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Welfare and the Environment
Implications of a recent tax reform in Norway

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Abstract:
Many countries have recently enacted tax reforms with the aim to increase efficiency and welfare. These reforms have side effects on the environment. If the effects on the environment are negative, a tax reform which increases efficiency is maybe not worth doing after all.

This paper evaluates the economic and environmental consequences of a recent Norwegian tax reform. Our dynamic CGE framework accounts for important links between the environment and the Norwegian economy as well as welfare from environmental quality.

As it happens, the tax reform in Norway seems to affect the environment very little, and delivers a total welfare gain of 0.9 per cent of welfare (wealth). The small environmental effect has to do with the size of environmental vs. economic parameters, and with the environmental component of tax reform package in Norway.

Keywords: tax reform, CGE-models, environmental economics, Norway

JEL classification: C68, O40, Q00

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Introduction

Many industrialized countries have recently enacted tax reforms with the objective to improve economic efficiency and welfare.

While higher economic efficiency has an obvious potential for welfare improvement, it may also lead to more pollution and environmental damage. For instance, a tax reform that increases private income will probably increase the demand for private transportation and add to the problem of air pollution from private vehicles. A tax reform that increases capital accumulation will expand the scale of production and the scale of pollution from production. The environmental damage will cut into the welfare gain and possibly overturn it.

From a public economics perspective, the problem with a tax reform is that it may increase the importance of remaining distortions. Often, "distortions" are taken to be tax induced distortions. But the same logic applies to environmental distortions. There is nothing to guarantee the success of a tax reform that obeys some principles from first or second best, given environmental distortions in the economy. The outcome is purely an empirical matter.

The problem should also be of consern from a policy perspective. With heavier emphasis on the environment in the public, policy makers have to face critical examination of environmental consequences of their actions. A policy that aims to increase production and growth is especially posed to such criticism.

We conclude that an evaluation of a tax reform should do well to consider the possible increase in environmental damage. This paper carries out such an evaluation. Our framework accounts for important linkages between the economy and the environment as well as welfare from environmental quality. We use a dynamic computable general equilibrium (CGE) model that captures "producer-consumer," "producer-producer," "consumer-producer" and "consumer-consumer" externalities between the economy and the environment.

We study the tax reform carried out in Norway. The reform combines a cut in capital and labour income tax rates with a wider tax base, and includes the introduction of a tax on CO_2-

emissions. It has many similarities to recent reforms in other countries. Indeed, countries seem to have inspired each other in their tax reform efforts. The results of this study should therefore have some general interest.

Our study is related to several strands of the literature. There is a vast literature on tax reform analyses based on CGE models. Some recent examples that analyse actual reforms are Jorgenson and Yun (1990) and Goulder and Thalmann (1993) on the US tax reform, and Holmøy and Vennemo (1991) on important parts of the Norwegian tax reform. None of these studies incorporate environmental impacts. Researchers typically find an increase in efficiency and welfare that amounts to a small percentage of initial welfare, but a (much) larger percentage of tax revenue, real capital wealth or annual GDP.

Tax reforms designed to reach environmental goals (especially emission limits) have been studied by, e.g. Glomsrød, Vennemo and Johnsen (1992) and Brendemoen and Vennemo (1994) for Norway, Bergman (1991) for Sweden and the EMF-12 project (Gaskins and Weyant, 1993) for the US. Jorgenson and Wilcoxen (1993) survey this literature, which estimates costs of reaching the specified goals.

Ballard and Medema (1993) and Brendemoen and Vennemo (1993) use static models that include "producer-consumer" and "producer-producer" externalities (Ballard and Medema) and "producer-consumer" and "consumer-consumer" externalities (Brendemoen and Vennemo) to estimate the marginal cost of public funds.

1. The model

The distinguishing features of the model of this paper are as follows: A small open economy faces an exogenous interest rate and prices on competitive products. An infinitely lived consumer with perfect foresight maximizes utility from goods and leisure. There are nine sectors of production. Six of them have competitive producers with perfect foresight. One of these produce tradables. This (large) sector

determines the wage, which with the exogenous interest rate and self fulfilling expectations of the future user cost of capital, determines the output prices of non-tradables. Exogenous sectors are two resource extraction sectors, production of petroleum and hydro-power, and a public sector.

Trade balances intertemporally. The annual trade balance reflects intertemporal optimization by consumers and changes with underlying economic conditions. A lump sum tax clear the public budget. We impose annual budget balance. This is an innocent assumption because of Ricardian equivalence.

The model tracks emissions to air of nine important pollutants, and road traffic volumes. We choose these for their national importance and because they are related to aggregate economic entities. A set of detailed emission coefficients links emissions to material inputs, heating fuel and gasoline consumption. Traffic volumes depend on gasoline and auto-diesel consumption. The emissions to air and the traffic volumes form the impacts from the economy to the environment.

The models of environmental effects of macroeconomic policy developed by Brendemoen, Glomsrød and Aaserud (1992)[1] and Glomsrød, Nesbakken and Aaserud (1994) emphasize eleven external effects of economic activity, namely acidification of lakes, acidification of forests, health damage and annoyance from exposure to NO_x, SO_2, CO and particulate matter, noise, corrosion of building materials, traffic accidents, congestion and road depreciation.

Based on this list, we identify three links from the environment to the economy. One is a link from the environment to consumer welfare. This link comprises all the effects on the list except corrosion and road depreciation. A second link concerns labour productivity. We argue that noise, traffic accidents and reduced quality of air will increase sick leaves and reduce labour productivity. The third link goes from environmental quality to the rate of capital depreciation. It has two motivations. One is the increase in corrosion caused by sulphur emissions in particular. Another is the impact of traffic on road depreciation. Heavy traffic wears down the roads and increases the need for

[1] This paper is in Norwegian. Alfsen, Brendemoen and Glomsrød (1992) or Brendemoen and Vennemo (1993) are English papers with some of the same material.

road maintenance.

The model of course gives only a rough indication of environmental effects of economic policy. Its merit is the general equilibrium perspective on the link between the economy and the environment. Fossil fuel consumption is the key. Higher fossil fuel consumption can be expected to give higher emissions to air, and more traffic, which will create environmental externalities that will feed back into the economic model. Vennemo (1994) gives a detailed presentation and discussion of the model.

2. Data

2.1 Parameters of the model

The important parameters of the model are the substitution parameters in production and consumption, and the parameters reflecting environmental damage. These are compiled from econometric evidence and other empirical studies in Norway.

Output is produced in multi-level CES production functions. At the top level, material input and a capital-energy-labour composite combine into gross production. The elasticity of substitution is zero, material input is a fixed factor. This is a standard assumption in CGE models, and a reasonable approximation to the data of Norway (compare, e.g. Glomsrød, Vennemo and Johnsen (1992), table 2).

The capital-energy-labour composite aggregates labour and a capital-energy composite, while energy aggregates fuel oil and hydro power, all in successive CES-nests. The elasticities of substitution, which differ among the "endogenous" industries, are derived from Alfsen, Bye and Holmøy (1993), and from Mysen (1991).

Table 1: Elasticities of substitution.

	tradables	petroleum refining	construc-tion	wholesale and retail trade	housing	other services
Material input vs. labour-capital-energy	0.0	0.0	0.0	0.0	0.0	0.0
Labour vs. capital-energy	0.72	0.0	0.0	1.08	0.16	0.8
Capital vs. energy	0.52	0.0	0.02	0.7	0.16	0.67
Heating fuel vs. electricity	0.42	0.0	0.13	0.37	0.0	0.18

The elasticities of substitution are listed in table 1. Elasticities of substitution are below unity, showing an inelastic production structure.

Like technology, we assume preferences to have a multi-level CES structure. The intertemporal elasticity of substitution is 0.5, a value broadly consistent with econometric evidence in Norway (Steffensen (1989), Biørn and Jansen (1982), Frisch (1959)). In the first stage of a three-stage budgeting procedure, the consumer spends total wealth on full consumption, i.e. consumption of goods and leisure.

The consumer then spends full consumption on leisure and consumer goods. Time series evidence in Norway points to a low wage elasticity of labour force participation (0.0 for men, 0.2 for unmarried women, Zakariassen (1994)). Cross section studies find a larger, but similar response (0.2 for men, 0.4 for women, Dagsvik and Strøm (1992)) and a significantly larger response in total labour supply: 0.3 for men, 0.9 for women. Dagsvik and Strøm (1992) report a low ($\approx$ 0.0) income effect on labour supply. Weighing up this information, we assume an uncompensated elasticity of 0.3 and a

compensated elasticity of 0.4. This gives credit in a time-series model to the time series information while using the cross-section information as well. We calibrate the time endowment and the elasticity of substitution between leisure and consumption to obtain the labour supply elasticities. Consumer expenditure is spread on each good in a Cobb-Douglas system.

The welfare function is additive in welfare from full consumption and welfare from the environment. The welfare function has the following properties: It rationalises the behaviour we have just outlined. It implies that environmental quality does not affect the choices made by the consumer. It implies that the marginal willingness to trade environmental goods in any period for full consumption in the same period equals the parameter we infer from our sources. The willingness to trade environmental goods of any period for full consumption of a later period equals the discounted value of the same parameter. Welfare is calibrated to base year wealth.

The parameters describing the interaction between the economy and the environment are difficult to pin down, for obvious reasons. The worst difficulties are associated with the impacts from the environment to the economy. Our strategy is to assume a constant marginal impact on welfare over the relevant range (here the difference between the pre tax reform and post tax reform scenarios), and a quadratic impact on productivity and depreciation. The quadratic form is truncated at a chosen maximum. The technical reason for imposing a maximum is to facilitate the steady state. The economic reason is that more than 100 per cent decrease in productivity, or higher than 100 per cent depreciation is impossible. By all accounts the maximum occurs before that. The maximum productivity loss is set at approximately 15 per cent. The maximum depreciation rates are three times the base year rates. The maxima have only academic interest in the present case.

The estimates of marginal economic impacts of environmental damage are based on Norwegian case studies. Theses combine production loss, avoidance costs and willingness to pay studies, with an emphasis on production loss. The impacts from traffic and the productivity loss from NO_x-emissions are the largest in value. NO_x-emissons are more severe than other emissions because of high concentration levels and because they occur in heavily populated areas. See Brendemoen,

Glomsrød and Aaserud (1992) or Brendemoen and Vennemo (1993) for further discussions.

We simulate the model on a baseline scenario aggregated from a similar scenario compiled by the Ministry of Finance for the last long term projection of the Norwegian economy. Gaskins and Weyant (1993) stress the importance of a sound baseline scenario for simulation output. The projection ends in 2030. From then on, we assume exogenous values consistent with a steady state.

2.2 The Norwegian tax reform

Taxes are high in Norway. In 1992, firms and households paid 46.8 per cent of GDP in taxes. Just the Swedes and Danes pay more. Norwegians also receive more transfers than most others. The high reliance on taxation in public policy makes it important to design taxes properly.

The recent reform in the Norwegian tax system has emphasised efficiency over redistribution, indirect taxation over direct taxation and made some efforts in the direction of green taxes. The main ingredients of the reform are:

Reduce the marginal tax rate on capital income. The system of capital income taxation used to be progressive, with a top personal marginal tax rate of 43 per cent until 1992. There is now a flat rate of 28 per cent, and no double taxation of dividends or retained profits. The corporate wealth tax is eliminated. The personal wealth tax is reduced.

Increase the tax base for capital income. The old system of capital income taxation allowed firms to deduct a share of income if used for financial investments of specific kinds, and allowed lax rules for capital depreciation allowances. The tax reform tightened depreciation allowances and ruled out tax deductible financial investment.

Reduce the marginal tax rate on labour income. The top marginal tax rate on labour income was 62 per cent in 1989, and is 49.5 per cent in 1994.

Reduce employers' contributions to social security. In Norway like in some other countries, employers contribute to the funding of social security through a tax on labour. The rate of contribution was reduced from fifteen to 13 per cent in 1993.

Increase the VAT. To make up for some loss in revenue, the VAT increased from twenty to 22 per cent in 1993.

Introduce a tax on CO_2. The government introduced a tax on CO_2 emissions in 1991. The tax treats emissions from different sources differently. The tax on gasoline is the highest at Nkr 342 per tonne CO_2 (around $50), while the tax on petrol-coke is the lowest at Nkr 84 per tonne CO_2.

3. Baseline estimate of welfare effects

We go on to study the welfare potential of the tax reform package. We assume that the tax reform is unexpected, and that the model and data are as described in sections 1 and 2. Some of these assumptions will be relaxed later.

3.1 Prices and quantities

One cannot explain the welfare impact without understanding the price and quantity impacts of the reform. The first column of table 2 lays out the changes in factor prices. The changes in capital taxation increase the user costs of capital for businesses, see the first entry in table 2. This is as intended, because real capital formerly yielded a too low return. Increasing the rate of return to real capital increases the user cost. The CO_2 tax increases the price of fuels, cf. the second entry.

Table 2: Changes in input prices and unit input demands. Per cent. 2030.

Input	Price	Quantity
Capital	9.9	-3.0
Heating fuel	4.2	-2.8
Labour	-5.8	2.7

These two changes create an upward pressure on costs that is not sustainable in an open economy facing fixed world prices. The reduction in the employers' contribution to social security eases the pressure, but to restore competitiveness, nominal wages received by consumers and households fall.

The second column of table 2 shows *unit* demand reactions to the input price changes. The economy restructures towards more labour intensive, energy efficient production as it shifts out of the factors that become more expensive. Unit capital demand decreases the heaviest. Unit labour demand increases. Table 2 reveals that quantities change less than prices. This is as expected, considering the rather inelastic technology of the model.

Given a set of unit demands, the labour supply determines the scale of production. The scale of production is for instance constant if the labour supply increases 2.7 per cent. Labour supply is influenced by the net real wage rate and by the scale of full consumption. The changes in labour supply and its determinants are given in table 3.

Table 3: Change in labour supply and its determinants. Per cent. 2030.

Labour supply	1.3
Wage, net of tax	5.3
Price of consumer goods	2.8
Full consumption	0.8

The net of tax wage increases because the reform lowers the income tax. The lower income tax offsets the two effects that reduce the real wage; the decreased nominal wage gross of tax, and the increased VAT-rate.

The increase in the real net wage induces an increase in labour supply that it "too strong" in the sense that if realized, production would increase to a point where the country would accumulate more foreign assets than is optimal in the long run. That is why full consumption increases. An

increase in full consumption reduces labour supply (and increases consumption) to balance the current account in the long run.

GDP is approximately constant despite the increase in (full) consumption. The reason lies in the business and capital aspect of the reform package. It increases the average return to investments, which gives the economy greater consumption possibilities in the long run. Consumption can increase without GDP increasing.

Gross production, which equals GDP plus energy and material input use, is the best measure of gross output. Gross production goes down as labour supply increases less than required for constant gross production. The fall is absorbed by proportionally lower material input consumption, and by lower energy consumption.

In summary, the reform makes energy and capital more expensive, inducing producers to shift out of these factors and into labour. Labour supply increases because the real net of tax wage increases. This has the potential to increase production. The reform however makes the country more affluent. It collects some of this affluence as more leisure, leaving GDP about unchanged.

3.2 Welfare

Table 4 lists the key factors that influence welfare.

Table 4: Change in welfare and its determinants. Per cent. 2030 except welfare, which is intertemporal.

Welfare	0.9
Full consumption	0.8
Gasoline consumption	1.4
Fuel consumption	-3.6

Welfare measured as willingness to pay increases 0.9 per cent. That is, the tax reform is equivalent for the consumer to receiving a 0.9 per cent increase in wealth (at pre- reform prices). This rather small percentage, which considering the literature should come as no surprise, translates into a monetary gain of sixty billion Nkr.

The welfare gain is based on annual increases in full consumption, which is 0.8 per cent in 2030 (and in the steady state). What about the impact from the environment? The change in gasoline and fuel oil consumption gives an indication. Gasoline consumption increases because households consume more after reform. Fuel oil consumption falls. Fuel oil consumption is mainly an input to production. It falls because production becomes more energy efficient, and because the scale of production goes down.

There are two opposing effects on the environment. Lower fuel oil consumption improves environmental quality, mainly through lower pollution. Higher gasoline consumption decreases environmental quality through higher pollution and traffic volumes etc. Table 5 lists some indicators of the contribution from the environment to overall welfare.

Table 5: Change in key environmental indicators. 2030 except welfare.

Welfare from the environment	0.4 billion Nkr
Productivity	0.01 per cent
Depreciation rate, buildings	-0.02 per cent
Depreciation rate, roads	0.04 per cent

On balance the two effects on the environment have about the same strength, but most environmental indicators improve slightly. Welfare from the environment increases 0.4 billion Nkr. Productivity increases because lower pollution and diesel consumption in businesses reduce the problems of respiratory illness. The problem of corrosion on capital is also diminished, but increased traffic (higher gasoline consumption) increases road depreciation.

4. Untangling the reform - the effects of different components

The tax reform in Norway, although relatively coherent, was instigated in steps. The reform in business and capital taxation came first, together with the reduced income tax rate. The introduction of the CO_2 tax was a separate development motivated by environmental (and fiscal) concerns. The final part was the cut in employers' contribution to social security, financed by an increase in the VAT rate. Thus, we have four components of the reform; the reform of capital taxation, the reduced income tax rate, the CO_2 tax and the reduction in employers' contributions/increase in VAT. Both from a policy perspective and as a mean to further understanding of the economic mechanisms involved, it is of interest to study how the various components of the reform contribute to the overall welfare result.

When describing the partial effect of each component of the reform, one can make different assumptions about the status of the remaining components. We choose to follow a chronological procedure. That is, starting from the old system we first introduce the reform in capital and business taxation, then introduce the new labour income tax, then add in the CO_2 tax and finally the reduction in employers' contributions/increase in VAT.

Table 6 lists the welfare gain or loss associated with each component of the reform. The benchmark is the old system of taxation. The table also shows the contribution to welfare from the environment.

Table 6: Welfare gain from different reform components, relative to no tax change.

	Welfare gain, per cent	Of which gain from the environment (bill. Nkr)
Capital tax reform	-0.7	20.2
Capital plus income tax reform	1.1	-4.5
Capital plus income plus CO_2 tax reform	0.9	0.01
Full reform	0.9	0.4

As noted in section 3, the reform in *capital and business taxation* increases the user cost of capital. This reduces the competitive gross wage in the small open economy. When no other tax-wedges change, a lower gross wage is transformed into a lower net of tax real wage. This decreases labour supply and implies a too low level of output to sustain an intertemporal balance in the current account. To counteract, households must work more and consume less, in other words enjoy lower full consumption. The lower level of full consumption is the basis for the welfare loss associated with the capital/business tax changes.

We could ask why not the increased return to investment gives the economy enough resources to balance the current account and yet realise higher full consumption. The reason, on a general level, is second best effects of interactions between taxes. An important second best effect here is that the increase in the user cost of capital decreases the wage. The net real wage is already lower than its shadow value, because of taxation. Taxation makes consumers work too little relatively to the social optimum. Increasing the user cost of capital aggravates the problem: As the wage is depressed, consumers are inclined to work even less.

If the capital tax reform reduces consumption and welfare, it does on the other hand ease the burden on the environment. Recall that the three forces determining the consumption of fuel oil and gasoline are the unit demand for fuel oil, the scale of production and the scale of consumption. The

scale effects work in the direction of lower fossil fuel use and lower pollution. The substitution effect on unit demand is ambiguous: The price of capital increases, motivating substitution away from capital, into, e.g. fuel. The price of labour falls, motivating substitution into labour, away from, e.g. fuel. The scale effects are clearly the most important. The positive effect on welfare from the environment is fifty times larger than in the full reform of section 3.

A positive impact from the environment in combination with a negative impact on traditional welfare makes it possible for a person who values the environment strongly to claim that the capital tax reform is worth doing anyway. A person must put a 2.4 times higher value on the environment than assumed here to find a positive total welfare impact in his or her judgement.

The tables are turned when we consider the *lower income tax* alongside the reform in capital income taxation. Because the income tax falls, the real wage of the consumer increases, increasing labour supply. As a result the current account becomes "too positive" and there is room for full consumption to increase. This scenario realises a higher welfare gain than any of the others in the table.

This scenario however also returns a larger loss in welfare from the environment than the other scenarios. The reason is the scale effect in consumption, which increases gasoline consumption, accentuating problems of pollution and traffic. The demand for fuel oil is approximately constant because the unit demand for fuel and the scale of production both are constant.

When we introduce the *CO_2 tax*, the strain on the environment introduced by the income tax cut is wiped out. On the other hand, the economic welfare gain becomes smaller. Again, the crucial variable is the real wage. When the CO_2 tax is introduced, unit costs of production rise. This decreases the wage paid by producers, which decreases the real wage compared with the situation before the CO_2 tax. Labour supply then becomes too low and consumption too high for a balanced intertemporal current account. Full consumption must fall compared with the situation before.

The positive effect on the environmental strain is due to a substitution effect in production, and the two scale effects: The scales of production and consumption both fall compared with before

the CO_2 tax. The total balance shows that the marginal impact of the CO_2 tax is a welfare loss.

A factor to bear in mind when evaluating the results so far is the correlation between tax cuts and welfare. The changes in capital taxation bring in more revenue, and cut welfare. The reduction in the income tax cuts revenue, and improves welfare. The CO_2 tax brings in revenue, and cuts welfare as a marginal impact. In effect, these reforms assume that lump sum taxes or transfers compensate the public budget. Less revenue from distorting taxes correlates with higher welfare. Although it is not a priori certain that a tax reform that decreases a distorting tax in favour of a lump sum tax increases welfare, it is by all accounts the "normal" case. A distorting tax that brings in more revenue and improves (economic) welfare would be a welcome policy tool!

The final piece of reform, the combination of *lower social security payments* by producers and a *higher VAT rate*, is approximately revenue neutral. It has almost no impact on long term welfare. The reason is that the net real wage is balanced by two opposing forces: the cut in employers' contributions to social security implies a higher wage, but the increase in the VAT raises the price level correspondingly. There is therefore no reason for the consumer to change behaviour, and there is no reason for producers to do so either: Their per unit wage costs will stay constant since prices of the other inputs are constant. The small improvement in the environment occurs because consumers and some producers (those exempted from VAT on outputs) pay VAT on their purchases of fossil fuels.

5. The importance of being elastic

The discussion of sections 3 and 4 has revealed that the degree of price/wage responsiveness in production and labour supply is quite important for the impact of the tax reform. For instance, the impact of price changes on unit fuel demand in production is important for the environmental impact, while the unit labour requirement is important for the scale of production. On the household side, the response of labour supply to a given wage increase determines the change in full consumption. This

section discusses the issue of price and wage responsiveness in some detail. We present sensitivity estimates with respect to production technology and labour supply.

5.1 Substitution in production

There are different directions in which to increase or decrease the price responsiveness in production. We choose to change all substitution elasticities parametrically. As substitution elasticities increase, we get a more elastic production structure with greater price responsiveness.

An alternative could be to study the impact of changing one parameter, for instance the elasticity of substitution between fuel oil and electricity, or a subset of parameters. However, we have no a priori information to restrict our attention to a subset of parameters. Moreover, even if we were interested in one factor of production (fuel oil for instance), we should be interested in more than one substitution parameter (the elasticity between energy and capital and the elasticity between fuel oil and electricity).

Figure 1: Welfare gain as per cent of elasticity of substitution

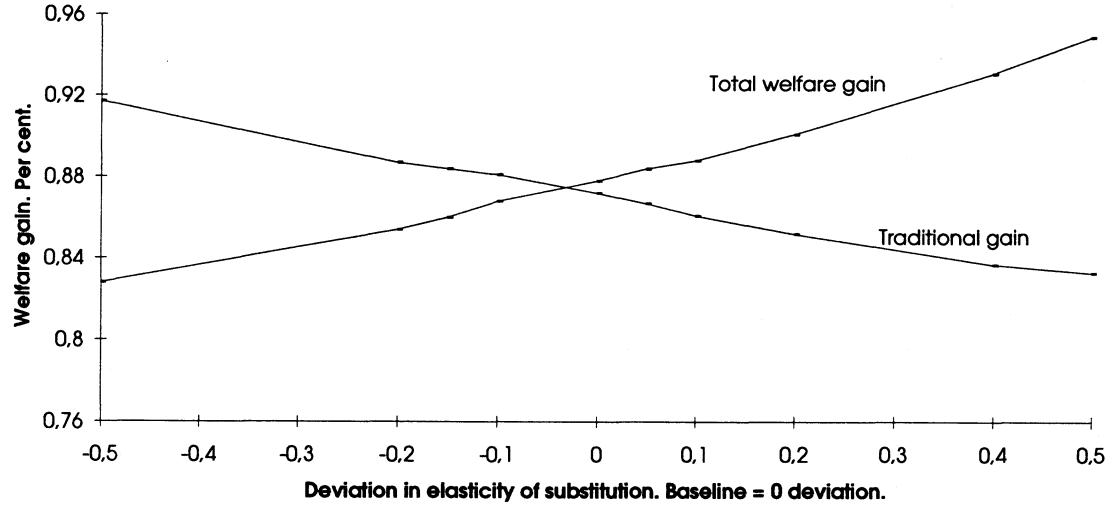

Figure 1 gives welfare and traditional welfare (i.e. disregarding welfare from the environment) as functions of the elasticities of substitution. The figure shows that total welfare increases in the elasticities of substitution, while traditional welfare decreases. Both effects are however quite small.

As we have seen in sections 3 and 4, the change in traditional welfare depends on the change in the wage. If the production structure is such that the wage increases, labour supply increases and there is room for full consumption and traditional welfare to increase. When the wage increases *more*, labour supply is inclined to increase more, and there is more room to increase full consumption and traditional welfare. Figure 1 in effect shows that the elasticities of substitution have only a minor influence on the increase in the wage. This is not strange if we consider that the substitution properties of technology only have a second order effect on the wage, the first order effect being determined by factor shares. The second order effect is that the wage increases more in a less elastic technology.

The change in total welfare depends on traditional welfare plus welfare from the environment. Total welfare increases in the elasticities of substitution despite the decrease in traditional welfare. This means that welfare from the environment increases in the elasticities of substitution.

The impact on welfare from the environment has two reasons. The main reason is that fuel demand responds more to the price increase of fuel as technology becomes more elastic. A second reason is that the expansion in output and consumption is lower as the technology becomes more elastic. Both of these reasons lead to lower fuel and gasoline consumption and lower pollution. The increase in welfare from the environment dominates the decrease in traditional welfare. The implication is that total welfare increases as technology becomes more elastic and elasticities of substitution increase.

The intersection between a negative impact from the environment and a positive impact occurs at a technology about five percentage points less elastic than the preferred best guess technology. This is a fairly small perturbation of technology. As figure 1 shows, a person must put a

much higher value on the environment than assumed in this study for the total welfare impact to be negative for any technology.

5.2 Elasticity of labour supply

The impact on welfare of less or more elastic labour supply is shown in table 7.

Table 7: Sensitivity of welfare gain to labour supply

	Welfare gain, per cent	Of which gain from the environment (bill. Nkr)
Small labour supply elasticity (0.0)	0.6	5.2
Baseline case (0.3)	0.9	0.4
Large labour supply elasticity (1.0)	1.6	-12.7

We focus on two alternatives to the best guess estimate of the labour supply elasticity: As the inelastic alternative, we assume the uncompensated labour supply elasticity to be zero. As the elastic alternative, we assume the uncompensated labour supply elasticity to be one.

Table 7 shows that the welfare gain from the reform is larger for a large labour supply elasticity. The reason is that a large labour supply elasticity elicits a large increase in labour supply, which makes room for a large increase in full consumption and welfare. A small labour supply elasticity by contrast implies a small labour supply response and a small increase in full consumption.

Since a large labour supply elasticity allows a large increase in labour supply, even after deducting for the increase in full consumption, the scale of production increases more. This explains the loss in welfare from the environment in this scenario.

It is conceivable that a person with strong environmental preferences will find the tax reform not worth doing in a setting with a large aggregate labour supply response. When the labour supply

response is small, traditional welfare and welfare from the environment point in the same direction.

6. Conclusions

The paper has evaluated the recent Norwegian tax reform in an integrated economy-environment model. Welfare increases 0.9 per cent in the baseline case. The impact on the environment is small, but positive.

The cut in the income tax rate contributes most to the welfare gain, because of its encouragement of labour supply. The CO_2-tax turns a negative environmental impact into a positive one.

The estimated welfare gain is robust to changes in technology and the labour supply elasticity. An inelastic technology or a large labour supply response damages the environment more.

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