon emission with these subsidies easily surpasses the carbon tax, see section 5 for more details.

The policy measures listed above all focuses on activities in the ESR-sector (non-ETS). Sweden has also some policy measures that are aimed at activities covered by EU ETS. This goes for the Swedish-Norwegian electricity certificate system. Another example is subsidies to households that invests in own solar power production. Sweden also have subsidies for the purchase of electric propelled vehicles (bicycles and boats).

In 2018, Sweden introduced a tax on flights to and from Sweden. The tax is levied on the ticket and amounts to 60 SEK for a domestic or a EES-internal flight. For longer legs the tax may be up to 400 SEK. The purpose of the tax is to reduce carbon emissions from aviation.

Industriklivet is a program that gives support to projects that reduces the industry process emissions of greenhouse gases. Support is given to pilot and demonstration projects as well as research and innovation projects. The budget for the program equals 300 million SEK per year during 2018-2040. Some programs is due to EU-directive (zero building). Energisteget is a program that aims at promoting energy efficiency in certain industries.

4.4.6 A summary

The Nordic countries have rather comprehensive climate policies. The main bulk of emissions are priced, either by EU ETS or national carbon taxes. There is a clear tendency to promote bio; biofuels often pay lower energy tax rates than fossil fuels and all countries have renewable energy quotas for transportation fuels. Furthermore, all countries have excises on cars and vehicle taxation that are differentiated with respect to specific energy consumption and/or carbon dioxide emis-sions. In addition, most/all countries have support schemes for investments that reduce emis-sions.

A significant problem is thus not one of a lack of policies, but overlapping regulations. The taxation gives incentives to all kind of adjustments, while other policy measures only gives incentives to specific adjustments, e.g., fuel switching, and vehicle choice. The result is a set of complex incentives that are far from uniform.

Table 2 reports the current tax rates on gasoline and diesel in the Nordic countries. We see that the both carbon tax rate and energy tax rates vary substantially over the countries, but in the opposite direction. Hence, the total energy taxation does not vary that much, ranging from 630.7–702.5 for gasoline and 471.1–570.1 for diesel. Denmark, Finland and Sweden all lie at the higher end of the scale in the EU when it comes to taxes on gasoline and diesel.

OECD (2018) has calculated the effective tax rates, taking into account tax exemptions and reductions for various users. The same structure as above emerges. Table 3 expresses the effective tax rates per tonne carbon dioxide (exclusive taxes on electrici-ty output and carbon from combustion of biomass) for gasoline and diesel used in transportation (OECD, 2018). The Table shows i) quite substantial differences in the carbon tax rates the Nordic countries employ, ii) that the energy tax rates tend to be higher in countries with lower carbon dioxide tax rates.

Table 2 Tax rates on gasoline and diesel 2018 in the Nordic countries, euro per m3 Source: National Tax Administrations

	CO2 tax	Energy tax	Total tax
Denmark			
Gasoline	55.8	574.9	630.7
Diesel	61.7	409.4	471.7
Finland			
Gasoline	173.8	521.9	702.5
Diesel	199.0	327.7	530.2
Iceland			
Gasoline			
Diesel			
Norway			
Gasoline	121.6	541.9	663.5
Diesel	139.4	393.1	532.5
Sweden			
Gasoline	255.3	391.6	646.8
Diesel	254.1	315.9	570.1

As a result, the sum of the tax rates does not vary that much between the countries. A similar pattern emerges when one studies the nominal tax rates in 2018.

Table 3 Euro per ton CO2. * ignores fuel tax credit or tax expenditure. Source: OECD (2018)

	CO2 tax	Energy tax	Total tax
Denmark			
Gasoline	25.7	243.1	268.8
Diesel	20.0	134.4	154.4
Finland			
Gasoline	71.6	228.4	300
Diesel	68.2	119.3(214.8)*	187.5(283)*
Iceland			
Gasoline	14.1	199.8	213.9
Diesel	13.6	143.4	156.9
Norway			
Gasoline	44.1	220.5	264.6
Diesel	26.5	147.0(197.0)*	173.5 (223.4)*
Sweden			
Gasoline	123.2	154.0	277.2
Diesel	129.4	73.9(107.8)*	203.3 (237.2)*

Finally, when we turn to energy taxation regarding fossile fuels of industry, the picture is substantially more fragmented, see table 4.

Table 4 Tax rates on Natural gas, oil products coal, coke and coal gases 2018 in the Nordic countries, euro per ton CO2 Source: OECD (2018)

	CO2 tax	Energy tax	Total tax
Denmark			
Natural gas	11.4	42.9	54.3
Oil products	2.9	11.4	14.3
coal, coke and coal gases	2.9	22.9	25.8
Finland			
Natural gas	40.9	30.7	71.6
Oil products	23.9	10.2(20.4)*	34.1(44.3)*
coal, coke and coal gases	20.5	8.5	29.0
Iceland			
Natural gas			
Oil products	16.5		16.5
coal, coke and coal gases	0	0	0
Norway			
Natural gas	44.1	541.9	44.1
Oil products	8.8	29.4	38.2
coal, coke and coal gases	0	0	0
Sweden			
Natural gas	12.3	12.3(80.1)*	24.6(92.4)*
Oil products	15.4	6.2(21.6)*	21.6(37.0)*
coal, coke and coal gases	15.4	6.2(37.0)*	21.6(52.4)*

5 A sample of empirical studies

In this section, we provide a simple calculation to bring home our basic point. We also give a very small sample of some relevant empirical work. We refer to The Danish Economic Council (reports M16-M18) (https://dors.dk/vismandsrapporter, Koljonen et al (2017), Government of Iceland (undated), Statistics Norway (2016) and NIER (2017), for more or less comprehensive reviews of climate policy in the respective Nordic countries. The Environment and Economy Group (MEG)at the Nordic Council has produced a number of relevant background reports, see https://www.norden.org/en/meg. As indicated above, it is also to be noted that there has been a considerable number of Commission reports on climate policy, to which we should add the fact that environmental and climate economics has been a very active research area in the Nordic countries. As noted, we provide a very small sample of this activity, but start with a simple calculation that buttress our main proposal of this paper.

5.1 Gains from emission trading between ESR-sectors a Nordic perspective

As indicated above, EU policy gives no room for using the flexible mechanisms of the Paris agreement to reduce any cost differences between EU and the rest of the world. Moreover, there is no mechanism capable of substantially reduce cost-differences between EU ETS and the ESR-sector. Below we focus on two ways of improving cost-effectiveness of climate policy (i) inter-governmental emissions trading under ESR and (ii) reduced overlap in existing policy.

Table 5 shows the gap between reference scenarios and national emission targets for 2030 and ditto for the EU. The reference scenarios are calculated given an assumption of a ”frozen” policy (the policies that prevailed 2013 or 2016). Thus, these reference scenarios include some climate policies and are therefore not ideally suited for assessments of the countries marginal abatement costs. At the moment, we do not have a feasible alternative.

Table 5 The Nordic countries 2030 reference scenarios for ESR emission, target levels and emission gaps, million ton CO2e

	2005 Mton	Ref scen	Emission Target	Gap 2030	Gap % Ref scen
Denmark	40	30,5	24.3	6.2	20%
Finland	33.7	26,6	20,6	6	23%
Iceland					
Norway	27.6	23.1	16.6*	6.5	28%
Sweden	41.8	26	17.1	8.9	34%
Nordic	143.1	106.2	78.6	27.6	26%
EU	2808	2238	1966	272	12%

Notes: *= Assuming that Norway has -40 percent in ESR obligation. Sources: Danish Energy Agency (2017), Finnish Ministry of Environment (2017), Norway Ministry of Climate and Environment (2017), Swedish EPA (2017), EU (2016) Energy, transport and GHG emissions: Trends to 2050 – reference scenario 2013.

The relative emission reductions required for attaining the national emission targets (the last column) vary somewhat among the Nordic countries, from 20 percent for Denmark to 34 percent for Sweden. In addition, the Nordic countries' relative emission reductions exceeds those of the EU as a whole by quite a margin. At the same time, the Nordic countries already tax at fossil fuels relatively high in a EU-wide context.

Assuming a common price elasticity for fossil fuel demand and noting that the Nordic countries have higher fuel prices incl. taxation (at least for gasoline and diesel for transportation), we infer that the Nordic countries must increase their tax rates more than what the average EU-country has to [11]. Table 6 shows how much the taxes must increases to reach the national 2030-emission targets.

Table 6 Factor to multiply today's gasoline tax to reach emission targets in 2030.

	$\epsilon = -0.5$	$\epsilon = -0.8$
Denmark	1.78	1.49
Finland	1.79	1.49
Norway	2	1.63
Sweden	2.23	1.77
EU median country	1.45	1.28

Note: EU median country in terms of gasoline taxation (Slovakia). The fuel price exclusive of taxes is kept fixed.

Thus, unless the price elasticity of the fossil-fuel demand varies over the countries in an unexpected way, unilateral fulfillments of the countries' 2030-emission targets implies increasing differences between the Nordic countries tax rates and ditto of the median EU country. For instance, the reference scenario for Bulgaria states an emissions level in 2030 that lies slightly below the target level (EEA, 2017). That is, a country with one of the lowest gasoline tax rates in the EU may lower its tax rate and still reach its target.

As explained in the framework, the distance between the tax rates in two countries informs us about the marginal welfare gains that are possible to reap by reallocating abatement efforts amongst two countries. As noted, the ESR includes mechanisms that may be used for that purpose. While simple, this calculation indicates that there are efficiency improvements available that also may increase welfare in other countries except the Nordic.

NIER (2017) investigates the cost-saving for Sweden of emissions trading under ESR. In the model runs, the costs (in terms of GDP-loss 2030) of attaining the 2030-emissions target is more than halved (from -2.2 percent to -.9) when Sweden use international emissions trading instead of fulfilling the target unilaterally.

5.2 Overlapping policies in the Nordic countries

As noted above the Nordic countries have overlapping policies both in the ETS-sector (e.g., support to power production using renewable energy resources) and the ESR-sector (e.g., energy tax deductions for bio fuels, carbon-dioxide differentiated vehicle taxation, schemes supporting emission reducing investments). Complementary policy measures is often added on top of carbon and energy taxation, rather than filling policy gaps. NIER (2017) looks at Swedish policies aiming at reducing carbon dioxide emissions from personal road transports. The study finds

[11] The own-price elasticity of the demand is given by $\epsilon = \frac{dx/x}{dp/p}$. Since -dx/x and p are larger for the Nordic countries than for the average EU country, the formers tax/price increment must exceed those of the latter.

that for some choices, such as choosing an electric car or using biofuels, the incentives add up to 4-7 SEK per kg carbon dioxide avoided. Corresponding incentives for an efficient fossil-fueled car equaled 2.2 SEK 4.08 SEK per kg carbon dioxide. At the same time, the carbon taxation of 1,13 SEK per kg, is the only instrument targeting the activity car transportation. Thus, the Swedish policy gives an incentive structure that are far from uniform over possible adjustments. Aurland-Bredesen (2017) studies the subsidies to electric cars in Norway using a partial equilibrium framework. She finds that reducing the subsidy and increasing taxation of conventional car will lead to efficiency gains.

Isberg et al (2017) evaluate the Swedish Klimatklivet and finds that the investment support given is not directed at activities with a low price on carbon dioxide and a large variation in the investment cost per assumed emission reduction unit, from 0.1 0.8 SEK per kg CO2 avoided, over and above other policies (carbon dioxide tax and no energy tax).

Bruvoll et al (2018) evaluate 41 Norwegian support schemes, i.a. those administrated by Enova. The study finds that 20 schemes should be cancelled, because of their inefficiency. 13 out of 41 were found to be efficient, because they either supported technological developments or addressed another market failure. The remaining are suggested to be modified to increase their efficiency.

6 Policy implications

Our framework and the empirical analysis, together with studies undertaken in the Nordic countries that are focusing on efficiency in climate policy, suggests that there are quite a number of possibilities to improve climate policy. Our main objective is to demonstrate some positive ways forward, but we begin by pointing to a sample of inefficiences that can be removed.

We have pointed to a number of obstacles to a more efficient Nordic policy. Our analysis above pointed the various overlapping regulations, typically when an instrument is added to a sector already covered by the EU-ETS; the use of sectoral goals and the widespread use of variety of subsidies (again, not seldom in sectors already covered by an instrument). To this list we can add Infrastructure investment (high-speed trains, in particular), often seen as a part of a progressive climate policy. One difficulty in evaluating such investments from a climate perspective is technological progress. Since electrical vehicles are likely to dominate transportation when high-speed trains are available, it is not obvious that the trains replaces much fossile fuel based transportation. In addition, all Nordic countries have instruments giving strong incentives to influence vehicle choices. There is thus ample scope for improving the structure. But, an important purpose of this paper is to propose some useful steps forward and we now turn to those,

Our most important proposal is for the Nordic countries to use existing flexibility mechanisms in the current EU policy packages. Norway and Iceland are not part of ESR but have stated that they want to be part of it. As noted, let us assume that they will be. There are significant marginal cost disparities in the Non-ETS sectors between the Nordic countries and, for example, Bulgaria. Our, admittedly simple calculation, suggest that is possible within the current flexibility mechanisms to arrange mutually beneficial non-ETS trades between the Nordic countries and countries such as Bulgaria. Since such trades are voluntary and in-between governments, it is hard to see why this opportunity should not be explored. Indeed, perhaps with the exception of Sweden, the Nordic countries seem positive to using flexibility mechanisms that entails reducing emissions elsewhere. An advantage with focussing on EU agreements is an existing and far-reaching intra-state co-operative framework. While even less costly opportunities may exist on a global scale, they might be slightly more difficult to implement. If the Nordic countries combines their efforts, perhaps led by the Nordic Council, significant resources may be available to allow for material changes in the recipient countries.

There are several other options within the EU climate policy framework, as we have noted. There are intertemporal options, some small possibilities to use ETS permits to comply with ESR and also possibilities to use the existing LULUCF-credits. Our framework does not cover carbon capture (whether using CSS or in some other way), but we briefly discuss here some aspects of this option. For quite some time the possibility to use forests in climate policy as a carbon sink has been discussed in the economics literature. Because Finland, Norway and Sweden are endowed with substantial forest resource this option could also be considered. While there are a large number of analysis of forest management with a carbon option at the stand level, there is less formal modelling of the issue at the sector (or national) level. Lintunen & Uusivuori (2016) provides a forest sector analysis and looks at the benefits and costs of carbon storage in sector equilibrium. Their model includes a carbon cycle module and the multiple uses of forest biomass. One of their more interesting arguments is that it is not correct to view wood-use as emission free. This is to be contrasted with how the energy taxation considers wood use as biofuels in the Nordic countries, as we have noted.

Lintunen & Uusivuori's (2016) proposal includes a comprehensive tax system with net subsidies, so that forest owners are paid for the uptake (and conversely for releases). The practical challenges to develop such a scheme are many, but it still a possibly useful policy option in countries with a rich forestry base. Of course, there are many other policy goals that cover forests, including biodiversity goals; more generally, the move to a "bioeconomy", which includes rather extensive plans e.g. in Finland to increase biofuels production. To assess this option, we thus need a comprehensive evaluation of the benefits and costs (that would take into account that if we e.g. replace cement with wood in housing construction, we must account for EU-ETS in the bookkeeping of how the athmosphere is affected).

Our recommendations can be considered alongside the current Nordic strategy for co-operation in climate policy, as described in Nordic Council of Ministers (2018). It notes that

> The Nordic countries are deeply committed to working together on the environment and climate, and the work is well embedded within the various national ministries and agencies. p.9

It provides 12 recommendations that, in some cases, are similar in spirit to what we offer here. In particular,

> The specific recommendation is that the Nordic environment and climate sector should draw up and implement an action plan for co-operation in order to achieve a low-carbon society by 2050 or earlier. p. 15

Our proposed "action plan" for Nordic co-operation seems to stress the possibilities within the EU-mechanisms more, but the recommendations do point to the necessity of international co-operation

> The primary objective of Nordic co-operation on the environment and climate must be to make a major contribution to the implementation of the Paris Agreement and Agenda 2030, both within the Nordic Region and at global level. p.13

Consequently, there seems to be ample opportunities within existing Nordic co-operative frameworks to pursue discussions about the shaping of climate policy. Our proposals may be viewed as an input to this ongoing discussion, focussing efficiency aspects.

7 Conclusions

This paper argues that Nordic climate policy can become more cost-efficient within currently existing policy frameworks, in particular using the existing EU frameworks to a larger extent than today. The most important pathway to explore is to try to even out the marginal cost of emissions in the non-trading sector, by agreements with countries within the EU. Since bilateral governmental agreements are purely voluntary, the key constraint appears to be the willingness to go beyond national borders in reaching domestic goals.

The prevalence of overlapping regulations is another target for those who seek to improve climate policy in the Nordic countries. In addition, there are a number of measures available within each Nordic country that helps reducing existing marginal cost differences; climate related subsidies and sectoral goals are important examples. Finally, Nordic countries with a substantial forest base are continuing to explore the role of forests in climate policy, which is another promising way forward.

In brief, while the Nordic countries have for long been used as internationally leading examples of how a modern and progressive climate policy can be shaped, it can be made considerably more efficient.

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