Ecological Tax Reform and Involuntary Unemployment: Simulation Results for Switzerland

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1. INTRODUCTION

The idea to use environmental taxes to improve the situation of the natural environment is not at all new; traced back to PIGOU (1920) it has extensively been discussed already in the beginning seventies, and first proposals for an ecological tax reform, i.e. to substitute distortionary labour taxes by correcting environmental taxes to cut unemployment have already been made during the eighties[1]. At this time, most if not nearly all economists and especially environmental economists believed that the double dividend of environmental taxation is for sure: environmental taxation would not only provide a «green dividend» by an increase in environmental quality but, if the revenue is used to cut distortionary labour taxes, also a «blue» one, by reducing the distortions of our tax system, thereby increasing economic efficiency and – hopefully – reducing unemployment. The reason why this was expected is very simple: in both cases we come closer to the conditions for Pareto-optimality. However, at this time there were only few outside academic economics who were in favour of such measures. Most people who were concerned about the environment rejected environmental taxes because it should not be possible that the rich can buy the nature and destroy it. Consequently, they demanded a bureaucratic environmental policy of command and control.

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1. See, e.g. by BINSWANGER, FRISCH, NUTZINGER et al. (1983).

In the meantime, things have changed. The limits of the traditional environmental policy and its partial failure increased the demand for other policy measures. In addition, unemployment increased dramatically in Europe, and it became common knowledge that too high gross (real) wages are one of its causes. Thus, the reduction of labour unit costs by a reduction of labour taxes or social security contributions is largely demanded. This is a situation where an ecological tax reform can gain public support. Correspondingly, during recent years there have been made several proposals for an ecological tax reform in Switzerland[2]. At the moment, there are several popular initiatives ongoing to change the federal constitution and to restructure the Swiss tax system in an «ecological» way. The basic idea of at least one of them is to partly finance old age pensions by a general energy tax. Moreover, the parliament is currently discussing a similar proposal, and the federal government has decided to start such a reform[3]. Within the next two years, voters will decide whether such a reform will be implemented. Despite the opposition of some important interest groups, especially those representing energy intensive industries, there are good chances that one of the initiatives (or a «counterproposal» which is currently discussed in the parliament) will be accepted by the votèrs.

While such a reform has more support by the general public than it had ever before, (academic) economists are much less convinced about its positive economic effects than 10 or 20 years ago. In 1991, PEARCE still believed that an increase of employment is granted. But BOVENBERG and DE MOOIJ (1994) started a second round of the double dividend debate, which impaired our earlier conviction[4]. Using optimal taxation theory and general equilibrium models, the main conclusion of this work is that environmental taxation rather reduces than increases employment and especially economic welfare, if narrowly defined, i.e. if ecological effects are not taken into account. Moreover, in most cases where economic efficiency gains result, there are other tax instruments which lead to even larger economic efficiency gains. Thus, an ecological tax reform might be appropriate from an ecological point of view, but one should be very cautious to expect (large) employment gains from such a reform.

The recent theoretical discussion about the possibility of the second dividend, i.e. of employment effects of such a reform, is, however, at best partially relevant in our current economic context. This also holds for many of the simulation models[5]. The simple reason is that these are general equilibrium models which assume full employment and,

2. See, e.g., MEIER and WALTER (1991), or MAUCH et al. (1992).
3. For an overview of the different proposals see EIDGENÖSSISCHES VERKEHRS- UND ENERGIEWIRTSCHAFTS-DEPARTEMENT (1997).
4. See, e.g., BOVENBERG and DE MOOIJ (1994, 1994a, 1996) and BOVENBERG and VAN DER PLOEG (1994, 1994a, 1994b, 1996). Overviews over this discussion are given in GOULDER (1995) and KIRCHGÄSSNER (1998). For a discussion highlighting the employment effects see also BOVENBERG (1995, 1998).
5. Simulation studies for Switzerland have been produced, e.g., by STEPHAN, VAN NIEUWKOOP and WIEDMER (1992), FELDER and SCHLEINIGER (1995), FELDER and VAN NIEUWKOOP (1996), or ECOPLAN and FELDER (1997). For an overview of studies for Germany see KIRCHGÄSSNER (1998).

therefore, only take into account *voluntary* unemployment. But the current situation is characterised by large *involuntary* unemployment. And while in case of full employment the level of employment is determined by the intersection of the labour *supply* function and the real *net* wage, in case of involuntary unemployment the intersection of the labour *demand* function and the real *gross* wage determines employment.

There are reasons why these papers only look at voluntary unemployment. It is rather difficult to consider a disequilibrium phenomenon like involuntary unemployment in an equilibrium model. This holds even more due to the fact that there is no theory available which, based on the usual primitives of economic theory, is really able to explain involuntary mass unemployment[6]. Nevertheless, the question whether such a reform increases or reduces unemployment can hardly be answered if a model does not explicitly take into consideration involuntary unemployment.

Using 1990 input-output data, in this paper we develop a static computable general equilibrium model for Switzerland which regards the existing unemployment as being involuntary, and we compare its results with a model based on the assumption that all unemployment is voluntary. While in the latter case we get only a small employment effect, the existence of involuntary unemployment makes it possible to reach a substantial decrease of the unemployment rate. However, the extent of this reduction is rather sensitive to the strategy followed by the trade unions, and the substitution elasticity between labour on the one side and the capital-energy composite on the other.

The paper is organised as follows. First, a graphical representation of the main results of the theoretical models developed by BOVENBERG et al. is given *(Section 2). Section 3* describes the applied general equilibrium model used. In *Section 4*, the simulation results are presented. *Section 5* concludes and summarises the results.

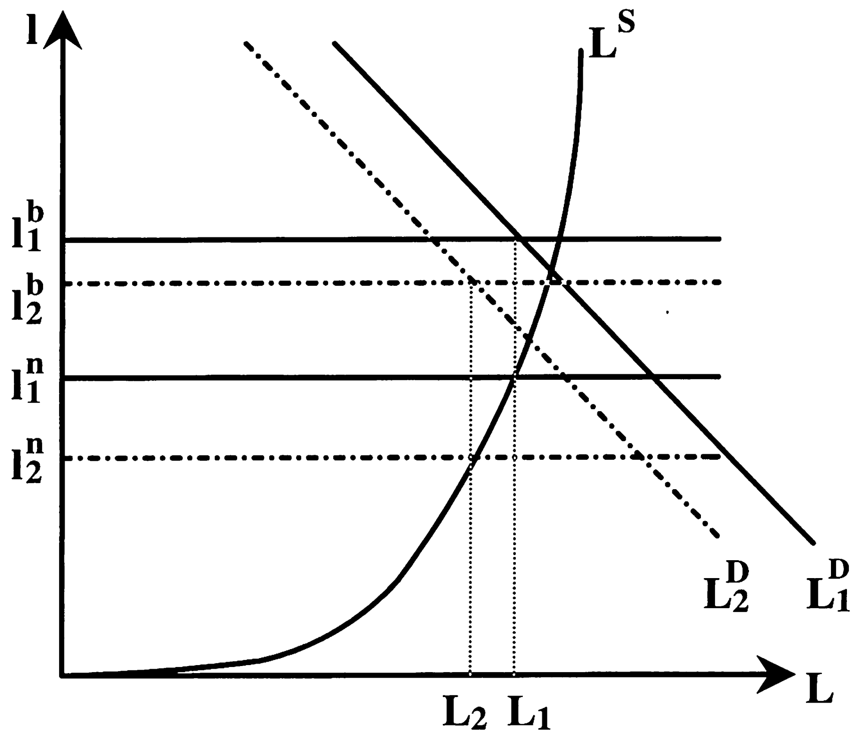
2. A GRAPHICAL REPRESENTATION OF THE BASIC THEORETICAL RESULTS

In a first best world, if the revenue of an environmental tax were (after all adjustments) large enough to finance the public good and if no other taxes were necessary, i.e. if taxes on capital and labour could be zero, then the introduction of the environmental (Pigouvian) tax would set the marginal excess burden to zero and lead to an optimal tax structure with a marginal cost of public funds equal to one. This holds quite generally. If the environmental tax revenue is not sufficient to finance the public good, however, we are in a second best world. There we have to look for indirect effects of taxation. Especially, we have to ask who is bearing the new tax. If we assume that capital cannot be taxed and, therefore, that all taxes are ultimately borne by labour, an ecological tax reform is essentially a substitution of a broad based labour tax by one with a narrow basis. This will increase the excess burden of taxation and, therefore, reduce welfare. More importantly,

6. For an overview of the different approaches to explain voluntary and involuntary unemployment see the contributions in GAHLEN, HESSE and RAMSER (1996).

however, it will reduce real income. If the labour supply curve is upward sloping, this will reduce labour supply and, in accordance, employment.

Figure 1: Employment effect of an ecological tax reform with only 'voluntary' unemployment



This can be shown by *Figure 1.* Let L^S be the labour supply function and L^D_1 the labour demand function in the original situation. l^b_1 is the gross and l^n_1 the net wage rate[7]. Actual demand and supply is at L_1. The ecological tax reform lowers the gross wage rate to l^b_2 since the revenue collected are used to reduce the income tax. At the same time, the net wage decreases to l^n_2 as a smaller tax base induces a higher dead weight loss. Thus, labour supply is reduced to L_2. In addition, because the green tax increases other than labour costs, the labour demand function shifts to the left to L^D_2, so that the economy is – with lower employment – again in equilibrium: Only the labour quantity L_2 is supplied

7. The wedge between the gross and net wage rates covers the total burden of taxation, including the one of the ecological tax.

and demanded. The change in employment depends in this model exclusively on the labour supply elasticity; if it is, as is usually assumed, positive, employment will decrease.

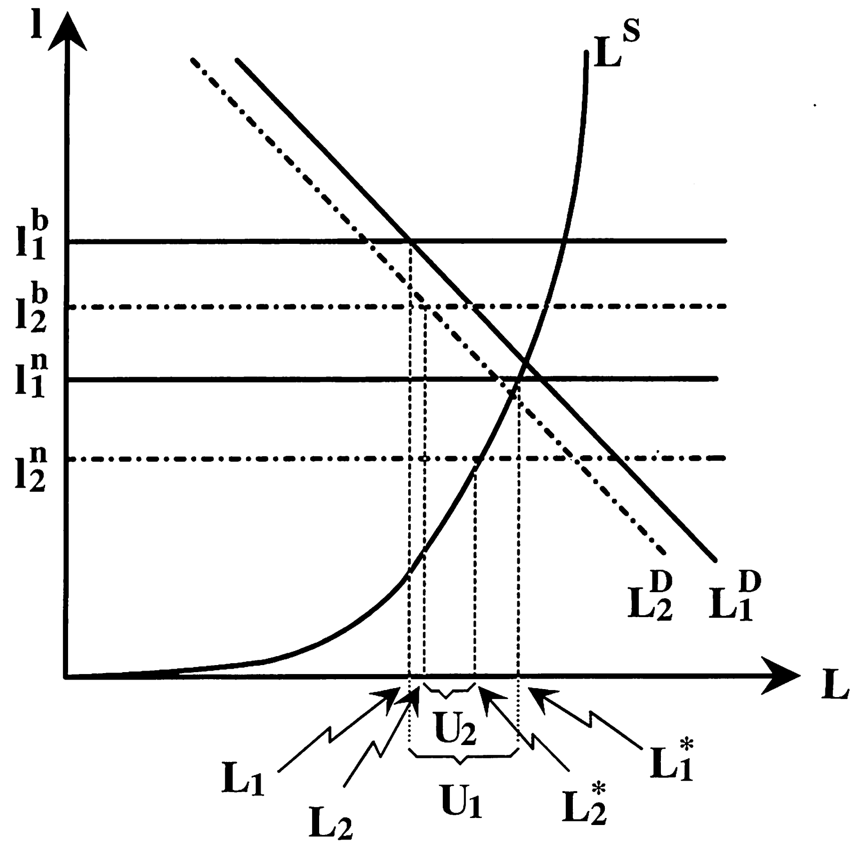
One might doubt whether this elasticity is really positive. Although this is often assumed, theoretically the sign of this elasticity is undetermined. The available estimates of labour supply elasticities of men have different signs, but are in most cases very close to zero, while those of wives are mostly positive and considerably higher[8]. Which estimates are relevant in this situation?

However, as long as there exists significant involuntary unemployment (as today in Europe), this elasticity is hardly relevant for employment, and the models mentioned so far are unable to give much insight into the employment effects of an ecological tax reform. In these models, all unemployment is voluntary and, therefore, given the real wage, labour *supply* determines employment. As soon as we accept the existence of involuntary unemployment, employment is determined by labour *demand,* which is – given the real wage – below labour supply. Thus, a cut in real income can only lead to a reduction of notional labour supply. And while the (negative) output effect leads to a reduction of labour demand, the reduction of the gross real wage should lead to an increase in employment. Thus, we have two contrary effects, and it is theoretically open which one dominates[9].

Again, this can be shown graphically. In *Figure 2* we have the same labour supply function L^S as before. In the original situation we also have the same labour demand function, $L^D{}_1$. The wage rate is now, however, so high that unemployment results: notional labour supply $L^*{}_1$ as caused by the net wage rate $l^n{}_1$ is higher than effective labour demand, L_1, as caused by the gross wage rate $l^b{}_1$. The latter determines, however, the actually employed quantity of labour. The ecological tax reform reduces the gross wage rate. This leads to an increase of labour demand. Because of the increased excess burden the real net wage rate is, however, even reduced stronger. Moreover, because of the output effect the labour demand function shifts left. This reduces actual labour demand, and notional labour supply is also reduced because of the reduced net wage rate. The effects on employment and unemployment are open. In the example of *Figure 2* the increase in labour demand as a result of the reduced gross wage $l^b{}_2$ outweigh the shift of the labour demand function, $L^D{}_2$, to the left. Thus, employment increases. Because at the same time notional labour supply is reduced to $L^*{}_2$, unemployment shrinks even further: the substitution dominates the income effect. If, on the other side, the output effect were larger than the substitution effect, employment would shrink, and if the labour supply were sufficiently inelastic, unemployment could increase.

8. See, e.g., HAUSMAN (1985), pp. 241 ff.
9. A reduction of unemployment can take place even if employment is shrinking. This would be the case if – given the real wage rate – unemployment is measured as the difference between notional labour supply and actual employment, and if the reduction of the latter is smaller than the reduction of the former.

Figure 2: Employment effect of an ecological tax reform with involuntary unemployment



The open question is, however, whether workers and/or their trade unions will accept the cut in real wages. If, as is assumed in *Figure 2*, wages are above their equilibrium values, there must be some distortion in the labour market. Despite the fact that until now no theory is available which could explain this based on the usual primitives of economic theory, i.e. rational agents with rational expectations, this distortion is usually claimed to be a result of trade union power. But independent of whether we have a sound theoretical basis for such a believe or not, if this is true it is highly probable that trade unions will use their power to restore the former income situation of their members. Under these conditions, even the model with involuntary unemployment might predict an increase of unemployment[10].

10. See, e.g., CARRARO and GALEOTTI (1995). However, KOSKELA and SCHÖB (1996) show that even in a model with trade union power a double dividend is – under certain additional conditions – possible.

If the trade unions accept at least a certain cut in real wages, it becomes plausible that the substitution of labour by energy taxes reduces involuntary unemployment. However, the opposite result can not be excluded theoretically. Thus, the gross effect of this substitution on employment is theoretically open and has to be determined empirically. To get some empirical insight, in the next section we therefore address this issue in the framework of an applied general equilibrium model of the Swiss economy.

3. DESCRIPTION OF THE MODEL

The simulation analysis of the effects of an energy tax on environment and employment is based on a static applied general equilibrium model of the Swiss economy for the year 1990. It is assumed that involuntary employment exists before the energy tax is introduced. Except for the explicit modelling of involuntary unemployment, the model corresponds in its broad characteristics to the model of MEYER ZU HIMMERN (1997).

In this model, there are three (primary) production factors: capital, labour, and energy. Energy is assumed to be internationally perfectly mobile, i.e. its market price is internationally determined. Labour is assumed to be internationally immobile. The critical assumption concerns capital. Taking the Swiss situation of a small open economy into account, it would make sense to assume that capital is also internationally (perfectly) mobile. However, under these assumptions any wage rate which is above its equilibrium level would immediately reduce domestic production to zero. Thus, to embed involuntary unemployment which is caused by too high a gross wage rate in our model we need one fixed factor of production besides labour. Therefore, we assume that capital is (quasi) fixed. However, this assumption is not only due to methodical reasons, it can also be justified by substantial arguments: Involuntary unemployment is – at least hopefully – a short or medium term phenomenon, and, as the studies of FELDSTEIN and BACHETTA (1991) and others show, the FELDSTEIN-HORIOKA-Paradox (1980) still holds: Real capital is much less mobile than economic theory suggests[11].

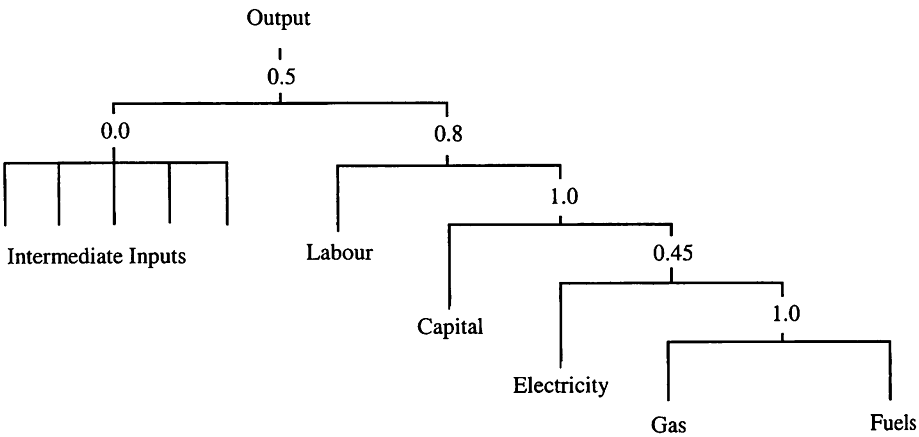
Thus, the structure of the model is as follows:

(i) *Producer behaviour:* The supply-side of the model is disaggregated into twenty industrial sectors which are listed in *Table A1* in the Appendix. Producers are assumed to maximise profits subject to their production technology. Nested linear homogeneous constant-elasticity-of-substitution (CES) production functions are assumed. The arguments of the production functions are the intermediate inputs and the primary inputs, labour, capital and energy. The latter input is disaggregated in electricity, gas and fuels. The substitution elasticities and the nesting structure are described in *Figure 3.*

11. See, e.g., FRENCH and POTERBA (1990), FELDSTEIN and SINAI (1994) or TAYLOR (1996).

The elasticity of substitution between intermediate inputs and the composite production factor labour-capital-energy is 0.5, whereas the elasticity between the various intermediate inputs is zero. The elasticity between labour and capital-energy its 0.8 and the one between capital and energy is 1.0. Energy itself is a production factor made of a combination of electricity and fossil energy with a substitution elasticity of 0.45. Within fossil energy the elasticity between gas and fuels is 1.0. These elasticities, together with the Input-Output Table of the year 1990, are used to calibrate the production functions of the twenty industrial sectors.

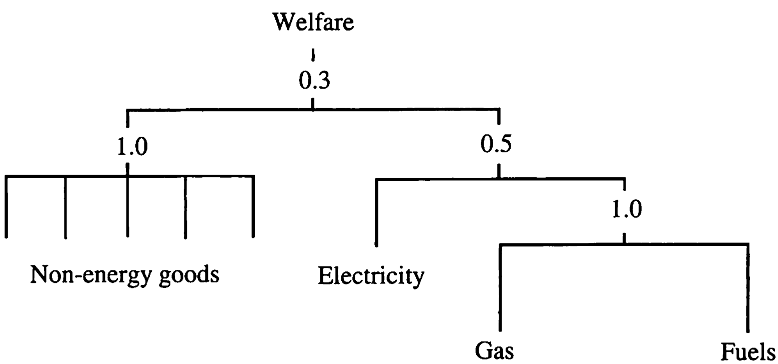
Figure 3: The nested CES production functions



(ii) *Household behaviour:* The demand-side of the model is disaggregated into four types of households: workers, unemployed, retired people living from social security transfers and retired people living from the return of their capital. The whole capital is owned by the latter. Households are assumed to be utility-maximisers. The utility functions are of the nested linear homogenous constant-elasticity of substitution (CES) type. The arguments of the utility functions are the twenty consumer goods. In an economy with involuntary unemployment leisure has no opportunity cost for workers and unemployed. The same is true for retired households because it is assumed that they do not have the opportunity to work. Therefore leisure does not enter the utility functions. *Figure 4* gives the nesting structure and the elasticities of the utility function.

The elasticity of substitution between non-energy goods and energy goods is 0.3. Within the non-energy (consumption and capital) goods the elasticity of substitution is 1.0. The energy goods are composed of electricity and fossil energy, which in turn is composed of gas and fuels. The elasticity of substitution is 0.5 in the former case and 1.0 in the latter case. The four types of households differ with respect to their budget constraints. The income of the workers is the product of the after-tax wage and the number of employed. An increase in employment may increase the income of this sector even if the after-tax wage falls. The income of the unemployed sector is the product of the insurance benefits with the number of unemployed. The numbers of employed and unemployed workers add up to the total working population which is assumed to be constant. The income of the (retired) capital owners is the product of the rate of return and the capital stock. The retired transfer earners get a pension fixed in real terms. The purpose of disaggregating the household sector in workers and capital owners is to display the effects of the energy tax on the functional distribution of incomes. The assumed elasticities together with the assumptions about the endowments of the households with labour and capital and their benchmark consumptions are sufficient to calibrate the utility functions.

Figure 4: The nested CES utility functions



(iii) *Government and social security:* The public sector is composed of the government sector and the social security sector, which pays retirement and unemployment insurance benefits. The revenues of this sector are a proportional income tax of 10 percent levied on labour and paid by the workers, the social security contributions which are also levied on labour but paid in equal shares by employers and employees, a tax of 15 percent on capital income, duties and indirect taxes as they were present in the Swiss 1990 economy, and the carbon tax levied on energy which is used for private consumption and as production input. The public sector spends these expenditures on government consumption (and government investment), transfers to the retired people, and transfers to the unemployed. The per capita benefits to the unemployed are 75 percent of the real wage paid to the workers.

Tax revenue are adjusted so that the budget of the public sector remains balanced. In particular the introduction of the carbon tax is revenue neutral: It is compensated by a decrease of the social security contributions. The transfers to the unemployed decrease with unemployment, while the transfers to the retired remain constant in real terms. The consumption expenditures of the public sector are assumed to be constant in relation to private activities, i.e. they are a constant share of GDP.

(iv) *Labour Market:* The real wage is assumed to be the result of negotiations. The negotiated real wage is fixed above the Walrasian equilibrium wage so that a level of involuntary unemployment of 5 percent results in 1990. The labour cost (gross wage) is the negotiated wage with half of the social security contributions added, while the net wage is the negotiated wage minus the other half of the social security contributions and the labour tax. The price index used in the negotiations is an implicit deflator of consumption expenditure, where the prices of the energy goods enter the index *before* the energy tax. Thus, it is assumed that workers accept that with the introduction of an energy or CO_2-tax the negotiated nominal wage remains constant, i.e. they accept a decrease of the negotiated real wage, because they are (at least partially) compensated by a reduction of their social security payments (in addition to the higher environmental quality). This is the crucial behavioural assumption of the model. The negotiated wage is kept fixed in terms of the price index. Other price changes than the introduction of an energy tax levied on the direct consumption of energy by households influence the nominal wage but leave it unchanged in real terms[12].

(v) *Foreign trade:* It is assumed that a foreign household demands the exports and represents the «rest of the world». The elasticities of substitution between the exported goods and a single 'multifunctional' good that the foreign household is endowed with, are given in the second column of *Table A1* in the Appendix. The terms of trade adjust so that the balance of trade remains in equilibrium. The imports of the foreign good are a substitute to the material intermediate goods produced in the domestic economy. The elasticities of substitution are found in the first column of *Table A1.*

(vi) *The environmental tax:* First, this tax is assumed to be a CO_2 tax. It is levied on the (direct) consumption of energy goods (fuels and gas) by private households as well as on energy goods utilised as inputs in the production sectors[13]. Thus, electricity is not taxed. In an alternative specification of the model a general energy tax replaces the CO_2 tax. Here again, energy goods are taxed at the consumption and production level, but electricity is taxed additionally. However, because only non-renewable energy is taxed, 60 percent of electricity (which is produced by waterpower) is exempted from taxation.

12. This implies that workers are compensated for increases of prices of consumer goods as a result of energy price increases, but they also do not gain from price decreases following the reduction of unit labour costs.
13. Because practically all fossil energy is imported, this corresponds to a tax which is levied on imports of fossil energy. The export of energy goods are, with the exception of electricity, of a small order of magnitude, and they are not taxed in the model.

4. SIMULATION RESULTS

The model is calibrated with Input-Output date for the year 1990[14]. The assumed elasticities of substitution and the input-output data fully specify the utility and production functions. Parametrised in this way, the model is solved for equilibrium prices and quantities[15]. This represents the benchmark relative to which the results of the simulations are compared. In the benchmark we assume that unemployment is involuntary and that the unemployment rate is 5 percent[16]. Under these assumptions an income tax of 22 percent (including social security contributions) balances the budget of the public sector.

4.1 The Scenarios

Eight scenarios, as listed in *Table 1*, are computed. Scenario I is the reference scenario. A carbon tax of 36.– Sfr per ton CO_2 is levied. The Scenarios II and III are a sensitivity analysis allowing to evaluate the effects of changes of this rate; the tax rate is reduced by 50 percent (to 18.– Sfr per ton CO_2) in the former and increased by 50 percent (to 54.– Sfr per ton CO_2) in the latter scenario. In Scenario IV the labour market is modelled in the usual Walrasian way. There, the elasticity of substitution between leisure and consumption is assumed to be 2.1[17]. This implies that employment (and leisure or unemployment, respectively) are endogenous, and unemployment benefits are paid to five percent of the workers. The three most energy intensive sectors (paper industry, mining and iron industry, chemical industry) are exempted from the energy tax in Scenario V. However, the share of the income tax paid by the firms in these sectors is not reduced either when the CO_2 tax is introduced; only the income tax owed by the workers in these sectors is decreased. Instead of a CO_2 tax, an energy tax of 2.50 Sfr per GJ (Giga-Joule) is levied in Scenario VI. But only non-renewable energy is taxed. The tax rate of 2.50 Sfr per GJ was chosen because it would give the same revenue to the government as the CO_2 tax of 36.– Sfr in the reference scenario[18]. Finally, a sensitivity analysis with respect to the assumption regarding the elasticity of substitution between labour and the capital-energy composite is performed: This elasticity is increased to 0.85 in Scenario VII and reduced to 0.75 in Scenario VIII.

14. This was the latest available Input-Output data for Switzerland when we started this project. A description of the data is given in ANTILLE (1995).
15. As it is (still) the usual practice in the applied general equilibrium literature, the computed relative prices are not compared with the actual relative prices in order to validate the model.
16. The actual rate of unemployment was 0.5 percent in 1990.
17. This corresponds to an elasticity of labour supply with respect to real wage of 0.15. See MEYER ZU HIMMERN (1997, pp. 208 ff.) for a description of the derivation of these values.
18. The revenue of the energy tax of 2.50 Sfr are the same as the revenue of the CO_2 tax of 36.– Sfr under the assumption that the equilibrium quantities are those of the reference Scenario I.

Table 1: The Scenarios

Scenario	Crucial assumption*	Change in GDP
I	Carbon tax: 36.– Sfr per ton	0.5
II	Carbon tax: 18.– Sfr per ton	0.3
III	Carbon tax: 54.– Sfr per ton	0.7
IV	Walrasian labour market	0.0
V	Carbon tax with three sectors exempted	0.5
VI	Energy tax: 2.50 Sfr per GJ	0.6
VII	Elasticity$_{L,K\text{-}E}$: 0.85	0.6
VIII	Elasticity$_{L,K\text{-}E}$: 0.75	0.4

* This gives the assumption which is changed relative to the benchmark model.

In Scenario I (or II and III) the tax rate corresponding to 36.– Sfr per ton (18.– Sfr, 54.– Sfr) is 17.4 percent (8.7 percent, 26.2 percent) on fuels and 9.1 percent (4.5 percent, 13.6 percent) on gas. In Scenario VI, where an energy tax of 2.5.– Sfr per GJ is assumed, the tax rates are 15 percent on fuels, 12 percent on gas and 1.7 percent on electricity[19].

Table 1 also gives the general economic impact for the different scenarios, i.e. the change in GDP. As long as there is only voluntary unemployment, there is no (measurable) change at all. As soon as involuntary unemployment exists, we get a positive impact on GDP. The change of GDP is the larger, the higher the CO_2 tax rate and the higher the elasticity of substitution between labour and the capital-energy composite. With revenue being identical, a general energy tax has approximately the same effect as the CO_2 tax. An exemption of the energy intensive sectors from the CO_2 tax reduces the positive effect on GDP, only very marginally.

In the following, these eight scenarios will be analysed with respect to their effects on the environment, the employment, the structure of the economy, the distribution and the competitiveness.

4.2 *Environmental Effects*

Table 2 presents the effects on the emissions of CO_2 (second column) and energy consumption (third column). The results are presented in percentage changes relative to the benchmark value which is given by 44 million tons, the amount of CO_2 which was emit-

19. Total consumption of energy in Switzerland was 733 million GJ in 1990. The most important parts were in form of oil (496 million GJ), electricity (168 million GJ) and gas (70 million GJ). (See BFS/OFS (1992, p. 179).) For each GJ of oil (gas) 8.05 kg (5.27 kg) of CO_2 is emitted. (See B. Fritsch (1990, p. 335).) The CO_2 emissions resulting of the use of oil (gas) can be estimated to be 39.96 (3.69) million tons.

ted in 1990 in Switzerland[20]. The reference scenario shows that a CO_2 tax of 36.– Sfr per ton leads to a reduction of these emission of 8.5 percent. A reduction (Scenario II) or an increase (Scenario III) of the tax rate by 50 percent reduces the emissions by 4.5 or 12.0 percent, respectively. The Scenario IV with a Walrasian labour market predicts a somewhat stronger reduction of the emissions (– 8.8 percent). This is a consequence of the fact that in this scenario economic activity is not changed contrary to the scenarios with involuntary unemployment. The exemption of the energy intensive sectors from the obligation to pay the CO_2 tax does hardly reduce the environmental effect (Scenario V). The reduction of the CO_2-emission is 7.9 percent as compared to 8.5 percent without this exemption. This is partly due to the fact that economic activity does not increase as much as in the reference scenario, and partly that the exempted sectors are nevertheless indirectly affected by the CO_2 tax. Scenario VI shows that a tax of 2.50 Sfr per GJ on renewable energy decreases the CO_2 emissions slightly less than in the reference scenario. Finally, the Scenarios VII and VIII reveal that the CO_2 emissions are hardly affected by variations in the substitution elasticity between labour and the capital-energy composite.

The third column of *Table 2* shows the results for total energy consumption. There the reduction is almost proportional to the reduction in CO_2-emissions. This holds for all scenarios except Scenario VI: As is to be expected, a general energy tax has a comparatively stronger effect on the reduction of energy consumption than of CO_2-emissions. The last column shows the revenue of the CO_2- or energy tax which corresponds to the reduction of the social security contributions. Its amount is 1.43 Mrd. Sfr in the reference scenario, 0.75 Mrd. Sfr at minimum and 2.06 Mrd. Sfr at maximum. This corresponds to 1.4 percent (0.73 percent or 2.02 percent, respectively) of total government revenue (and expenditure), and 5.25 percent (2.75 percent or 7.57 percent, respectively) of the contributions for the public social security system including the «first pillar» of the old age pension system (AHV), the unemployment insurance (ALV) and the insurance for invalidity (IV).

Table 2: Emissions of CO_2, Use of Energy, and Revenue of the Ecological Tax

Scenario	Tons of CO_2*	Giga-Joules*	Tax Revenue
I	– 8.5	– 7.4	1.43 Mrd
II	– 4.5	– 3.9	0.75 Mrd
III	– 12.0	– 10.5	2.06 Mrd
IV	– 8.8	– 7.7	1.43 Mrd
V	– 7.9	– 6.9	1.44 Mrd
VI	– 7.6	– 7.0	1.45 Mrd
VII	– 8.4	– 7.4	1.43 Mrd
VIII	– 8.5	– 7.5	1.43 Mrd

* These results are given in percentage changes relative to the benchmark.

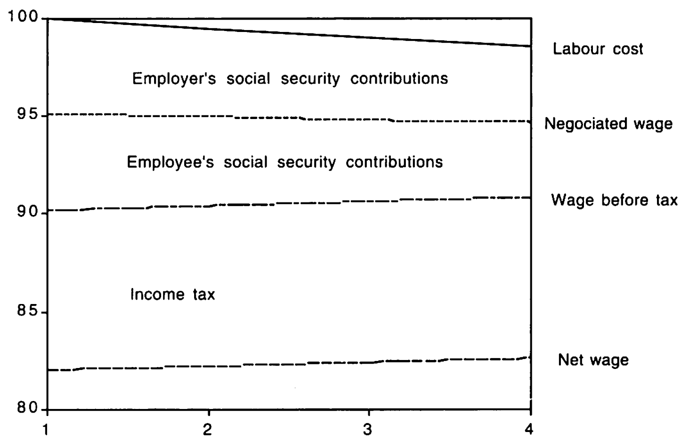
20. FELDER and VAN NIEUWKOOP (1996, p. 243) get a similar figure of –11.31 percent in their «Scenario high-low».

4.3 *Effects on Wages and Employment*

It is assumed that the negotiated nominal wage remains constant. Thus, the real wage does not fully adjust to changes of the prices of the energy goods consumed. The introduction of the CO_2 tax causes therefore a decrease of the negotiated wage in real terms. Because the green tax reform is assumed to be revenue neutral, the introduction of the CO_2 tax is also followed by a reduction of the social security contributions. Furthermore, as the base of the CO_2 tax is smaller than the base of the labour tax (or the social security contributions, respectively), the green tax reform implies a distortion effect which lowers the marginal product of labour. Consequently, as explained above, the question on how a green tax reform affects the labour cost and the net wage is theoretically open.

Because of the reduction in the employers' part of the social security contributions, in our model the gross wage rate and, therefore, real labour costs fall even more than the negotiated real wage. This leads to an increase in production and also in employment which reduces the amount of revenues which are needed for unemployment compensations. Thus, an additional reduction of social security contributions is possible, which again increases the real net wage. As this overcompensates the initial reduction the real net wage after the introduction of the environmental tax is even higher than before. This is shown in *Figure 5* where labour costs (real gross wages), the negotiated real wage and the net real wage calculated in Scenarios I, II and III, compared to the benchmark, are displayed. The real wages are given in percent of the benchmark gross real wage which is normalised at 100 percent.

Figure 5: Reaction of real wages on the introduction of a CO_2 tax



1: Without carbon tax (benchmark).
2: Carbon tax of 18.- Sfr. per ton (scenario II).
3: Carbon tax of 36.- Sfr. per ton (scenario I).
4: Carbon tax of 54.- Sfr. per ton (scenario III).

In the reference Scenario I, the decrease in the negotiated wage is – 0.3 percent relative to the benchmark. The fall in labour cost is more substantial: – 1.2 percent. Nevertheless the net wage of the workers increases relative to the benchmark by 0.6 percent. Compared to this, in the Scenario IV with voluntary unemployment labour cost decreases only slightly: by 0.4 percent, and the net wage increases by a mere 0.1 percent. This effect which is contrary to the result of L. A. BOVENBERG (1998) is due to the fact that through their consumption, capital owners share the tax burden which in the benchmark situation is only borne by labour.

The green tax reform decreases labour costs and hence increases economic activity. Involuntary unemployment is reduced. *Table 3* shows the magnitude of theses effects. The first three scenarios show that the higher the CO_2 tax rate is, the larger the increase of economic activity (measured in percentage change of (real) GDP relative to the benchmark situation) and the smaller the unemployment rate will be. In the reference scenario I unemployment falls from 5 to 3.7 percent. Contrary to this, in Scenario IV with only voluntary unemployment the effects on economic activity and employment are negligible. Scenario V shows that the exemption of energy intensive sectors from the obligation to pay the CO_2 tax has only a small effect on unemployment. The energy tax (Scenario VI) has a somewhat larger effect on unemployment than the CO_2-tax. It has a broader base than the latter and the income tax is with 20.0 percent slightly lower in this scenario than in the reference scenario with 22.0 percent.

Table 3: Economic Activity and Unemployment

	Tax rate on labour income*)	Unemployment Rate
Status quo	22.0	5.0
I	20.1	4.0
II	21.0	4.5
III	19.3	3.5
IV	21.2	4.9**
V	20.2	4.0
VI	20.0	3.9
VII	19.8	3.7
VIII	20.3	4.2

The tax rate on labour income is given in percent. The rate of change of GDP is the rate of change relative to the benchmark GDP. The rate of unemployment is the percentage of unemployed relative to the total number of (potential) workers.

* This is the total tax on labour which includes social security contributions.
** Unemployment is voluntary in Scenario IV.

4.4 Distributive Effects and Terms of Trade Effects

More interesting than the overall welfare effect of an environmental tax reform is the question of how the income distribution is affected. This gives an indication whether such a reform has any chance to be accepted by the voters in a referendum.

Distributive questions can be handled within our computable general equilibrium model by calculating the changes in the utility indices for the four different economic groups. These are given in *Table 4.* Of course, as utility is an ordinal concept the rate of change of utility is – per se – meaningless. Nevertheless the sign of the rate of change indicates whether welfare increases or not, and within the same group larger figures indicate larger welfare changes. Because it is impossible – at least in the framework of our model – to compare the change (improvement) of the environment with the change in the economic situation we only calculate the changes in economic welfare.

The welfare of the retired and unemployed people does not change by assumption, as the transfers to these groups are fixed in real terms. The welfare of the employed increases by the introduction of a carbon tax or an energy tax. This is not surprising given that the net real wage increases. The welfare of the capital owner is also improved. Given a fixed stock of capital, the increase of employment leads to an increase of the marginal product of capital which – in this model – more than counterbalances the effect of the larger prices of the consumer goods. There is also a fifth group to be considered, those who have been unemployed and who do get a job now. Because their unemployment was involuntarily, their welfare is improved by definition. Thus, looking at the different groups the ecological tax reform leads to a Pareto improvement[21].

Table 4: Welfare Effects of the introduction of a carbon tax

	worker	capital owner	retired	unemployed
I	0.5	0.3	0.0	0.0
II	0.2	0.2	0.0	0.0
III	0.7	0.4	0.0	0.0
IV*	0.0	- 0.4	0.0	0.0
V	0.4	0.3	0.0	0.0
VI	0.5	0.3	0.0	0.0
VII	0.6	0.4	0.0	0.0
VIII	0.4	0.2	0.0	0.0

The results are given in percentage change relative to the benchmark. Only the sign of the figures is meaningful.

* In Scenario IV with voluntary unemployment, leisure has an opportunity cost. Therefore, the utility index can hardly be compared with the index of the other scenarios.

21. This does not hold, of course, within the groups, because there are winners and losers of such a reform in the different industries.

This is quite contrary to the result of the equilibrium model employed in Scenario IV. While the situation of the workers remains (nearly) constant, the situation of the capital owners deteriorates slightly, because – being also consumers – they have to pay higher prices for the energy goods.

The impact on the competitiveness of the Swiss economy is described in *Table 6*. In the model with involuntary unemployment, a CO_2-tax, or alternatively, an energy tax is followed by a reduction in the terms of trade and an increase in exports and imports. These effects are small but they become larger with higher tax rates and a higher elasticity between labour and the capital-energy composite. We get the opposite picture in the model with only voluntary unemployment. There, the terms of trade improve, and exports and imports decline. Moreover, these effects are (in absolute terms) stronger than in the reference scenario with involuntary unemployment but all other assumptions being the same.

Table 5: Terms of trade effects

	Exports	Terms of trade*
I	0.1	– 0.1
II	0.0	– 0.0
III	0.1	– 0.1
IV	– 0.4	0.2
V	0.1	– 0.1
VI	0.1	– 0.1
VII	0.2	– 0.1
VIII	0.0	0.0

The results are given in percentage change relative to the benchmark.

* The terms of trade are defined here as the average price of the goods exported, weighted with their export shares, relative to the price of the foreign domestic good. The terms of trade adjust so that the balance of trade constraint is fulfilled.

4.5 Effects of Trade Union Behaviour

As has been explained above, the behaviour of the trade unions may be crucial for the economic consequences of an ecological tax reform. If the employers' part of social security contributions is reduced, this opens a leeway for trade union policies. Up to now, we have assumed that the trade unions do not use this leeway: The negotiated nominal wage remains constant because workers accept that they are (partially) compensated for the higher energy prices by the reduction in their share of the social security contributions (and a cleaner environment)[22]. Thus, the gross real wage can decline and generate the positive employment effect. A possible alternative trade union strategy might be to exploit this leeway to keep the negotiated real wage constant. Between these two (extreme) policies any policy of partial adjustment of the negotiated real wage is possible.

Table 6 presents the basic results for the two extreme policies as well as for a partial (50 percent) adjustment of the negotiated real wage. The trade union strategy is of little importance for the environmental effect of the CO_2 tax. The reduction of the CO_2 emissions is the largest in the case if the negotiated real wage remains constant, but the difference to the results of other strategies is small, and it is due to the decrease of economic activity which is caused by this strategy. On the other hand, the different strategies have quite different economic and employment consequences. If the negotiated real wage remains constant, GDP falls relative to the benchmark by 0.2 percent and unemployment raises from 5.0 to 5.3 percent. If workers accept that the negotiated wages is only partly adjusted and covers only 50 percent of the CO^2 tax then unemployment decreases from 5.0 to 4.6 percent and the economic activity increases slightly by about 0.2 percent. This is only about one half of what can be reached in the reference scenario: an increase of GDP by 0.5 percent and a reduction of the unemployment rate from 5.0 to 4.0 percent.

Table 6: Effects of Trade Union Strategies

Trade Union Strategy	Reduction of CO_2	Rate of change of GDP	Unemployment Rate
Constant nominal wage	– 8.5	+ 0.5	4.0
Partial adjustment of real wage	– 8.6	+ 0.2	4.6
Constant real wage	– 8.7	– 0.2	5.3

The results for the emissions of CO_2 and for GDP are given in percentage changes relative to the benchmark. The rate of unemployment is the percentage of unemployed relative to the total number of (potential) workers

22. In a (more realistic) world where consumer prices are changed also for other reasons this implies that in the CPI calculations which are relevant for the bargaining between trade unions and employers organisations (direct) changes of the energy prices which are due to changes in the energy tax rate are not taken into account. There might be indirect effects because the prices of other consumption good change as well. However, these indirect effects are not distinguishable from 'normal' changes in relative prices and they are largely compensated by the decrease of labour unit costs. Therefore, we did not correct the calculated price index for these secondary effects.

These results are hardly surprising. If trade union policy keeps the real gross wage constant or even leads to an increase, involuntary unemployment cannot decrease. Moreover, the «BOVENBERG-effect» of a higher excess burden might lead to an increase. However, these results also show that it is rational for the trade unions not to exploit the leeway which is generated by the ecological tax reform and to accept the reduction of the negotiated real wage while keeping the nominal wage constant. This «concession» is essential for the success of this reform; without such a concession no positive employment effects are possible.

5. SUMMARY AND CONCLUDING REMARKS

Using 1990 Input-Output data, in this paper a static computable general equilibrium model for Switzerland is developed which takes the existing unemployment as being involuntary. The results are compared with those of a model based on the assumption that all unemployment is voluntary. While in the latter case we get only a small employment effect (if at all), the existence of involuntary unemployment makes it possible to reach a substantial decrease of the unemployment rate. However, the possibility and the extent of this reduction very much depends on the strategy followed by the trade unions.

This is of special importance, because the ecological tax reform opens a leeway for the trade union policies which might be exploited. Thus, our expectations about the success of such a reform depend very much on our expectations about future trade union policy. Today, with high unemployment, the position of the trade unions is rather weak. As the recent years have shown, this holds for Switzerland, but, e.g., as well for Germany. Thus, as long as the negotiated nominal wage is not lowered and the trade union members at least nominally benefit from the reduction of their social security contributions we can expect moderate and not aggressive trade union policies. From this point of view a positive employment effect of an ecological tax reform can be expected. Its extent is, however, sensitive with respect to the substitution elasticity between labour on the one side and the capital-energy composite on the other hand. The available empirical information from estimates of this elasticity vary between zero and one. This is not precise enough to make strong conclusions[23]. Thus, while the sign of the effect is clear, its size is still open, and further research in this direction is needed.

In our model, the capital stock is assumed to be given and fixed[24]. As has been explained above, this is a necessary assumption to capture involuntary unemployment in a model with three factors of production, capital, labour, and energy, were energy is assumed to be fully mobile internationally. Nevertheless, this might be seen as being a major shortcoming of this model, since for Switzerland this assumption holds at best in the

23. Most estimates are above 0.5. See, e.g., KEMFERT and WELSCH (1997).
24. This also implies that investment does not change the stock of physical capital.

short-run, and the idea of the ecological tax reform is to change the economic structure of a country in the long-run.

One might argue that involuntary unemployment, as persistent as it may be, is not a long run phenomenon. Therefore, it might be appropriate to represent involuntary unemployment in a short-run model. This is, however, questionable if, as in many European countries, we observe involuntary unemployment for more than two decades. Nevertheless, a deeper analysis should dynamise the model so that the capital stock is adjusted[25]. Physical capital would be mobile internationally and the balance of trade constraint would have to be replaced by a balance of payment constraint. Such a model could also analyse the time paths of the effects we have analysed here.

For at least two reasons, the assumption of a fixed capital stock should, however, not invalidate our results. First, the effect on GDP is in all our simulation rather small; the estimated change is smaller than one percent. Thus, the (in the long-run) necessary adjustment of the capital stock would also be rather small. Second (and more important) is, however, that according to the calculations with our model the ecological tax reform improves the situation of the capital owners. Though this improvement would be smaller if the capital stock growed, the incentive would be to increase and not to decrease the stock of physical capital. Thus, there is no danger of a «capital flight». If new capital were invested domestically, however, the marginal return of labour would increase which would lead to higher real net wages and even higher employment. Thus, a dynamisation of the model might even predict higher and not lower employment gains.

One caveat remains, however. Even if the overall effect of an ecological tax reform on the Swiss economy is positive, in different sectors of the economy we have winners and losers. The simulations where we except the energy intensive producing sectors from the CO_2-tax show that we can take measures which improve the situation of the losers without really deteriorating the gross result. Nevertheless, to evaluate the political chances of such a reform one has to study the sectoral effects carefully. This is possible with the model we have developed, but it goes beyond the scope of the present study.

25. This would not necessarily imply perfect international mobility of capital, as a risk premia might still exist which drives a wedge between the rates of return of domestic and international investments.

APPENDIX

Sectoral Disaggregation

Table A1: Elasticity of substitution between imports and exports *

Sectors	home country	foreign country
1) Electricity	1.5	2.0
2) Gas	4.0	4.0
3) Oil products	4.0	4.0
4) Agriculture and forestry	1.5	2.0
5) Water supply	0.0	0.0
6) Food and beverages	1.5	2.0
7) Textile and clothing products	2.0	2.0
8) Paper products	2.5	1.5
9) Chemical products	0.0	2.0
10) Mining and iron industry	5.0	1.3
11) Non-ferrous metal products	1.5	1.5
12) Products of the machine industry	3.0	0.5
13) Rest of industry	1.5	2.0
14) Construction	0.0	0.0
15) Wholesale and retail trade	1.5	2.0
16) Tourism and gastronomy	0.0	0.0
17) Transportation	1.5	2.0
18) Finance and Insurance	1.5	2.0
19) Education and health	0.0	0.0
20) Government and social security	0.0	0.0

* The elasticity of substitutions are the one between the corresponding home produced good and imports and the exports and the (unique good) produced in the foreign country. The elasticity are taken from MEYER ZU HIMMERN (1997) p. 110, who refers to ANTILLE et al. (1993).

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ZUSAMMENFASSUNG

Mit Hilfe eines berechenbaren allgemeinen Gleichgewichtsmodells werden die Auswirkungen einer ökologischen Steuerreform auf die schweizerische Wirtschaft untersucht. Dabei wird eine CO_2-Steuer erhoben, und deren Erträge werden zur Verringerung der AHV-Beiträge eingesetzt. Eine solche Reform führt zu einer beträchtlichen Reduktion der CO_2-Emissionen und des Verbrauchs an erneuerbarer Energie (erste Dividende), sowie zu einer Verringerung der unfreiwilligen Arbeitslosigkeit. Die Existenz dieser zweiten Dividende hängt jedoch von der Politik der Gewerkschaften ab. Diese Ergebnisse werden verglichen mit Modellen, die nur freiwillige Arbeitslosigkeit kennen, mit einem Modell, in welchem eine Energiesteuer an die Stelle einer CO_2-Steuer tritt, sowie mit einem Modell, in welchem die energie-intensivsten Sektoren von der CO_2-Steuer ausgenommen werden.

SUMMARY

Using an applied general equilibrium of the Swiss economy the economic consequences of an environmental tax reform are analysed. Such a reform is followed by a substantial reduction of CO_2 emissions and the use of non-renewable energy (first dividend), and a reduction of involuntary unemployment. The existence of this second dividend depends, however, on the strategy followed by trade unions. These results are compared with the results of models with voluntary employment, with an energy tax rather than a CO_2 tax, and a model where the three most energy intensive sectors are exempted from paying the CO_2 tax.

RÉSUMÉ

Les effets d'une taxe environnementale sont analysés à l'aide d'un modèle d'équilibre général de l'économie suisse. Une telle réforme fiscale entraîne d'une part une réduction substantielle des émissions de CO_2 et de l'utilisation d'énergies non-renouvelables (premier dividende), ainsi que d'autre part une réduction du chômage involontaire. L'existence de ce deuxième dividende dépend cependant de la stratégie suivie par les syndicats. Les résultats sont comparés à ceux de modèles avec chômage volontaire, avec une taxe sur l'énergie plutôt que sur le CO_2, et avec une exemption de la taxe pour les trois secteurs consommant le plus d'énergie.