Linking the Swiss Emissions Trading System with the EU ETS: Economic Effects of Regulatory Design Alternatives[a]

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1. Introduction

The Swiss government intends to link the Swiss Emissions Trading System to the EU ETS after 2012. This will make it necessary to adapt the current Swiss Emissions Trading System to EU regulations to a large extent. Participation in the current Swiss ETS is voluntary, and emission rights are allocated for free. Participating firms accept a binding cap on their CO_2 emissions. In return, they are exempted from the Swiss CO_2 tax. The current system has typical features of a pilot phase in which firms participate to gain experience and to avoid costs. Linking to the EU ETS after 2012 will require, among other things, mandatory participation of installations in certain sectors above a threshold of greenhouse gas emissions and partial auctioning of emission rights.

The Swiss government is convinced that the linking will be beneficial for Swiss industry, mainly because Swiss emitters gain access to a more liquid and efficiently working market as well as to the same reduction potentials as their EU competitors. Still, parts of Swiss industry oppose the linking in fear of additional costs.

a The simulations were performed during a project financed by the Swiss Federal Office for the Environment and the Swiss State Secretariat for Economic Affairs, which was executed by First Climate and Econability (Classen et al., 2009). A special thank you goes to my project collaborators Wolfgang Knoke, Mischa Classen, Tuomas Rautanen, and Alina Averchenkova. The author's research is supported by the Swiss National Centre of Competence in Research on Climate (NCCR Climate).
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We investigate the macroeconomic and sectoral effects of a post-2012 Swiss ETS with linking to the EU ETS, considering the regulatory changes necessary for a Swiss ETS to be compatible with EU regulations. Regulatory issues include participation thresholds and the share of auctioned permits.

The CGE literature has neglected participation thresholds, leaving the issue for discussions among lawyers and lobbyists. We are not aware of any CGE simulations that address the issue. In contrast, CGE modelers have intensively looked at the question what share of emission permits should be auctioned. Most publications emphasize the existence of windfall profits from grandfathering and contrast them with positive welfare effects of auctioning when revenues are recycled such that overall efficiency increases, see e.g. EDWARDS and HUTTON (2001) for the UK, GOULDER et al. (2010) for the USA. JENSEN and RASMUSSEN (2000) show the same qualitative results for Denmark, but also underline for the case of full auctioning the high adjustment costs in energy-intensive industries e.g. in terms of stranded investment. It is thus important to consider both sectoral effects and economy-wide welfare effects.

Several studies evaluate the economic impacts of Swiss post-2012 climate policy including the Emissions Trading System, notably MÜLLER and BÖHRINGER (2008), MÜLLER and VAN NIEUWKOOP (2008 and 2009), and SCEIA et al. (2009). In contrast to the aforementioned studies, this paper has an exclusive focus on the ETS and pushes the ETS analysis one step further: We have performed extensive data work to adequately represent the Swiss ETS sectors. Each ETS sector is split up into three aggregates according to size in terms of CO_2 emissions, using (confidential) firm level data. This allows us to distinguish between installations in the same sector that are inside or outside the ETS. To simulate the macroeconomic and sectoral effects of different regulatory choices, we built a dynamic computable general equilibrium model of the Swiss economy (GENESwIS).

The structure of the paper is as follows: Section 2 contains a model description. Section 3 elaborates on the data that has been used for model calibration. Section 4 presents the scenarios that have been simulated. Section 5 presents and interprets the simulation results. The main conclusions are summarized in Section 6.

2. Model

2.1 General Description

GENESwIS is a dynamic computable general equilibrium model for the Swiss economy. Firms and the representative household optimize supply and demand decisions under given technologies and preferences. The government collects taxes, grants subsidies and supplies a public good. We assume a constant supply with public goods, which implies that the government must compensate revenue increases or losses by changes in the VAT rate.[1] The consideration of distortionary benchmark taxes and subsidies ensures that efficiency gains due to the recycling of revenues from the auctioning of emission rights are taken into account. The GENESwIS model includes income taxes, value added taxes, fuel taxes and subsidies.

Flexible prices coordinate supply and demand on all commodity and factor markets. The two factors, capital and labor, are assumed to be homogeneous. Switzerland is represented as a small open economy. Following the Armington assumption, domestic and foreign goods are imperfect substitutes. In the model with Ramsey-type dynamics, the economic agents are forward-looking and rational. Although the simulated policies concern the period up to 2020, the time horizon of the model is 2025 to ensure that results for the policy period remain unaffected by end of time horizon effects.

2.2 Sectoral Aggregation

The main objective of the sectoral disaggregation is to combine the ETS installations in appropriate aggregates. We distinguish twelve industry sectors (metals and metal products, cement, wood and wood products, other construction material, paper and pulp, food and beverages, chemical products, oil refining, electricity, district heating, other energy, rest of industry). These sectors are further disaggregated into installations of different sizes according to greenhouse gas emissions:

– Installations with annual greenhouse gas emissions of more than 10,000 t CO_2e. These installations are regulated under the ETS and are exempted from fuel taxes.

1 In reality, revenues (actually: two thirds of the revenues) from the Swiss CO_2 tax are recycled partly lump-sum and partly in proportion to firms′ payrolls. Choosing the VAT rate as an equal-yield mechanism emphasizes the opportunities for efficiency gains through recycling.

- Installations with annual greenhouse gas emissions of less than 5,000 t CO_2e. These installations are excluded from the ETS and pay fuel taxes.
- Installations with annual greenhouse gas emissions of more than 5,000 t CO_2e, but less than 10,000 t CO_2e. These installations are excluded from the ETS in most scenarios and pay fuel taxes. In the low threshold scenario, these installations are included in the ETS and exempted from fuel taxes.

Technologies depend on the size category of the installation, because benchmark fossil fuel inputs to ETS installations are allocated according to the EnAW database (see also Section 3.1). These inputs are deducted from the totals for fossil fuel inputs to the respective industry sector, and the remainder is allocated to the non-ETS installations. The other intermediate inputs are scaled to fill the remaining gap, keeping input shares within the non-fossil inputs constant.

The following seven industry sectors produce homogeneous commodities which are demanded both by industry sectors (intermediate demand) and households: metals and metal products, wood and wood products, other construction material, paper and pulp, food and beverages, chemical products, rest of industry. The public good consists of transport and other services, which in our aggregation are produced by the sector rest of industry. Cement is assumed to be demanded by the construction sector only, i.e. in the aggregation of the model, by rest of industry.

Furthermore, we distinguish seven energy carriers (coal, natural gas, crude oil, heating oil, petrol/diesel, electricity, other) and two additional energy-related goods (transport and heat). This enables us to allocate energy-related CO_2 emissions and sector-specific mitigation options correctly to the sectors. It is especially important to distinguish between heating oil on the one hand and petrol/diesel on the other, mainly because large differences in taxation and gross prices imply very different CO_2 emission factors with respect to value data. While petrol, diesel and heating oil are partly produced in Switzerland (in the sector oil refining), there are no extraction activities in Switzerland for the primary energy carriers crude oil, natural gas and coal. Another specialty concerns the district heating sector, which next to heat produces electricity. Please consult Section 3.1 and the appendix for details on the construction of the social accounting matrix with respect to supply and demand of energy commodities.

2.3 *Opportunities for Substitution*

The degree of substitutability between inputs in production as well as between goods in consumption can be depicted in a nesting tree. It represents the nesting structure and the elasticities of substitution in the respective constant elasticity of substitution (CES) function. Figures 1 and 2 show the CES nestings in GENESwIS for production and consumption, respectively.

The composition of intermediate inputs is considered as given. Geogenic CO_2 emissions in the production of cement, lime and steel are also proportional to output. There are, however, possibilities of factor substitution and the opportunities to reduce energy consumption through increased factor inputs, i.e. through investment in energy efficiency. The elasticity of substitution between energy and the factor aggregate is therefore important in the context of emissions trading.

Energy is divided mainly according to areas of use (motor fuels, electricity and heat, including process heat). District heating and other energy sources are added. Between the different uses, there are few substitution possibilities (e.g. electric heat pumps, electric heaters, electric cars). An important substitution possibility concerns the fuel switch in heating between heating oil and natural gas. In some sectors, particularly in the cement industry, coal use is prominent, too.

Energy-related CO_2 emissions are represented through energy-specific emission factors.[2] The emission factors for other sources of energy are sectors-specific, i.e. a sector that uses mostly renewable energy sources within this category receives lower CO_2 emissions than a sector that uses other fossil fuels. The CO_2 emissions of district heating are taken into account in the production of district heating.

The representative household chooses between leisure, energy and other consumer goods (see Figure 2). The nesting in the energy aggregate is similar to the one in production. Due to differing value shares in the initial equilibrium, the substitution possibilities still differ between consumption and production. For example, coal is unimportant in the household sector.

2 Physical emission factors are taken from Bundesamt für Energie (2007), p. 60. In the model, emission factors apply to value data. Physical energy flows have been transformed into value data by applying prices derived from Table 37 on page 45 of the same publication. For further details, please consult Section 3.1.

Figure 1: CES Nesting in Production

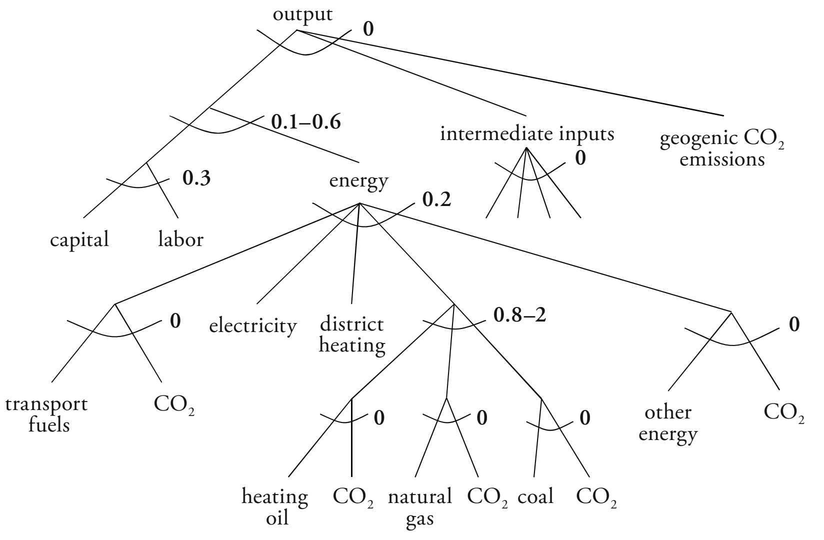
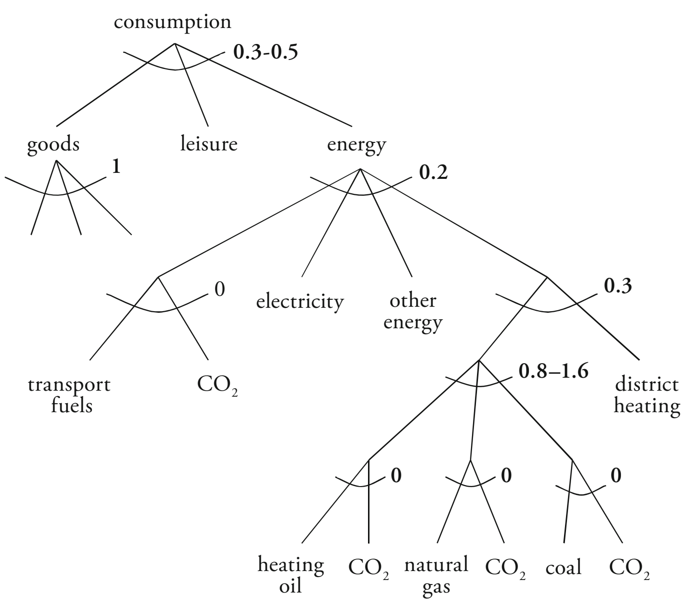


Figure 2: CES Nesting in Consumption



2.4 Emissions Trading System

The representation of the Swiss emissions trading system allows allocating tradable CO_2 emission allowances for free (grandfathering) or via an auction. Foreign allowances and certificates can be purchased at given import prices. Prices of Swiss emission allowances are also determined by the prices in the European system. Firms behave as price-takers.

The model considers all greenhouse gas emissions that are regulated under the Kyoto Protocol. However, mitigation options are modeled only for carbon dioxide, which – according to data from the Swiss federal administration – accounted for 86% of all Kyoto gases. The emissions of the other greenhouse gases follow the Business As Usual path in all scenarios.

A decisive factor is the correct distinction between emissions covered under the ETS and those not covered under the ETS. In many sectors, the boundary runs through the sector. Thus, we split these sectors to correctly represent the different regulation of large and small sources.

3. Data

3.1 Base Year Equilibrium

The base year data of 2005 (Swiss input-output table, foreign trade data as well as project-specific data, see below) have been inflated to 2012 GDP predictions. 2012 was chosen as the base year, as in 2013 post-Kyoto emissions trading is scheduled to begin.

Nathani gathered and consolidated data on physical energy use in Switzerland by NOGA sectors and kindly provided this information for the project. Meanwhile, this work has materialized in the publications of the NAMEA Energy and of an input-output table for Switzerland that is differentiated in the energy sectors (Nathani et al., 2011a and 2011b). As the latter has only recently been published, we used the preliminary data by Nathani to construct a social accounting matrix that contains the necessary detail with respect to energy flows. Please find further details on this procedure in the appendix.

In 2005, Switzerland emitted 54 million tons of CO_2 equivalents. Only a fraction of this is relevant for inclusion in the ETS, given that large point sources account for less than 60% of the industrial emissions of 11 million tons reported in Table 1.

Table 1: Swiss Emissions in Million Tons of CO_2e (2005, According to the Kyoto Protocol)

Industry	Agriculture	Services	Households	Transport	Waste	Total
11.13	5.84	5.64	11.99	15.94	3.13	53.66

Source: BUNDESAMT FÜR UMWELT (2009).

For the ETS-related sectors, the EnAW database (for 2007) provides detailed firm level information on the use of different fuels and on CO_2 emissions. To protect the firms′ confidentiality interests, details of the database may not be published. We amended the database with information on emissions from industrial waste incineration and on process emissions. Moreover, we aggregated the information in the database in three dimensions:

1. by fuel according to the aggregation of energy carriers in the model (see Figure 1);
2. by ETS sector in the aggregation used in the model (see Section 2.2);
3. within each sector, according to the amount of greenhouse gases emitted by each installation (x), with the two size categories: 5,000 tons $CO_2e < x < 10,000$ t CO_2e and $x > 10,000$ t CO_2e). As the EnAW database does not provide information on greenhouse gas emissions by installation, but only emissions and number of installations per firm, we divided the emissions per firm by the number of installations per firm to receive a rough estimate of installation sizes in terms of emissions.

3.2 Marginal Abatement Costs

The simulation of emissions trading relies on information regarding sectoral marginal CO_2 abatement cost curves. However, reliable information on a sectoral level is scarce in this respect. We consulted the relevant publications of JÜLICH RESEARCH CENTER (2003), UCE (2000), IPCC (2007), INFRAS (2006, 2007, 2008), BSS (2008) and BUNDESAMT FÜR ENERGIE (2006a). Assumptions on discount rates and reference paths differ between the sources, and so do marginal abatement costs. Moreover, to account for bottom-up information in the equilibrium model, the data has to be adapted to the specific sectoral conditions in Switzerland. In summary, there is currently no such thing as a bottom-up marginal abatement cost curve that could serve as a consistent basis for the calibration of marginal abatement costs.

Instead, the procedure adopted consists of the implicit representation of the abatement costs and potentials through substitution possibilities by means of nested CES functions. As typical for CGE models, mitigation options are represented in an aggregate way through the above nesting trees rather than through individual technical measures. The most important areas for mitigation in production and consumption include:

- reduction of the polluting activity,
- increased energy efficiency,
- fuel switch to less carbon intensive fuels.

Table 2 provides information on the sector-specific elasticities of substitution, which are based on the available bottom-up information. In the model, the elasticities of substitution determine the sectoral opportunities for greenhouse gas abatement in the model, together with the nesting structure and the sector-specific base year input value shares.

The marginal costs of greenhouse gas abatement for the relevant period (2013–2020) that result from the chosen model structure and parameterization are depicted in Figure 3. They are an endogenous model result based on the calibrated sectoral substitution possibilities and the given Business As Usual path. Two aspects of this curve are typical for general equilibrium models:

- The abatement costs are always positive. Although it is known that there are mitigation measures that pay off in short time periods, it is assumed that information costs, financing constraints and the like have so far prevented their implementation. It is a concession to the assumption of rational actors. This aspect concerns the first percentage points of the reduction, for which abatement costs may be even lower than simulated.
- The curve is exponential. Abatement is cheap up to a certain point, but becomes much more expensive once the potential for cheap abatement has been exhausted.

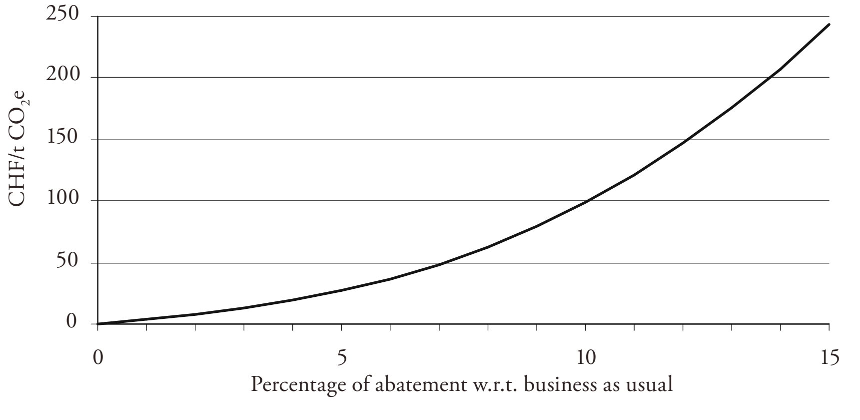
Unfortunately, there is limited information regarding the potential of cheap abatement measures in the Swiss ETS sectors. Our parameterization implies a potential of cheap measures of about 5–6% w.r.t. business as usual. However, this is a rather cautious estimate, which means that Swiss industry possibly has greater opportunities for cheap abatement than assumed here. Further research on this issue is very much needed. It is, however, clear that Swiss ETS abatement costs are higher than in the EU for a given percentage reduction. This is mostly

Table 2: Elasticities of Substitution in GENESwIS

Elasticity of substitution between		energy and factor aggregate		fossil fuels		installation size classes*
Sector	NOGA	2012	2020	2012	2020	
Metals and metal products	27	0.1	0.3	0.8	1.6	0.7
Other construction materials	26	0.3	0.5	0.8	1.6	0.8
Cement	26.51	0.1	0.3	1.0	2.0	--
Wood and wood products	20	0.3	0.5	0.8	1.6	0.8
Paper and pulp	21	0.4	0.6	0.8	1.6	0.7
Food and beverages	15	0.3	0.5	0.8	1.6	0.5
Chemical products	24	0.3	0.5	0.8	1.6	0.7
Oil refineries	23	0.1	0.3	0.0	0.0	--
District heating	40.3	0.3	0.5	0.3	0.3	0.5
Rest of industry	Remaining	0.3	0.5	0.8	1.6	0.3

* Different classes of installations in the same sector according to size of emissions (small installations: $x < 5{,}000$ t CO_2e; medium size installations: $5{,}000$ t $CO_2e < x < 10{,}000$ t CO_2e; large installations: $x > 10{,}000$ t CO_2e)

Figure 3: Marginal Abatement Costs in the ETS Sectors (2013 to 2020)



due to the fact that Switzerland has only few energy-intensive industries and generates electricity almost entirely without the use of fossil fuels.

Outside the ETS, there is considerable potential for cheap emission reductions in the heating of buildings, mainly through improved insulation and through the replacement of oil-fired boilers. In the model, this potential is mostly reflected by a high fuel switch elasticity which drives the replacement of oil-fired heating systems. Further emission reduction potential is found in transport, where large reductions are, however, more costly. This is reflected in the model nestings and parameterization, which permit energy efficiency improvements and to a limited extent a switch to electric mobility, but do not admit large cheap reduction opportunities in transport.

4. Scenarios

4.1 Reference Scenario

The reference scenario of this study is not a Business As Usual scenario. Rather, it represents a climate policy that is suitable to comply with the Swiss reduction target for 2020 (20% compared to 1990 for the aggregate of all greenhouse gases regulated under the Kyoto Protocol), but without an emissions trading scheme. All scenarios, including the reference scenario, are comparable in terms of CO_2 emissions and public revenues, although with emissions trading, actual domestic emissions may vary as ETS installations trade allowances internationally.

The climate policy of the reference scenario concerns only CO_2 emissions, and only CO_2 emitted by burning heating fuels: All firms, households and public entities have to pay a CO_2 tax on fuel oil, natural gas and coal. The heating fuel tax rates of the reference scenario, which are designed to achieve the 20% reduction target for 2020, are higher than the current CO_2 tax of 36 Swiss Francs per ton of CO_2. This is in line with the findings of Müller and van Nieuwkoop (2009). The heating fuel tax in the reference scenario increases from 55 Swiss Francs per ton of CO_2 in 2013 to 110 Swiss Francs per ton of CO_2 in 2020.

Transport fuels, such as petrol and diesel, are not subject to the CO_2 tax, but to an average mineral oil tax of 75.1 Swiss Cents per liter.

We assume for the reference scenario 1.5% economic growth per year. We use population projections by the Swiss Federal Office of Statistics[3] and greenhouse

3 Scenario A-00-2005/09, as updated in 2009. This scenario does not provide estimates for labor supply, but population. However, assuming that the increase in retired people is offset by an increase in the participation rate of women, we use population growth as an indicator for the increase in labor supply.

gas emission projections by the Swiss Federal Office for the Environment. The barrel of crude oil is assumed to stay at the 2005 benchmark price of 55 US Dollars. Energy efficiency parameters have been adjusted to match the above specifications.

4.2 Emissions Trading Scenarios

The ETS scenarios apply to the ETS-regulated greenhouse gas emissions an annual reduction of 1.74% from 2013 to 2020, starting from the basis of average annual emissions between 2008 and 2012.

A major difference to the fuel tax is that in the ETS, greenhouse gas emissions are regulated even if they are not emitted by combustion processes. Geogenic CO_2 emissions in the production of cement and to a lesser extent of limestone and steel are relevant in this respect. They represent more than 4% of Swiss baseline emissions.

Despite the inclusion of these emissions, the installations that are included in the ETS reduce somewhat less greenhouse gases under the ETS than under the fuel tax. As the overall reduction target for Switzerland may not be compromised, the lower abatement contribution of the ETS installations must be compensated by additional emissions reductions by other sources. This requires a slight increase in the CO_2 tax rates for the rest of the economy. Thus, the rate of the fuel tax that applies to emission sources outside the ETS is slightly higher than in the reference case. It increases from 61 Swiss Francs per tonne of CO_2 equivalent in 2013 to 112 CHF/t in 2020. For comparison: the respective tax rates in the reference case are 55 CHF/t and 110 CHF/t.

The main ETS scenario assumes that the most important provisions of the European ETS are carried over to the Swiss ETS, especially those regarding rules for grandfathering and auctioning. Starting from the main ETS scenario, the ETS scenarios are differentiated in three dimensions.

Dimension 1: Prices of European Emission Allowances (EUAs)

It is assumed that Switzerland has no influence on the prices of EUAs. Rather, the European market determines the prices also in the Swiss ETS. For 2020, we assume prices (in € of 2005) of 36 € (medium, main scenario), 72 € (high scenario), and 18 € (low scenario). The main scenario reflects a medium choice out of the commercial forecasts that were available at the time of writing. The price paths are chosen such that prices increase at 4% annually, which corresponds to the model's annual discount rate of 4%. A given stock of emission permits can be interpreted as a depletable resource. This implies that rational actors will take decisions that are in line with the Hotelling rule, which suggests that the price of the depletable resource increases with the interest rate.

Dimension 2: Swiss threshold for the inclusion of installations in the ETS

The main ETS scenario is based on an annual emission threshold of 10,000 t CO_2e. In addition, we simulate a low threshold of 5,000 t CO_2e. Both these threshold have been considered by the Swiss administration.

Dimension 3: Share of auctioned allowances

Since the EU rules for the share of auctioned allowances imply small auctioning quantities for Switzerland, an alternative scenario assumes that Switzerland auctions a higher proportion of allowances than the EU intends. In both scenarios, we assume increasing shares of auctioned allowances over time: The EU rule implies that the share of auctioned allowances increases from 20% in 2013 to 70% in 2020. Sectors that are exposed to carbon leakage risks receive the allowances for free, up to a specified benchmark.[4] We assume that in Switzerland these sectors (in the GENESwIS sector classification: paper, metals, chemicals, construction materials including cement), receive 95% of their emission allowances for free. In the scenario with increased auctioning, between 50% (2013) and 100% (2020) of emission allowances are auctioned, with the exception that carbon leakage sectors receive 80% of their emission allowances for free. Proceeds from auctions are redistributed via variations in the value added tax rate.

Table 3 provides an overview of the scenarios.

4 For the specifics of the EU benchmarking please consult European Commission (2011). The sub-sectors which are classified as exposed to carbon leakage risks are listed in European Commission (2009).

Table 3: Scenario Overview

Scenario	GHG emission reduction in 2020 w.r.t. 1990	CO_2 tax on heating fuels in 2020 in CHF('05)/t	ETS & exemption of ETS installations from CO_2 tax	ETS prices in 2020 in €('05)	Swiss ETS threshold value in t CO_2e	Share of auctioned GHG permits
business as usual (for calibration only)	–3.8%	none	no	n.a.	n.a.	n.a.
reference case	–20.0%	110	no	n.a.	n.a.	n.a.
main ETS scenario	–20.0%	112	yes	36	10,000	as in EU
alternative low ETS prices	–20.0%	112	yes	18	10,000	as in EU
alternative high ETS prices	–20.0%	112	yes	72	10,000	as in EU
alternative low ETS threshold	–20.0%	112	yes	36	5,000	as in EU
alternative high auctioning share	–20.0%	112	yes	36	10,000	more than in EU

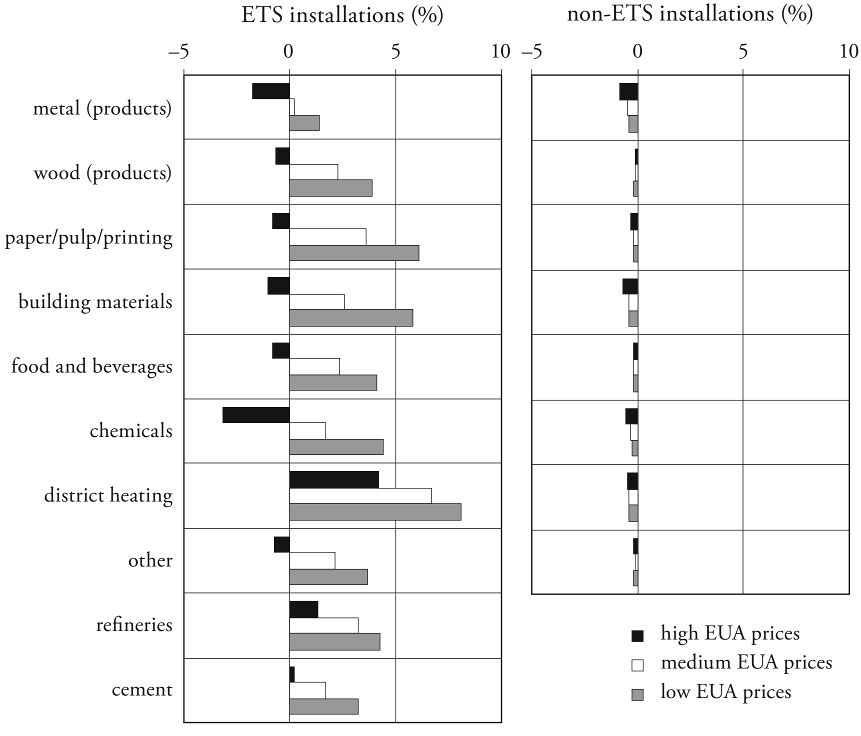
5. Results

5.1 The Influence of EUA Prices

5.1.1 Sectoral Emission Reductions

Figure 4 shows a negative correlation between EUA prices and emissions in 2020 for the installations participating in the Emissions Trading System. This is in line with expectations. In the scenario with high allowance prices (dark), EUA prices are slightly higher than the fuel tax in the reference scenario. Consequently, emissions in most ETS sectors are lower than in the reference scenario. In the other two price scenarios, EUA prices are well below the level of the fuel tax. As a result, CO_2 emissions of the ETS sectors increase. This is primarily not due to lower reduction requirements in the ETS, but because Swiss companies can buy carbon credits from abroad. In a global view, the additional domestic emissions are compensated abroad.

Figure 4: Greenhouse Gas Emissions by Sector and EUA Prices: Percentage Change in Cumulative Emissions 2013 to 2020 w.r.t. Reference Scenario



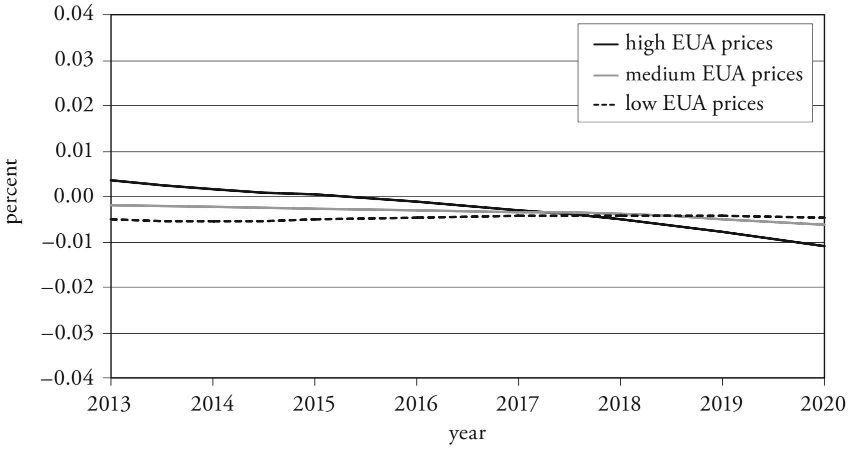
5.1.2 Macroeconomic Impacts

Figure 5 shows a slightly negative effect of the ETS on consumption. Behind this result lies the interaction of different effects:

(A) Marginal abatement cost effect

Cost effectiveness is achieved when the last avoided unit of greenhouse gases is associated with the same cost for all emitters. A uniform fuel tax, as it is contained in the reference scenario, is geared towards this optimum. For Switzerland, however, several inefficiencies arise from the fact that certain CO_2 emissions are not taxed. This concerns especially the emissions from the combustion of motor fuels (assuming that the mineral oil tax exists due to other externalities than climate change) and geogenic CO_2 emissions.

Figure 5: Consumption by EUA Price Scenarios: Percentage Change w.r.t. Reference Scenario



The implementation of an emissions trading system leads to non-uniform prices for emissions of greenhouse gases. Sectors which participate in the ETS can buy or sell emission allowances at market prices. All other sectors face the uniform fuel tax. Thus, decentral abatement decisions are not solely influenced by the technical abatement options and their costs, but also by the type of regulation that applies to the respective installation. This distortion makes the marginal abatement cost effect negative for the ETS scenarios. This is true, although this marginal abatement cost effect is mitigated by the inclusion of geogenic CO_2 emissions into the ETS (as including additional emitters brings marginal abatement costs closer together for different sources). Overall, the marginal abatement cost effect is negative and leads to a reduction in welfare.

(B) Cost reduction effect

Within the emissions trading system, there is the option to buy emission allowances from abroad. Foreign marginal abatement costs are often lower than in Switzerland. The main reasons for this are the CO_2-free electricity production and the low share of energy intensive industries in Switzerland. This option reduces domestic abatement costs.

(C) Excess burden effect

The excess burden effect results from the fact that the participation of Switzerland in the EU ETS changes public revenues. Depending on the share of auctioned emission rights and on the importance of carbon leakage sectors, which are assumed to receive their emission rights largely for free, the revenues from climate policy instruments rise or fall as compared to a pure tax solution. As we assume a constant supply with public goods in the model, the government must compensate revenue increases or losses by increasing or cutting taxes elsewhere. In the model, the VAT rate is adjusted accordingly. Compared to the fuel tax, the Swiss VAT causes a lower excess burden, since it has a broader tax base and the rates are lower. The economic excess burden effect is therefore positive in the considered scenarios when the VAT rate has to be increased.

(D) Transaction cost effect

The transaction cost effect is negative and is composed of the costs which arise for firms participating in the ETS and for the government. This includes all costs that are generated besides the prices for emission credits, for example, information costs, strategy costs, costs of monitoring the market, and the trade itself. With the same reduction target for firms and households, fuel taxation is associated with less transaction costs. However, these costs are very difficult to quantify and are therefore not included in the model.

The negative marginal abatement cost effect dominates slightly the positive effects on consumption, particularly the cost reduction effect. In comparison, the excess burden effect is small. The revenues from auctions, which are available for redistribution, are higher, the higher the prices of emission allowances are. Aggregated over the period 2013 to 2020, the difference between the highest and the lowest price scenario in terms of public revenues from auctions is 0.6 billion francs.

Figure 5 shows that consumption at the beginning of the ETS period is higher at high prices. However, the curves intersect, because net emissions rights are sold to the EU at the beginning, whereas towards the end emission credits are rather imported from the EU than exported to the EU. This effect is related to the way the model has been calibrated to exogenously given emission trajectories (business as usual and reference case) and an exogenously given path for the CO_2 tax in the reference case (Müller and van Nieuwkoop, 2009). More specifically, the calibration to the reference path for the CO_2 tax implies that the marginal abatement costs for emissions covered by the CO_2 tax follow that same path in the reference scenario. This tax path is steeper than the assumed price path for European emission allowances, which implies that marginal abatement costs rise quicker in Switzerland than in the EU. As a consequence, Swiss installations have a tendency to be more active sellers in the beginning of the period considered.[5] Fortunately, this intertemporal effect, which must be attributed to arguable exogenous requirements, is pronounced only for the high EUA price scenario.

5.1.3 Sectoral Impacts

Figure 6 shows that sectoral output depends on the prices for emission allowances.

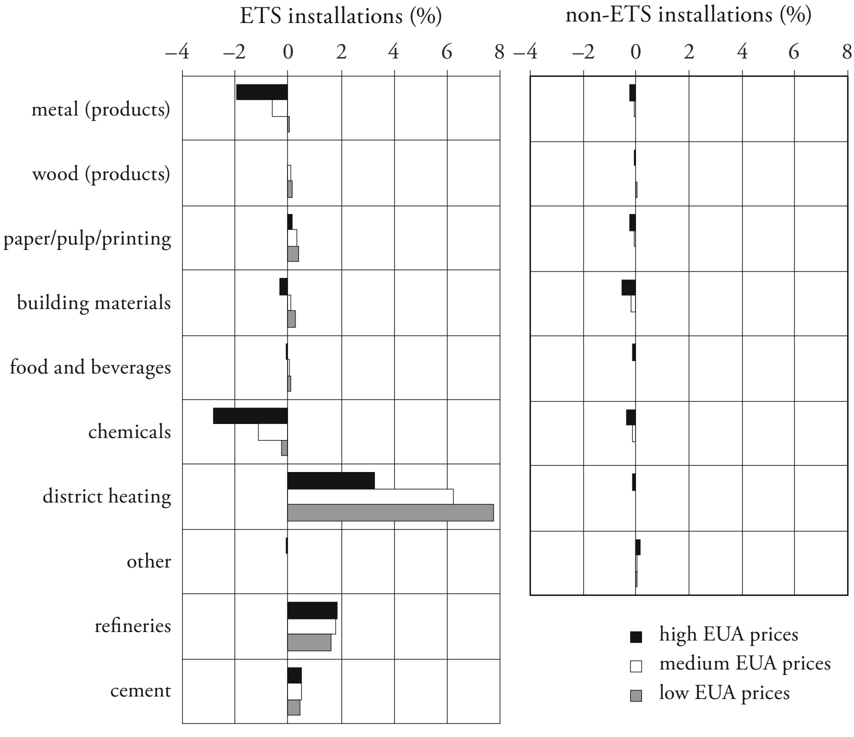
For most ETS sectors, output falls with higher EUA prices. This can be explained through higher costs related to emissions. It is striking that the cement sector and oil refining react differently. The reason is that these sectors, which are classified as carbon leakage sectors, according to our parameterization receive more emission rights than they need after exhaustion of their cheap abatement potential (especially in the cement sector). Therefore, they benefit from the ETS by selling unrequired emission allowances. With the resulting revenues, they reduce unit costs of their main products and supply to the market at lower prices. In the model, this results in an increase in sales. This effect is larger at higher ETS-prices.

It should be noted, however, that this effect crucially depends on the assumption of perfect competition, which implies that windfall profits do not persist. Perfect competition leads to zero profits, i.e. cost savings through grandfathering reduce average costs throughout the respective ETS sector. In this setting, free allocations of emission permits effectively become a side payment to the sector which attracts new competitors. As a result, sectoral output increases and prices fall until zero profit holds for the sector. In contrast to this, grandfathering in combination with market power leads to windfall profits. Under the assumption of perfect competition / zero profit, the positive sectoral effects take the form of increased output rather than increased profits. It is important to note that the welfare implications of grandfathering would be less favorable under imperfect competition.

Also striking in Figure 6 is the important increase in output of district heating and oil refining. An explanation is the relative energy intensity of production in these sectors. The district heating installations in the ETS are mainly operated with natural gas, and the sector is not only a user, but also a supplier

5 Alternatively, we could have assumed a similarly steep price path for EUAs. As the model interest rate would then be lower than the annual price increase for EUAs, the effect would be reversed, and Swiss installations would have become more active sellers towards the end of the period considered.

Figure 6: Output by Sector and EUA Prices: Percentage Change in 2020 w.r.t. Reference Scenario



of energy (heat and electricity). When its competitive position worsens, output is also influenced by shifts in power and heat demand towards more favorable energy sources. This is strongly the case in the reference case. Therefore, the sector benefits significantly from the ETS. Similarly for the refineries: The fuel tax in the base scenario is a big expense for this sector as an energy consumer and producer of heating oil.

In the cement industry, production processes are characterized by high geogenic CO_2 emissions. While these are not covered by the fuel tax in the reference scenario, they are regulated under the ETS. Thus, a decline in output should be expected. However, the cement industry benefits from the ETS, because as a carbon leakage sector it obtains considerable free allocations of emission allowances. Furthermore, the energy input in the production of cement is relatively high, and fuel switch opportunities are present to a significant degree, for example by increasing the gas share compared to the more CO_2-intensive fuels, such as coal.

5.2 The Influence of the Threshold for Inclusion into the Swiss ETS

5.2.1 Sectoral Emission Reductions

Figure 7 considers the threshold for the inclusion of installations into the emissions trading system Threshold values of 5,000 t CO_2e and 10,000 t CO_2e are distinguished. The medium-sized installations with emissions between 5,000 and 10,000 t CO_2e deserve special attention. They pay less for their greenhouse gas emissions than under the fuel tax (cost reduction effect of the ETS). Especially in the carbon leakage sectors (in the model: metal processing, paper, construction materials, chemicals, and cement), the large free allocations are an additional advantage. As a reaction to lower costs for emissions, the relevant installations increase the emissions with the entry into the ETS. Other installations are only marginally affected by the issue of the inclusion of the medium group into the ETS (see left and right part of the figure).

5.2.2 Sectoral Impacts

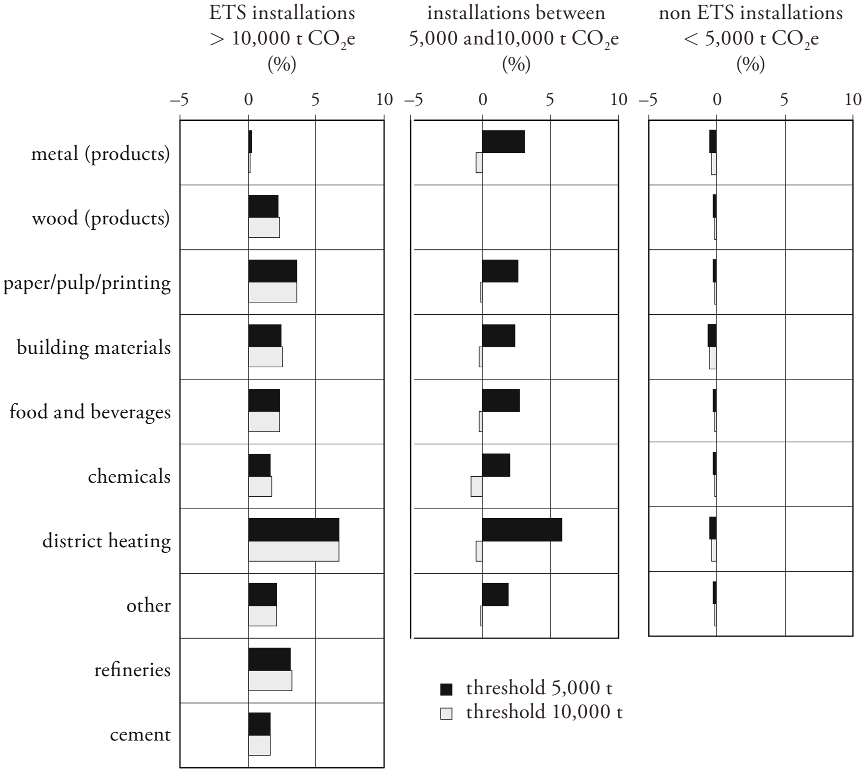
The middle part of Figure 8 shows that the participation in the ETS for those installations with emissions between 5,000 t and 10,000 t CO_2e would be an advantage. The particular sensitivity of district heating goes along with the high energy intensity of these installations. However, the caveat applies that the model calculations do not capture the transaction cost effect. The benefit of participation in the ETS is thus overestimated. For those installations that are included in the ETS in any case (> 10,000 t CO_2e) as well as for those outside of the ETS, the results are almost completely independent of the threshold value of the inclusion into the ETS.

5.3 The Influence of the Rules for Free Allocation of Emission Rights

In the alternative allocation scenario (“more than EU”), the free allocation of allowances is lower than intended by the EU.

Figure 9 shows the changes in emissions of the individual sectors in comparison to the reference case in 2020. Considering both scenarios of the figure in comparison, it is clear that the rules for the free allocation of emission permits

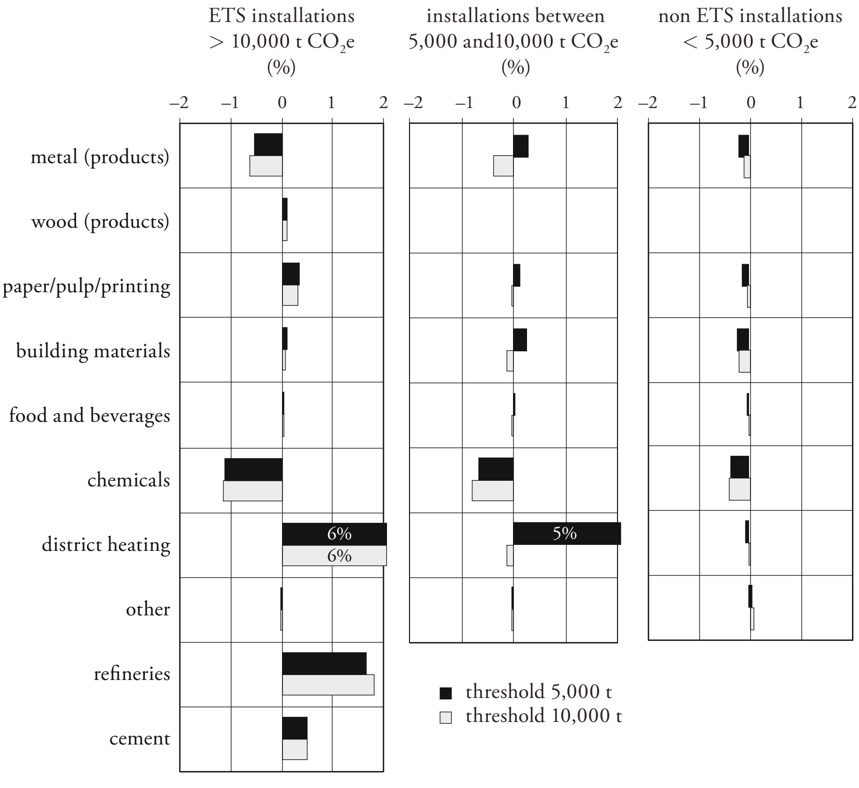
Figure 7: Greenhouse Gas Emissions by Sector and Threshold Value for ETS Inclusion: Percentage Change in Cumulative Emissions 2013 to 2020 w.r.t. Reference Scenario



hardly have any influence on sectoral emissions. The reason is that the level of free allocations is, although a relief on the cost side, unimportant for the marginal calculus for the abatement decisions. The slight differences between the scenarios are only due to an output effect, which arises because cost reductions increase sales and output under perfect competition (see also Section 5.1.3). Only for the very energy intensive district heating, this output effect leads to significant changes in emissions. The other sectoral and macroeconomic variables are hardly affected by different rules for the allocation of emission rights, even if grandfathering is known to cause a loss of efficiency as it is a distorting subsidy.

The revenue from auctions, which can be recycled, is higher if more emission rights are auctioned. Aggregated over the period 2013–2020, the difference

Figure 8: Output by Sector and Threshold Value for ETS Inclusion: Percentage Change in 2020 w.r.t. Reference Scenario

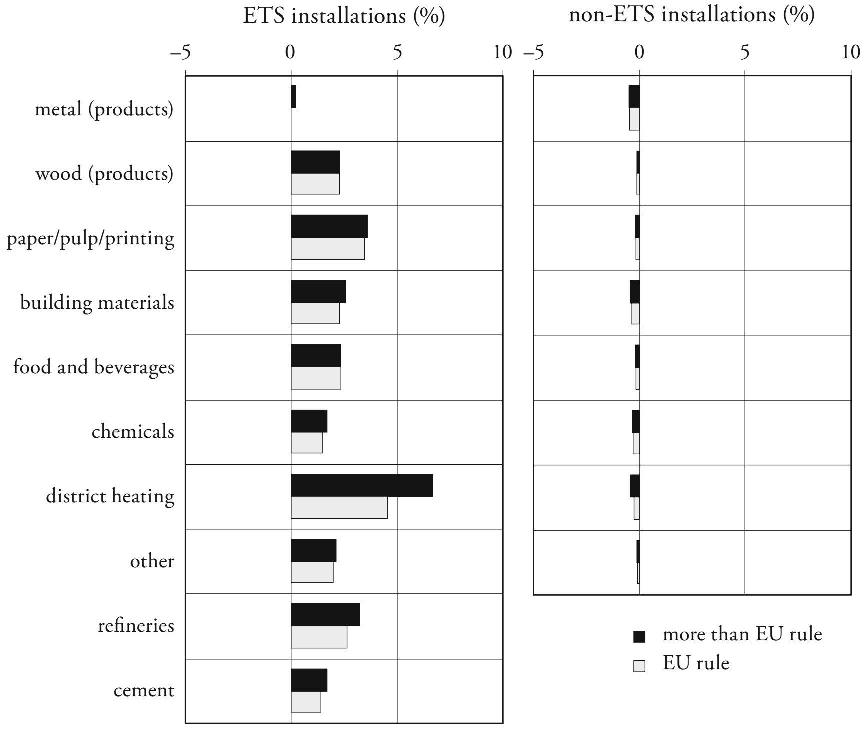


between both scenarios is around half a billion Swiss Francs at the assumed prices.

5.4 Overview of Welfare Effects

The welfare measure used here is Hicks Equivalent Variation based on discounted consumption, including leisure, over the entire model horizon. Table 4 shows that neither a lower threshold value nor increased auctioning are favorable in terms of welfare. In other words: The main ETS scenario, which is characterized by a threshold of 10,000 tonnes and auctioning in accordance with EU rules exhibits the lowest welfare loss.

Figure 9: Greenhouse Gas Emissions by Sector and Auctioning Share: Percentage Change in Cumulative Emissions 2013 to 2020 w.r.t. Reference Scenario



A possibly surprising result is that high permit prices increase welfare as compared to low permit prices. The reason for this is the very moderate reduction requirement for Swiss ETS installations compared to Business As Usual. The resulting low marginal abatement costs enable many Swiss companies to sell rather than buy emission permits in the EU market. Furthermore, the distortion that is caused by differing CO_2 prices between installations that pay the CO_2 tax and those under the ETS becomes smaller as ETS prices increase.

Table 4: Hicks Equivalent Variation, Percentage Change with Respect to Reference Case

ETS threshold value Auctioning share	5,000 t as in EU	10,000 t as in EU	10,000 t more
High permit prices		–0.0027%	
Medium permit prices	–0.0064%	–0.0035%	–0.0039%
Low permit prices		–0.0048%	

6. Sensitivity Analysis

We examine the influence of key model parameters on the results of the main ETS scenario (see Table 5). We increase the respective parameter values by 50% and alternatively decrease them by a third. Results of the sensitivity analysis are given with respect to respective reference scenarios which have been calibrated with the same modified parameter value. This is necessary, because we want to see, for example, how a change in the oil price influences the welfare effect of the emissions trading system (rather than how a change in the oil price influences welfare).

As one would expect, the price of oil has considerable influence on the model results, especially on the share of emission reductions that are implemented domestically. With a higher oil price, the ETS does not increase domestic emissions in the way reported in Figure 4. This is important given that the oil price has risen considerably since 2005.

High Armington elasticities as well as high elasticities of substitution between energy and other factor inputs have a similar effect, because increasing these parameters has a decreasing effect on baseline emissions, similar to a hike in oil prices. Furthermore, high elasticities of substitution between energy and other factor inputs turn the small welfare loss of the ETS policy into a small welfare gain. This confirms the well-known importance of this parameter, which influences substantially the marginal abatement costs. In the absence of strongly accelerated technical change, increasing this elasticity by 50% is, however, a bit of an odd assumption.

In comparison to the above, the elasticity of substitution between fossil fuels ("fuel switch elasticity") is less critical.

Table 5: Sensitivity Analysis

	Welfare (*)	Consumption	Sectoral emissions
		percentage change w.r.t. reference case in 2020	
Main ETS scenario	–0.004%	–0.006%	2.380%
Elasticity of substitution between fossil fuels			
low	–0.004%	–0.007%	3.158%
high	–0.002%	–0.004%	1.572%
Elasticity of substitution between energy and factor inputs			
low	–0.007%	–0.014%	4.011%
high	0.003%	0.012%	–0.099%
Armington elasticities			
low	0.000%	–0.002%	2.707%
high	–0.008%	–0.021%	–0.046%
Oil price			
low	–0.009%	–0.011%	4.309%
high	–0.006%	–0.009%	–0.177%

(*) = percentage change with respect to reference case

7. Conclusions

Emissions trading systems are reputed to be efficient instruments for emission reductions. In the case of the participating firms in Switzerland, they replace an emissions tax, which is, in theory, another such instrument. Even if both instruments come with real world imperfections, it is not a surprise that we simulate a macroeconomic impact of the ETS that is very small.

In contrast, sectoral effects are not negligible. We have simulated maximum changes of output of −3% to +8% for individual ETS sectors. Thus, we find in this case that distributional consequences of regulatory choices are far more important than efficiency considerations. Most installations in the ETS benefit from moderate reduction targets and also from the possibility of buying foreign carbon credits. For some of the installations, the latter option is cheaper than ambitious abatement efforts.

However, the model does not consider transaction costs. It has to be assumed that the transaction costs of an emissions trading system for the participating companies, but also on the side of the regulators, are higher than in a pure tax solution. For most of the ETS installations, the advantages of the ETS are likely to overcompensate the transaction cost disadvantage. It remains to investigate whether this also applies to installations that emit less than 10,000 tons of CO_2 equivalents per year.

An important feature of the proposed Swiss ETS is that geogenic CO_2 emissions of the cement, lime and steel industries are included in the ETS, while they remain unregulated under the emissions tax of the reference scenario. This increases the regulated emissions from ETS installations by approximately 50%, which provides the chance for a substantial efficiency gain.

This gain is however thwarted by efficiency losses due to differing marginal abatement costs for ETS installations on the one hand and other sectors of the economy on the other hand. To reach the Swiss reduction target for 2020 of 20% with respect to 1990, the other sectors face a CO_2 tax that is much higher than the assumed prices for European allowances. Despite the inclusion of geogenic CO_2 emissions, ETS installations abate less under the ETS than in the reference scenario. The ETS reduction target implies a reduction of only about 8% compared to business as usual. As a consequence, the rest of the economy has to accept a slightly higher fuel tax. However, given that the actual business as usual path is uncertain, it has to be said that this uncertainty carries over to the conclusions. This highlights the importance of further investigation into the business as usual emissions path.

Appendix: Energy-Related Details on the Construction of the SAM

According to BUNDESAMT FÜR ENERGIE (2006b), Table 6, storage pumps consume 1,731 GWh of electricity. This information is used to assign a realistic number of own demand of electricity to the respective field in the diagonal of the input output matrix. Other own demand of the original NOGA sector 40 (energy) is related to district heating. Own demand, energy inputs as well as output of district heating are taken from data that has been provided by the Swiss association of district heating (Verband Fernwärme Schweiz). Where necessary, priority has been given to this data over the original input output data and over data from general energy statistics. Electricity output from combined heat and power is treated as a by-product of district heating and has been deducted from the electricity column in the input output table, which had previously represented all electricity generation. The producer price of heat has been set at 11 Swiss Cents per kWh. This allows for a realistic assignment of energy inputs in value terms to the district heating sector. However, consumers pay only 7.2 Swiss Cents per kWh. In the model, we assume the difference to be covered by subsidies. In reality the low prices paid by consumers are related to other sources of revenue and by-products such as waste disposal, other public services and electricity. Any remaining own demand of the original NOGA sector 40 has been eliminated, because it mainly represents deliveries between different stages of the value chain, especially in the electricity sector.

2005 nominal prices for energy carriers per TJ are calculated from Bundesamt für Energie (2006c), Table 37. The resulting average prices in Swiss Cents per kWh are 17.3 for electricity, 7.2 for natural gas, and 7,0 for heating oil. Consumer prices for transport fuels are 153 Swiss Cents per litre, of which 75.1 Swiss Cents are mineral oil tax. These numbers represent a weighted average of petrol and Diesel. Based on an international internet search for 2005, prices for crude oil and coal are assumed to be 55 US Dollars per barrel and 50 US Dollars per tonne, respectively.

Final energy demand in TJ for the disaggregated elements of NOGA sector 40, i.e. electricity, natural gas, district heating and other energy, have been taken from Bundesamt für Energie (2006c), Table 4. The same publication provides on pages 32 ff. accounts for crude oil and petroleum products in tonnes. This data has been converted into values in Swiss Francs by applying specific energy contents and prices. It has been prioritized over the original input output data for supply of crude oil and petroleum products, both domestic and imported.

In contrast to the original input output table, transport is fully represented by the transport columns and rows of the social accounting matrix, including the demand for petrol and diesel. Crude oil, natural gas and coal have been introduced into the social accounting matrix as separate commodities and deducted from the imports of NOGA sector 14 (mining and quarrying). For these primary energy carriers, there is no domestic production. Demand for crude oil is split into demand for the production of heating fuels and transport fuels, taking into account the respective quantities produced in Switzerland as well as the respective average conversion rates (39% for heating fuels, 22% for transport fuels).

The cement sector has been separated from NOGA sector 26 (other non-metallic mineral products) in proportion to output. Demand for cement is fully allocated to the construction sector, i.e. in the aggregation of the model, to rest of industry.

References

AMANN, MARKUS, LENA HÖGLUND ISAKSSON, WILFRIED WINIWARTER, ANTTI TOHKA, FABIAN WAGNER, WOLFGANG SCHÖPP, IMRICH BERTOK and CHRIS HEYES (2008), *Emission Scenarios for non-CO2 Greenhouse Gases in the EU-27,* Final report of the International Institute for Applied Systems Analysis, Laxenburg.

BSS (2008), *Vermeidungskosten Industrie und Verkehr*, Basel.

BUNDESAMT FÜR ENERGIE (2006a), *Der Energieverbrauch der Industrie, 1990–2035. Ergebnisse der Szenarien I bis IV und der zugehörigen Sensitivitäten BIP hoch, Preise hoch und Klima wärmer*, Bern.

BUNDESAMT FÜR ENERGIE (2006b), *Schweizerische Elektrizitätsstatistik 2005*, Bern.

BUNDESAMT FÜR ENERGIE (2006c), *Schweizerische Gesamtenergiestatistik 2005*, Bern.

BUNDESAMT FÜR UMWELT (2009), *Emissionen nach CO_2-Gesetz und Kyoto-Protokoll*, Bern.

CAPROS, P., L. MANTZOS, V. PAPANDREOU and N. TASIOS (2008), "Model-Based Analysis of the 2008 EU Policy Package on Climate Change and Renewable", Report to the European Commission.

CLASSEN, MISCHA, FRANK VÖHRINGER, TUOMAS RAUTANEN, ALINA AVERCHENKOVA and WOLFGANG KNOKE (2009), *Studie Schweizer Emissionshandelssystem nach 2012 – Auswirkungen für die Wirtschaft,* Bundesamt für Umwelt, Bern.

EDWARDS, T. HUW, and JOHN P. HUTTON (2001), "Allocation of Carbon Permits within a Country: A General Equilibrium Analysis of the United Kingdom", *Energy Economics*, 23, 371–386.

EUROPEAN COMMISSION (2009), *Commission Decision of 24 December 2009 determining, pursuant to Directive 2003/87/EC of the European Parliament and of the Council, a list of sectors and subsectors which are deemed to be exposed to a significant risk of carbon leakage,* Brussels.

EUROPEAN COMMISSION (2011), *Commission Decision of 27 April 2011 determining transitional Union-wide rules for harmonised free allocation of emission allowances pursuant to Article 10a of Directive 2003/87/EC of the European Parliament and of the Council,* Brussels.

GOULDER, LAWRENCE H., MARC A.C. HAFSTAED and MICHAEL DWORSKY (2010), "Impacts of Alternative Emission Allowance Allocation Methods under a Federal Cap-and-Trade Program", *Journal of Environmental Economics and Management*, 60, pp. 161–181.

Jensen, Jesper, and Tobias N. Rasmussen (2000), "Allocation of CO_2 Emissions Permits: A General Equilibrium Analysis of Policy Instruments", *Journal of Environmental Economics and Management*, 40, pp. 111–136.

INFRAS (2006), *Cost effectiveness of GHG Emission Reductions in various sectors*. Study for DG Enterprise and Industry in collaboration with ifeu, IVL, TNO, TU Graz, Brussel.

INFRAS (2007), *Wirkungsanalyse EnergieSchweiz 2006. Wirkungen der freiwilligen Massnahmen und der Förderaktivitäten von EnergieSchweiz auf Energie, Emissionen und Beschäftigung*, Bundesamt für Energie. Bern.

INFRAS (2008), *CO2-Vermeidungskosten im Inland: Erneuerbare Energien, Industrielle Prozesse und Mobilität. Kurzbericht zuhanden der UREK-S, Subkommission Energiepolitik*, Bundesamt für Energie, Bern.

IPCC (2007), AR4 WG III: Mitigation, URL: http://www.ipcc.ch/ipccreports/ar4-wg3.htm.

Jülich Research Center (2003), „Das IKARUS-Projekt: energietechnische Perspektiven für Deutschland", Abschlussbericht des Projekts IKARUS.

Müller, André, and Christoph Böhringer (2008), *Schweizer Emissionshandelssystem: Wie weiter nach 2012? Analyse mit einem Mehrländer-Gleichgewichtsmodell*, Bundesamt für Umwelt, Bern.

Müller, André, and Renger van Nieuwkoop (2008), *Volkswirtschaftliche Auswirkungen von CO2-Abgaben und Emissionshandel für das Jahr 2020 – Analyse der volkswirtschaftlichen Auswirkungen mit Hilfe eines allgemeinen Mehrländer-Gleichgewichtsmodell*, Bundesamt für Umwelt, Bern.

Müller, André, and Renger van Nieuwkoop (2009), *Volkswirtschaftliche Auswirkungen der Schweizer Post-Kyoto-Politik – Analyse mit einem dynamischen Gleichgewichtsmodell für die Schweiz*, Bundesamt für Umwelt, Bern.

Nathani, Carsten, Sonja Kraner, Daniel Sutter and Jürg Heldstab (2011a), *Erstellung einer NAMEA Energie für die Schweiz*, Bundesamt für Statistik, Neuchâtel.

Nathani, Carsten, Daniel Sutter, Renger van Nieuwkoop, Martin Peter, Sonja Kraner. Matthias Holzhey, Heinz Rütter, Remo Zandonella (2011b), *Energiebezogene Differenzierung der Schweizerischen Input-Output-Tabelle*, Bundesamt für Energie, Bern.

Sceia, André, Philippe Thalmann and Marc Vielle (2009), *Assessment of the Economic Impacts of the Revision of the Swiss CO2 Law with a Hybrid Model,* Bundesamt für Umwelt, Bern.

UCE (2000), ICARUS-4,URL: http://www.uce-uu.nl/index.php?action=1&menuId=1&type=project& id=2&.

SUMMARY

The Swiss government intends to link the Swiss Emissions Trading System to the EU ETS after 2012. Employing GENESwIS, a dynamic computable general equilibrium (CGE) model of the Swiss economy, we investigate the macroeconomic and sectoral effects of a post-2012 Swiss ETS with linking to the EU ETS. It is the first such CGE analysis for Switzerland with disaggregated sectors according to magnitude of CO_2 emissions from installations, which allows distinguishing ETS installations from non-ETS installations in the same sector. The reference scenario represents the announced post-2012 Swiss climate policy without ETS, implying a GHG emissions target for 2020 of -20% with respect to 1990. In the ETS policy scenarios, regulatory issues include participation thresholds and the share of auctioned permits. We show that the Swiss ETS reduction targets are not ambitious when declining baseline emissions are assumed. Thus, most ETS installations profit from an ETS, while non-ETS sectors have to reduce more emissions (and pay a higher CO_2 tax). In the context of the simulated Swiss ETS scenarios, we find that distributional consequences of regulatory choices are far more important than efficiency considerations.