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Survey

Europe's experience with carbon-energy taxation

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Abstract

The COMETR project is a comprehensive attempt to account ex-post for the implications of carbon-energy taxation, taking into account differences in sectoral tax burdens and within a suitable macro-economic framework capable of providing an overall assessment, the E3ME model of Cambridge Econometrics. The results indicate reductions in greenhouse gas emissions for six member states as a result of carbon-energy taxation under revenue-neutral environmental tax reform (ETR). These effects are mirrored by reductions in total fuel consumption, with the largest reductions occurring in countries with the highest tax rates. Accordingly, the European environmental tax reforms had by 2004 caused reductions in greenhouse gas emissions of 3.1% on average for the six member countries examined, with the largest fall recorded for Finland (5.9%). E3ME-results also suggest that ETR-countries did not experience marked impacts on economic growth (GDP). There was a negative effect for energy-intensive industries but due to many exemptions the burden has remained modest and, where revenues have been recycled to lower employers' costs for social security contributions, generally below 2% of gross operating surplus.

Keywords: *Taxation, fiscal reform, carbon, Europe, CO_2.*

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The disappointment over outcomes in Copenhagen has in certain countries reverberated on unilateral efforts towards factoring in carbon costs in energy prices. The French government, which had announced a carbon tax at 17 euro/ton CO_2, backed out from the initiative following judicial concerns that more than 90 per cent of industrial emissions were to be exempted. The Irish government, on the other hand, recently did implement a domestic carbon tax (at a rate of 15 euro/ton CO_2). No unilateral measure will of course tackle climate change *per se* and it can also be argued that a low tax mainly addressing households and private transport will have limited impact on carbon emissions. However, all tax changes come gradually and limited unilateral measures may offer prospects for the longer term, in particular if more countries implement comparable systems for pricing of carbon.

Competitiveness vis-à-vis emerging economies, in particular China, is at the heart of concerns over carbon leakage with emissions pricing approaches. Some policy-makers in Europe now propose that a border-tax adjustment should be introduced for products imported from non-annex-1 countries without carbon reduction commitments, and WTO's secretariat has indicated that under certain conditions compatibility with international trade law could be obtained for such schemes (WTO & UNEP, 2009).

However, while on one hand China rejects to accept binding caps on its carbon emissions under international agreement, it pursues vigorously energy savings and promotion of renewable energy in order to sustain its high economic growth-rates. China is since 2007 no longer self supplying with energy, and it is clear to its leadership that sufficient energy supply is a real bottleneck to its continued economic growth, and in turn to its political stability. With continued annual growth rates above 10 per cent China will in less than a decade have doubled its energy consumption, unless energy productivity improves. State regulated prices on gasoline, coal and gas have in recent years been increased, whereby the gap to world market prices has been closed. Even a system for carbon taxation (Task Force, 2009) is under consideration and has been receiving serious attention in the process of preparing the next 5 year plan. The purpose of this survey paper is to present experiences with carbon-energy taxation obtained in northern Europe, as not only in European countries but also in several Asian countries carbon-energy taxation is now for some time on the decision-making agenda. Analysis of the experiences obtained from actual experiments with carbon taxes is a useful complement to insights from ex-ante economic modelling.

Finland (1990), Sweden (1990), Norway (1991) and Denmark (1992) have been frontrunners in launching specific CO_2-taxes to curb CO_2 emissions (Andersen, 2004). Concerns over climate change coincided with policies in these countries aiming at reducing income taxes—and by addressing these two issues in combination a series of tax shifting packages were created, which have been in the main revenue-neutral. Netherlands (1996) and Slovenia (1997) followed the policy trend a few years later, and towards the close of the 1990s two of the largest EU economies, Germany (1998) and UK (2000) introduced carbon-energy taxation policies too, adding more weight and significance to the approach. While UK introduced a specific climate change levy on fossil fuels, Germany increased more broadly its energy taxes as part of a so-called 'ecological tax reform'.

The implication for the European economy as a whole has been the shifting of an annual tax bill of more than 25 billion euro—these taxes having been converted mainly from labour taxes to what is here termed 'carbon-energy' taxes. The reforms involved shifting taxes amounting for up to 1.1% of GDP; highest in Denmark, Sweden and Germany.[1]

Equity issues figure prominently in all considerations over tax policy and the environmental tax shifting has in European countries been accompanied with tailor-made compensations for vulnerable subgroups, such as pensioners, unemployed and families with many children. Taxes related to heating fuels and end-use of electricity tend to be regressive and have warranted compensating measures, such as targeted 'green checks'. Overall, however, VAT is found to be three times more regressive than environmentally related taxes as a whole. Detailed studies have demonstrated that taxes related to gasoline and vehicles are in fact progressive, as high-salary earners—unsurprisingly—tend to drive in relatively more expensive and fuel-consuming vehicles than do low-salary earners (Jacobsen *et al.*, 2001:74).

A considerable number of studies have been carried out to determine the broader environmental and economic implications of introducing carbon-energy taxes (for an initial survey see Andersen (2004)). In contrast to the 1990s, where mainly ex-ante modelling studies prevailed (such as Carraro and Soubeyran, 1996; Harrison and Kriström, 1997; Bach *et al.*, 2002), the focus has in recent years been towards better empirically based ex-post studies that, by employing a range of analytical approaches and modelling techniques, attempt to disentangle the actual impacts of carbon-energy taxation (Enevoldsen *et al.*, 2007; Agnolucci, 2009). It is no small challenge to figure out the impact of a specific tax measure when considering a time-series of observations for, say, greenhouse gas emissions, energy consumption and economic performance. With an ex-ante model, strong assumptions are often involved, including perfect competition and fully rational actors, while the results will depend on the values of a range of intermediate variables, for instance what is assumed about economic growth or about ongoing structural change in the composition of the manufacturing sector. With an ex-post approach the analyst is constrained by the actual historical data, but nevertheless must employ stringent analytical methods of econometric nature, that allow for attribution to the specific impacts of the tax increase, as further explained in the section below.

1 Following ETR carbon-energy taxes comprise 4.5-6.8% of total taxes in these countries, amounting to 1.8-2.6% of GDP. In addition there are transport and pollution taxes in place. http://ec.europa.eu/taxation_customs/taxation/gen_info/economic_analysis/tax_structures/index_en.htm Accessed: 2011-01-07. (Archived by WebCite® at http://www.webcitation.org/5vYrPBe87)

According to basic behavioural and economic theory carbon-energy taxes are expected to curb emissions and improve on energy productivity. Controversy accompanies the broader macro-economic implications of carbon-energy taxation, including for competitiveness, employment and economic growth. The misty character of this debate would appear to some extent to stem from the heat of vested interests, as in fact a degree of consensus has emerged concerning the properties of environmental tax reforms that are specifically revenue-neutral, c.f. overview of theoretical debate in part II below. In a final section this article addresses the differences between taxing and trading carbon, and considers possible implications of double-regulation due to the co-existence of the European Union's emissions trading system (ETS) with the unilateral schemes of carbon-energy taxation in individual EU member countries.

1. IMPLICATIONS OF CARBON-ENERGY TAXATION FOR CO_2 EMISSIONS AND ENERGY CONSUMPTION

Basically one expects carbon-energy taxes to provide incentives in two directions; a demand effect whereby the demand for energy is reduced as a result of the price increase caused by the tax; and a substitution effect whereby carbon fuels are substituted by low-carbon or carbon-neutral fuels that are taxed at lower rates. As reduced energy demand may reflect either a lowering of output or actual energy savings it is often more appropriate to monitor energy intensity. In other words we would expect to see changes in energy intensity as well as carbon intensity as a result of carbon pricing.

While some analysts have suggested that a global carbon price will need to be increased to a level of 30-40 euro/ton CO_2 by 2020 to stabilise atmospheric concentrations (Barker, 2007), the price at which CO_2 is traded under the cap in the European ETS is presently about 15 euro/ton.[2] Unilaterally applied carbon-energy taxes in individual EU member states have been more modest and for industries range generally from a low, to some extent symbolic level (for the most energy-intensive industries) up to approximately 25 euro/ton in the case of Sweden and Finland. Denmark is exceptional with a tax on energy consumed for heating purposes (including for industries) at an effective rate of about 80 euro/ton CO_2.

In evaluating the impact of carbon-energy taxes on CO_2 emissions a complicating factor is that in some cases they have replaced pre-existing energy taxes, and now come under a different name and with a modified tax base according to carbon content rather than energy content. Sweden, for instance, has had taxes on industrial energy consumption in place already since 1974, which then were modified in 1990 towards a CO_2 tax base.

Whereas in Germany and UK carbon-energy taxes were introduced only from the end of the 1990s, the four Nordic countries and the Netherlands, with time series of more than a decade, generally provide the firmest basis for ex-post assessment. Slovenia has a longer timeline too, but as a country in transition, one associated with data and conversion difficulties.

It goes without saying that carbon-energy taxes are not (yet) applied across-the-board with uniform rates for all emitters and fuels. Over time countries have adjusted tax rates and tax bases, so as to achieve carbon-energy taxes more in accordance with theoretical prescriptions, but in the short run pragmatic considerations have prevailed. For this reason effective fuel tax rates vary considerably from sector to sector and while it is not always immediately clear what kind of exemptions, liability caps or special arrangements that specific industries or target groups have obtained, these circumstances are of course crucial when a proper ex-post evaluation of impacts and effectiveness is to be made.

The COMETR project[3] (Andersen *et al.*, 2007; Andersen and Ekins, 2009) is a comprehensive attempt to account ex-post for the implications of carbon-energy taxation, taking into account differences in sectoral tax burdens—in addition to other complications indicated above. In order to tackle the specific challenge of disentangling and attributing the specific impact of the tax shift COMETR relies on a suitable macro-economic framework: the E3ME model of Cambridge Econometrics which is a comprehensive time-series estimated macro-economic model of economy-energy-environment relations within the EU, which also can account for EU trade relations with the rest of the world[4]. For the purposes of modeling changes in fuel consumption and CO_2 emissions as a result of relative price changes and feed-backs in the economy, the model has a high resolution, featuring here eleven different fuels and more than 40 economic sectors.

E3ME is overall an empirically oriented, data-rich model, which does not employ assumptions about a long-tem general equilibrium in the economy, and which hence is strongest in analysing trends in the short—and medium term. The COMETR project carefully improved and sharpened the modeling base of E3ME by retrieving country-specific data for carbon and energy taxes, including all the relevant sector-specific exemption arrangements, in order to be able to model and disentangle the impacts with E3ME.

In order to tease out the specific impact of the tax shifting, two scenarios were set up in E3ME. First, a 'baseline case' was calibrated constrained by historical data to match observed outcomes over the period from 1994-2003 for all seven countries with environmental tax reform (ETR) and the rest of the EU. Second, a 'counterfactual reference case' scenario was modeled, which basically involved a projection of 'what if' there had been no tax shifting as a result of environmental tax reform, keeping everything else in the model constant (Barker *et al.*, 2009).

2 See http://www.pointcarbon.com/ Accessed: 2011-01-07. (Archived by WebCite® at http://www.webcitation.org/5vYqlEY9L)
3 COMETR was supported by a grant from the European Union's Sixth Framework Programme for Research and the author of the present article was its scientific coordinator. (FP-6 contract no. 501993). http://ec.europa.eu/research/fp6/ssp/cometr_en.htm). Accessed: 2011-01-14. (Archived by WebCite® at http://www.webcitation.org/5vjT4o52N)
4 http://www.camecon.com/ModellingTraining/suite_economic_models/E3ME.aspx Accessed: 2011-01-07. (Archived by WebCite® at http://www.webcitation.org/5vYs5lrMK)

By subtracting the outcome of the 'what if no ETR' case from the historical case it became possible to disentangle and attribute the specific impact of the carbon-energy taxes introduced under the revenue-neutral ETR.

The model has information for historical energy tax burdens prior to the introduction of the carbon-energy taxes, and hence E3ME can account for the specific impact only of the additional carbon-energy taxes introduced—and the associated tax shifting. The 25 billion euro in new carbon-energy taxes came on top of pre-existing energy taxes amounting to about 80 billion euro annually. Exemptions, non-payments and negotiated agreements for specific industrial sectors are included as accurately as possible as they happened, subject to the total revenues matching the published figures in each case.

In summary, E3ME illustrates the difference between what did happen and what would have happened had there been no ETR. As any modelling exercise it is a 'best guess', but the model is well suited to the purpose.

In addition to analysing the historical period from 1994-2003, E3ME also included a projection for the period up to 2012. During this period, forecast increases in energy prices as well as the introduction of the EU's emissions trading scheme influence results. Both the ex-post and ex-ante parts of the modelling were undertaken with the same set of equations, for instance for the labour market wage formation (Barker *et al.*, 2009:166).

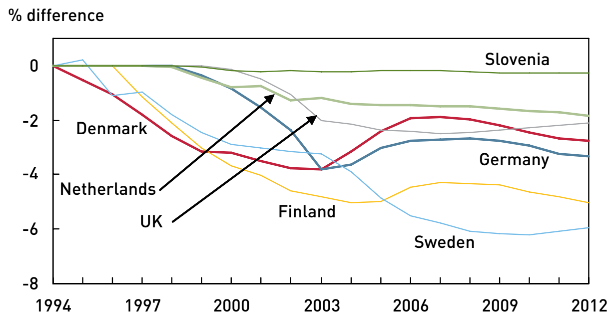

Figure 1: The effect of ETR on total fuel demand (note: % difference between the base case and the counterfactual reference case). Source: Cambridge Econometrics.

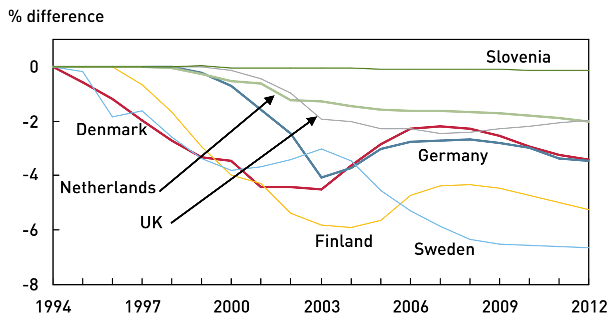

Figure 2: The effect of ETR on GHG emissions (note: % difference between the base case and the counterfactual reference case). Source: Cambridge Econometrics.

According to the estimations six countries show a reduction in fuel demand that results from the ETR (see Figure 1). The size of this reduction is dependent both on the tax rates imposed (how they are applied to the various fuels and fuel user groups, how easy it is for fuel users to substitute between the various fuel types and non-fuel inputs) and the scale of the secondary effects from resulting changes in economic activity. On average the reduction in fuel demand estimated for 2004 was 2.6% in six ETR-countries although it was slightly higher in Finland than the other countries. No reduction was identified in Slovenia, which in fact mainly relabelled its pre-existing mineral oils tax into a CO_2-tax.

We would expect to see a reduction in greenhouse gas emissions from lower consumption, but total emissions will also depend on the relative consumption levels of each fuel type. For example, a tax system that encourages the use of coal is likely to produce higher emissions than one that encourages the use of natural gas or biofuels. E3ME includes explicit equations for fuel shares of hard coal, heavy oil, natural gas and electricity. Assumptions are made about the other fuel types linking them to the closest modeled alternative (e.g. other coal is linked to hard coal, crude oil to heavy oil). For middle distillates (petrol, diesel, etc.), demand is linked to total fuel demand by sector. The reason for this is that demand for these fuels is dominated by the transport sectors. This sector does not generally use any other fuels, so fuel share equations are not required.

The scenario results indicate that there are reductions in greenhouse gases for six member states as a result of the ETR (see Figure 2). The effects closely follow the results for total fuel consumption, with the largest reductions estimated for the countries with the highest tax rates. Finland and Sweden, for example, experience the largest reductions in emissions, in most cases exceeding the decline in fuel demand, providing evidence for the efficiency of ETR in reducing emissions. In contrast, the German ETR was not particularly efficient in reducing emissions as it did not include coal. According to E3ME the European environmental tax reforms had by 2004 caused reductions in greenhouse gas emissions of 3.1% on average for the six member countries examined, with the largest fall recorded for Finland (5.9%).

Enevoldsen (2005) studied Danish and Dutch experiences with carbon-energy taxation and matched outcomes against developments in Austria, a country that has introduced neither market-based instruments nor ETR. Denmark's policy of ETR began in 1992, whereas the Netherlands introduced its ETR only in 1996 after some years promoting voluntary long-term agreements with industry. In Denmark, industry improved energy intensity by close to 30% in the decade from 1990-2000, whereas the Netherlands and Austria obtained improvements in the range of 10-15%. A particular aspect of Denmark's program of carbon-energy taxation, believed to have been significant for the marked impacts on energy productivity, was the earmarking of 20% of the revenues to co-finance energy efficiency measures and upgrade production technology. These funds were made available in a Danish Energy Agency supervised program. Auditors provided an independent review of company energy practices and made recommendations for improvements as well as for investments based on up to four year returns. For Denmark, Enevoldsen *et al.* (2007) found somewhat larger CO_2-reductions in industry than the E3ME-model, which does not attribute effects to the specific energy-efficiency earmarking of revenues. Still, Bjørner and Togeby (1999) have confirmed that companies participating under the Danish program undertook more substantial energy savings than companies subject to the tax only, on average 60% extra.

2. IMPLICATIONS FOR COMPETITIVENESS AND ECONOMIC PERFORMANCE

2.1 THE THEORETICAL DEBATE ON TAX SHIFTS

Harvard economist Michael Porter argued in 'The Competitive Advantage of Nations' (1990) that, contrary to conventional wisdom, environmental policies may encourage process—or product-oriented innovation and improve competitiveness, in particular when anticipating requirements that will spread internationally (Porter and van der Linde, 1995; Porter, 1998). From a few initial remarks in his book Porter elaborated the argument and cautioned that many environmental regulations presently violate the principles for a positive impact on competitiveness as they involve command-and-control requirements for specific pre-defined technologies, often end-of-pipe, rather than leaving room for adaptation, flexibility and innovation. References to the Porter hypothesis in the literature tend to neglect that use of market-based instruments for environmental policy implementation is the premise for improvements in competitiveness (Porter, 1991). Although in real world company management the challenge to identify and harvest the readily available savings persists, there was vigorous controversy in the 1990s over Porter's claims that there were indeed 'low-hanging ten-pound notes' that had not been picked up by business.

David Pearce (1991) called attention to the possible 'double dividend' feature of carbon-energy taxes, by which he referred to the improvement in social welfare that could arise if taxation was shifted from 'goods' to 'bads'—e.g. from labour to carbon. Since environmental taxes serve to correct market failures, by definition they do not share the distorting properties of many other taxes. By adopting a fiscally neutral package that exchanges existing taxes for carbon-energy taxes, the opportunity arises to reap positive benefits in terms of a higher employment rate, which may improve short-term economic performance, while also delivering a long-term environmental dividend. David Pearce's approach was soon adopted in the famous European Commission White Paper that argued a shift in taxation in order both to reap the short—and the long-term dividends (Commission of the European Communities, 1993). However, complications arise where environmental taxes are introduced in the realistic context of pre-existing taxes that are distorting to the economy.

Many economists have had difficulties with the 'free lunch' implied in the double dividend argument as well as with the rhetoric on the win-win options of environmental policy applied by its adherents and as a consequence Goulder (1995) proposed to differentiate between *weak* and *strong* versions of the double dividend argument. The strong version is the claim that any environmental tax that replaces another tax will by definition improve social welfare, which is regarded as a controversial claim. The weak version, on the other hand, focuses on the revenue-recycling aspect and states that once environmental taxes have been introduced, using revenues to reduce distortional taxes is preferable to a lump-sum return of revenues—merely to reduce on the pure costs and not a controversial claim. An *intermediate* version of the double dividend argument implies, according to Goulder, that whether overall social welfare will indeed be improved as a result of ETR depends on the specific properties of the distortional tax which is being replaced with an environmental tax—in other words whether the sign of the costs is positive or negative depends on context and circumstances of the specific tax shift in question. Many have accepted this call for a much more careful examination of the opportunities for a double dividend, which also was a lead for the COMETR project to examine outcomes of ETRs in Europe.

Bovenberg and de Mooij (1994) have pointed to the existence of a possible 'tax interaction effect', according to which the costs of environmental taxes will cause commodity prices to increase, lowering the real value of after-tax income. As relief on income taxation provided under ETR could be too small to offset the price increases, the resulting loss in workers' purchasing power in turn will cause employees to either lower their labour (or productivity) supply or lead to demands for salary increases that in turn will trigger inflation. In essence, the negative tax interaction effect will usually exceed the positive revenue-recycling effect, except under special circumstances where highly distortional taxes are replaced. The formal argument hinges on the crucial assumption that income taxation *a priori* minimises the excess tax burden, as well as on the presumption that ETR is introduced on top of existing environmental taxes or regulations that sufficiently internalise externalities (Weinbrenner, 1996).

There is much to suggest that many of the analyses that focus on the tax interaction effect are too stylised and restrictive. Bovenberg and de Mooij's first article was based on a static model. In a second article where they explore the relationships in the context of a dynamic model, the findings are relaxed somewhat: if the ETR leads to lower regulatory pressure on companies then a double dividend may arise (Bovenberg and de Mooij, 1997). Nielsen *et al.* (1995) explore the double dividend hypothesis with a dynamic model that includes unemployment. They show that unemployment will be reduced if a pollution tax is introduced. In this case the tax interaction effect also influences the value of the unemployment benefit, causing more unemployed to enter the labour market. The overall effect on the rate of economic growth could, however, still become negative. Goodstein (2003) questions the basic assumption of the tax interaction effect that higher prices will reduce labour supply, as in empirical studies based on micro-data the relationship is found to be ambiguous. When dual wage earner families are considered, higher prices are seen to lead to an increase in labour supply, as workers seek to compensate the reduction in family income generated by the price increases (Gustafson and Hadley, 1989).

The concerns over the direction and magnitude of the tax interaction effect relate to the labour market implications of swapping labour taxes for environmental taxes, mostly where income taxes are in focus for reductions. Where the tax shift targets employers' payroll taxes, such as the compulsory social security contributions, the implications will be different. Provided that the net increase in environmental taxes is offset by a lowering of payroll taxes, a pass-over in product prices will not be required and the labour market implications for real wages need not materialise. Ekins and Barker (2003) argue that in this specific case one would not expect a negative tax interaction effect from ETR.

2.2 REVENUE RECYCLING PROGRAMS

In view of the theoretical debate it is interesting that European countries have practised different strategies for revenue recycling:

- Sweden and Finland have mainly recycled revenue by lowering income taxes. For Sweden it has for many years been a tax policy aim to lower the pressure of income taxation on labour. The tax reforms in these two countries have aimed at lowering direct income taxes, and the carbon-energy taxes have contributed to securing alternative revenues for some, but not all, of the income tax reductions. This observation applies for Sweden's early environmental tax reform (1990) as well as the most recent phase (after 2001). It also applies to Finland for the more comprehensive tax shifts introduced since 1996. It would have been difficult for both countries to follow the recommendations from the fiscal literature to aim reductions at employers' social security contributions, because such contributions are relatively small in both countries.
- Denmark and the UK, on the other hand, have followed the recommendations from the fiscal conventionalists more closely, inasmuch as revenues have been aimed predominantly at a lowering of employers' social security contributions, so as to avoid inflationary effects. However, because of the imbalance between energy consumption on the one hand and number of employees on the other, lowering social security contributions at the company level does not necessarily lead to full compensation for the individual company. In Denmark as well as in the UK the imbalance has been then mitigated via various mechanisms for energy-intensive industries, such as agreements and reduced rates for heavy industries. The real purpose of the exemptions seems to have been to avoid the tax interaction effects. Finally, both countries have earmarked some revenues (5-20%) for direct energy efficiency subsidies, e.g. via the Carbon Trust (UK), perhaps out of concerns that incentives would otherwise be too weak.
- The Netherlands and Germany have followed 'mixed' approaches. The Dutch reduced income taxation in the initial phase, and a particular issue here was social concerns, which led to an increase in the basic tax free allowance for income as well as to complicated formulae for exempting basic consumption of electricity and gas (Vermeend and van der Vaart, 1998). In the second phase the Dutch adhered more to the side of fiscal conventionalists and reduced the employers' payroll taxes, but they also reduced corporate taxes. In Germany the ecological tax reform split the revenue recycling equally between a reduction in employers' and in employees' social security contributions, thereby establishing a program of revenue recycling less concerned with fiscal orthodoxy and more with political appeal, taking into account that the eco-tax reform aimed equally at gasoline prices and other fuels.

We can summarise the revenue recycling approaches by dividing the member states in question into three different groups: the fiscal conventionalists (UK and Denmark), the fiscal pragmatists (Sweden and Finland) and finally the political pragmatists (Netherlands and Germany). The political pragmatists are so labeled because reforms were designed so as to accommodate the pressing concerns with the tax systems and the electorate, rather than fiscal theory.

2.3 MACRO-ECONOMIC RESULTS

European countries that implemented ETR did not experience negative implications for their economic growth (GDP); according to E3ME estimations there was a small effect amounting overall to economic growth for one quarter (see Figure 3). In Sweden, the effects took slightly longer to come through, as the very large increase in household electricity taxes depressed real incomes in the short run. Finland experienced a short-term boost to GDP from the effects of the taxes on fuel demand, because a reduction in the demand for imported fuel improved the country's trade balance (Barker *et al.*, 2009).

As ETR results in higher fuel prices it is considered likely that there will be an increase in the overall price level. The degree of this is likely to be dependent on the scale of the increase in fuel costs, how easy it is for industry and consumers to switch between fuels to cheaper alternatives (and non-energy inputs), and how much of the cost is passed by industry on to consumers (this is dependent on the level of competition in the industry, which is estimated econometrically for each region and sector). It should also be noted that revenue recycling may have a deflationary effect when the revenues are recycled through reductions in employers' social security contributions (i.e. labour costs). This is demonstrated for Germany in Figure 4 below (where just under half the revenues were used for reducing employers' contributions). In Denmark and the UK there were no significant increases in the overall price index. In the UK this is because the tax was relatively small and was compensated by slightly cheaper labour costs. In Denmark the tax was larger but again was compensated by lower labour costs (see Figure 5).

The measure of inflation, the consumer price index, will record a larger increase in cases where the taxes are levied on households rather than industry. The reason for this is that the consumer price index is a weighted average of the price of consumer products, including energy. In the cases where the tax is levied on households the whole tax is reflected in the consumer price index rather than just the share that is passed on by industry. Therefore it is not unexpected that the largest increases in the consumer price index are seen in the Netherlands and, in particular, Sweden (see Figure 5).

Except for the Netherlands and Sweden, the countries with full or part revenue recycling via income taxation, the impact on the consumer price index is negligible. The Swedish experience suggests that combining carbon-energy taxes on households with reductions in income taxes could cause inflation rates at a level triggering a possible tax interaction effect, but further analysis is required to corroborate this. The logic behind the ETR implemented in the UK and Denmark is that there is no discernable effect on the consumer price index; this is because the revenue recycling here is mainly via lowering of social security contributions.

2.4 ENERGY-INTENSIVE INDUSTRIES

A complication arises with energy-intensive companies, because the compensation they receive via the reduction in social security contributions does not fully match the additional energy costs. They often have a small labour stock, while they consume large amounts of energy. Their sensitivity

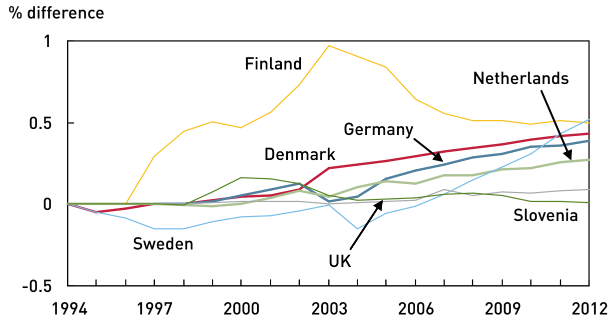

Figure 3: The effect of ETR on GDP (note: % difference between the base case and the counterfactual reference case). Source: Cambridge Econometrics.

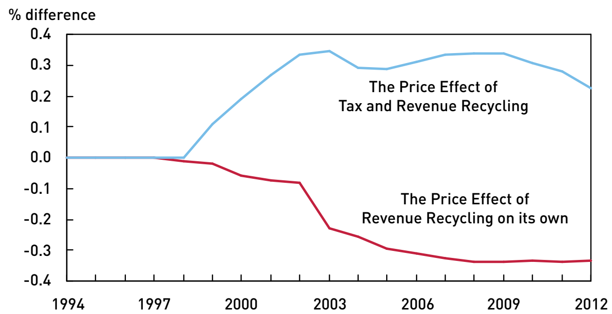

Figure 4: The price effect of ETR in Germany (note: % difference between the base case and the counterfactual reference case). Source: Cambridge Econometrics.

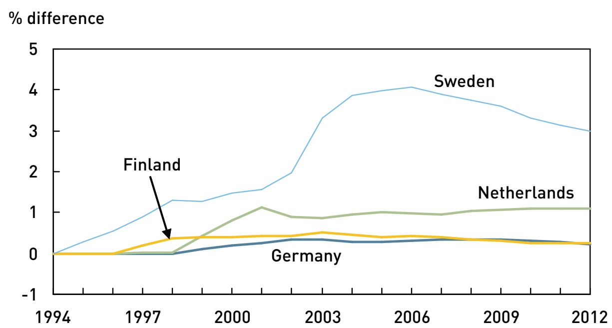

Figure 5: The effect of ETR on inflation (note: % difference between the base case and the counterfactual reference case). Source: Cambridge Econometrics.

depends on the degree to which they use carbon-intensive fuels. In Sweden, Finland and Slovenia the energy-intensive industries benefit from the availability of hydropower and nuclear power, and so are less sensitive to carbon-based energy taxes. However, in other member states complicated schemes have been designed to balance, cap or reduce the tax burden of energy-intensive industries.

EU guidelines (European Commission, 2001) offer certain opportunities for reducing the tax rates of energy-intensive industries, especially if these are higher than the EU's minimum tax rates. These opportunities are to some extent modeled on the basis of the 1995 decision regarding the Danish CO_2 taxation scheme[5], Denmark being the first member state to obtain approval of its carbon-energy taxation system. A system of 'agreements' between energy-intensive industries and the regulatory agencies play a role in obtaining tax rate reductions in the Danish scheme. The Commission's guidelines reflect the role of agreements vis-à-vis selective tax reductions as accepted in the Danish case.

The burden for energy-intensive industries nevertheless remains negative, but at what scale? Company managers in energy-intensive industries often focus on the gross burden of ETR, which in energy-intensive sectors has amounted for up to 5% of the gross operating surplus. However, detailed analysis in COMETR indicates a lower net burden when considering the impact of lower payroll taxes and the energy efficiency gains which can be attributed specifically to the tax (Andersen and Ekins, 2009). While for cement and glass a net burden below 1% of the gross operating surplus has been identified, it has for ferrous and non-ferrous metals reached about 2% of gross operating surplus (see Figure 6). In Sweden, with no reductions in employers' social contributions, the costs are estimated to be higher and up to 4% of gross operating surplus.

3. TRADING CARBON WHILE TAXING IT AT THE SAME TIME

3.1 EFFECTIVE CARBON PRICE SIGNAL AS A RESULT OF THE ETS CAP ON EMISSIONS

The creation of a CO_2 emissions trading system (ETS) in the European Union has created a more complex regulatory environment, in which unilateral carbon-energy taxation and EU minimum energy tax rates now coexist with trading of mainly grandfathered emission certificates for carbon.

The EU ETS covers large installations, i.e. power plants larger than 20MW, as well as refineries and certain energy-intensive industries, notably ferrous metals, cement, glass, ceramic products as well as pulp and paper. Member states can extend the trading system to other energy-intensive industries. The ETS requires member states to limit emissions to the number of allowances that their ETS installations hold, which may include both EU allowances (EUA) and certified emission reductions (CER) from the clean development mechanism (CDM) and joint implementation projects. National allocation plans have in most cases provided certificates to industry that match historical emissions, whereas allocation to power plants often have been restricted to levels lower than historical emissions, as power producers are able to pass on the added costs to the consumer.

The carbon price signal from the scheme arises along two routes: direct costs may arise as emitters need to acquire

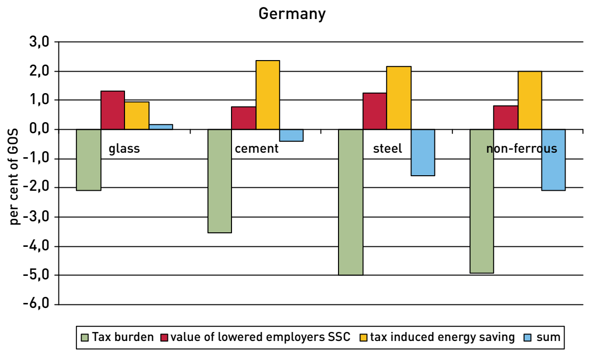

Figure 6: Energy-intensive sectors in Germany: tax burden, value of lower employers' social contributions (SSC) and energy savings induced by the tax as percent of gross operating surplus. Source: COMETR database

certificates for additional production activities; and more importantly, indirect costs arise as power producers will factor the opportunity costs of certificates into electricity prices with a carbon shadow-cost component.

Numerous studies have investigated the pass-on rates from power producers of the carbon shadow-cost. The most pessimistic studies assume a 100% pass-on rate, e.g. McKinsey comes to a figure of 10 euro/MWh for a 20 euro/tCO_2 allowance price (McKinsey and ECOFYS, 2006). However, several studies show that the pass-on rate will be 100% only during the time where power demand exceeds the base load and a fossil fuel plant sets the marginal price. In those periods where non-carbon energy carriers set the marginal price in the electricity market, it is not likely that power operators will be able to factor in the value of the certificates. One study for Germany and the Netherlands hence comes to a pass-on rate of 40-60% (Sijm *et al.*, 2005). The International Energy Agency (IEA) points to the Nordic electricity market (Nordpool) as one region where electricity trade has been successfully liberalised and where pass-on of ETS costs should be expected (Reinaud, 2007). One Finnish study concludes that due to the significance of hydro and nuclear power in Nordpool the average pass-on rate should be in the region of 40%, e.g. 4 euro/MWh for a 20 euro allowance price (Honkatukia *et al.*, 2006).

The implication of the ETS-cap for a 20 euro/tCO_2 allocation price hence is likely to be an induced carbon price in the range of 4-10 euro/MWh. In comparison carbon-energy taxes on electricity are in the range of 6-12 euro/MWh for smaller business users in ETR-countries with predominant use of fossil fuels in power generation. These observations suggest that, with effect from 2008, ETS has effectively increased the CO_2 costs per MWh to a carbon price level comparable to that of smaller business users in member states with carbon-energy taxes—a significant increase and for all consumers—also highly energy-intensive industries.

5 State aid case N459/95, Official Journal C324, 5.12.1995

One important caveat with ETS, however, is that no revenue becomes available for recycling to reduce other taxes, and in contrast to ETR, that business is not compensated for the burden imposed with the carbon price shadow-costs from grandfathered emissions certificates to electricity prices (for this important point see Parry, 2003).

3.2 DOUBLE-REGULATION WITH ETR AND ETS

Participation in ETS is a legal obligation under EU law for emitters in member states. The EU ETS system was introduced with effect from 2005, whereas most of the unilateral carbon-energy taxes had been introduced before that year. The co-existence of unilateral carbon taxes for emitters subject to cap-and-trade have evoked concerns over double regulation. Notably ETR-countries with taxes specifically aimed at CO_2 raised the issue.

Some complications with the avoidance of double-regulation have occurred because of two aspects of EU law: the state aid regulations and the Energy Tax Directive (ETD)[6].

The Treaty for EU Article 87 prescribes that state aid can only be allowed with the approval of the European Commission. According to EU case law, even reductions in energy taxes count as state aid, as a functional perspective applies. Hence, while member states are free to introduce unilateral carbon-energy taxes, paradoxically they must obtain Commission approval for any reductions in these. For this purpose the Commission has issued a set of guidelines which stresses that selective reductions can be a concern because they may violate fair terms of competition. Lifting CO_2-taxes for the specific sectors subject to ETS would in fact be a selective approach and Commission approval is not straightforward.

A further aspect to consider is the interaction with ETD, a directive agreed in 2003 that introduced minimum energy tax rates for fuels and electricity. The purposes of ETD relate to energy efficiency and security of supply. The minimum tax rates place a floor for the tax rates that must be imposed to constrain energy use. Now in some cases the CO_2-taxes had been seen to meet the minimum requirements for energy taxation, despite having a name that referred to carbon emissions. If CO_2-taxes under the impression of double regulation had simply been removed, there would have been no taxes in place to make up for the minimum rates required by ETD. For this reason it took several years before the Commission was able to sort out with member states how to adapt the unilateral carbon-energy taxes to the coexistence with ETS.

The approach now agreed is that sectors falling under ETS should not be subject to carbon-taxes *per se*, but they remain liable to energy taxes. In Denmark the government renamed the end user tax on electricity from a CO_2-tax to an 'energy savings tax' to comply with ETD—and maintain the revenue stream. Non-ETS sectors continue to be subject to unilateral carbon taxes and no double-regulation issue has been raised over them.

4. CONCLUSIONS

The environmental tax reforms in European countries have provided empirically based insights into the implications of carbon-energy taxation. Many different studies, including the ex-post simulation with the E3ME model referred to here, show that the impacts on fuel consumption and emissions of greenhouse gases have been in the expected directions. E3ME indicate that they are generally small as a result of relatively modest changes in the tax rates (Barker *et al.*, 2007). More significant impacts obtained in countries with higher tax rates indicate plausible scale effects from extended tax shifts.

In view of the controversy over a possible double dividend from carbon taxes and environmental tax reform, the results from the analysis with the E3ME-model are innovative, but do not suggest that the macro-economic implications of ETR are profound. Rather the tax shifting seems to have had only small impacts on overall economic performance, even for those energy-intensive industries that tend to be the relative losers under ETR. On this point the findings are in line with other recent research findings (Agnolucci, 2009). Nevertheless it may also be a worthwhile observation that such tax shifts could be implemented without dramatically negative impacts, and that reducing other taxes with a recycling of the revenues seems to play the expected role in this regard.

In view of the financial crisis it is likely that the introduction of unilateral carbon-energy taxes will be considered by more countries. It will hardly be possible to maintain revenue neutrality, but increases in such taxes are likely to be preferable to many of the alternatives, which include further increases in income taxes that could be more distorting to overall economic performance.

6 Directive 2003/96/EC.

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