Analyzing Regionally Differentiated Transport Pricing Strategies in Switzerland*

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Abstract

Because of its specific landscape and its vulnerable ecosystem, the Swiss Alpine region suffers a lot from transport-related pollution which is much higher per transport unit than in the rest of Switzerland. The introduction of a regionally differentiated transport pricing would reduce negative impacts of transportation in the Alps. Applying SwissTRANS, a multi-sectoral general equilibrium model of Switzerland introducing both the Alpine region and the rest of Switzerland, our results suggest that a change from the current pricing regime in transport towards a marginal social cost pricing scheme is beneficial for both the Alpine region and the rest of Switzerland. However, concerns about regional environmental efficiency provide little justification in terms of aggregate welfare for tax differentiation across Switzerland. Nevertheless tax differentiation does matter at the regional level suggesting that regional policies in terms of compensation policy instruments play a critical role.

JEL classification: C68; R13; R41; R48

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1 Introduction

In the political debate on transport policy, higher transport taxes and charges are often mentioned as an appropriate approach to address increasing environmental costs in sensitive areas. In particular, because of its specific landscape and its vulnerable ecosystem, the Swiss Alpine region suffers a lot from transport-related pollution which is much higher per transport unit than in the rest of Switzerland. The introduction of a regionally differentiated transport pricing would reduce negative impacts of transportation in the Alps.

In our analysis, we evaluate the relative economic impacts on the Swiss economy of regionally differentiated transport pricing strategies reflecting the especially high costs of transport in a sensitive area like the Alps. We also look at cost recovery considerations within each transport mode, which is still a major concern for policy makers. In addition, the importance of the recycling of transport tax revenues to reduce existing distortionary taxes is examined.

Transport policy scenarios are simulated applying SwissTRANS, a multi-sectoral general equilibrium model of Switzerland introducing both, the Alpine region and the rest of Switzerland, and calibrated to an initial economic equilibrium in 2001. The model combines inter-sectoral linkages within regions together with linkages among regions. Transport per mode is represented in an aggregate way using aggregate congestion functions for road transport.

Simulation of different transport pricing scenarios in an economy-wide perspective suggests the following policy recommendations:

- Departure from the current Swiss transport pricing regime towards a marginal social cost pricing scheme is beneficial for both the Alpine region and the rest of Switzerland. Moreover raising transport prices above marginal social costs may also be welfare improving as long as the recycling of transport tax revenues is used to reduce distortions of existing taxes.

- Concerns about regional environmental efficiency provide little justification in terms of aggregate welfare for tax differentiation across Switzerland. Tax differentiation does however matter a lot at the regional level suggesting that regional policies in terms of compensation policy instruments play a critical role.

- Though often favoured in political discussions, a policy of cost recovery per transport mode is clearly not beneficial for households in terms of welfare and should therefore not be an objective *per se*.

- Additional transport revenues should aim at reducing current distortionary taxes, especially when the policy raises transport prices above marginal social costs as it generates substantial additional revenues.

- Appropriate pricing of transit transport is important as it plays a crucial role in the determination of the net welfare effect for Switzerland.

The paper presents first the SwissTRANS model. It is followed in section 3 by a description of the data required to implement SwissTRANS. Section 4 lays out the policy scenarios and the analysis of the economic impacts on Switzerland is provided in section 5. Section 6 concludes with policy recommendations.

2 The SwissTRANS Model

The SwissTRANS model is designed to analyse the economic impacts of transport policy within Switzerland. The current version of the model is a multi-sectoral computable general equilibrium (CGE) model of Switzerland. CGE models are particularly well-suited for policy analysis as they link markets into a single system and capture therefore feedback and flow-through effects induced by policy changes.

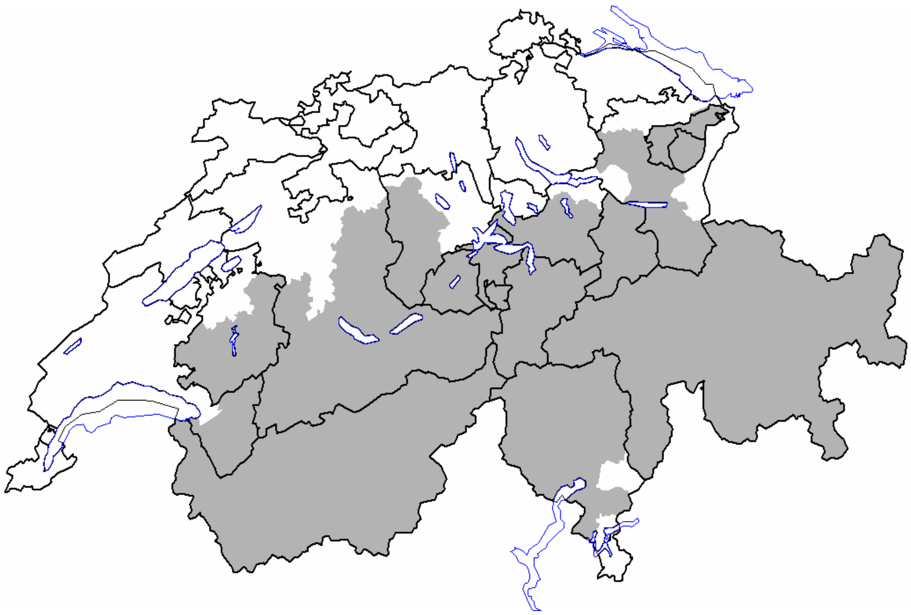
The SwissTRANS model introduces two different regions and the existence of fixed costs for transportation sectors. SwissTRANS combines therefore inter-sectoral linkages within regions together with linkages among regions. The model assumes optimizing behaviour from agents. Consumers' demand is determined by budget-constraint optimization and producers combine intermediate inputs, and primary factors at least cost subject to given technology.

2.1 The regional dimension

Regional analyses within a computable general equilibrium model range from *top-down* to *bottom-up* approaches. In the former, national results are disaggregated on an ad hoc basis into regional variations in quantities but not in prices. The latter consists in specifying agents' behaviour at the regional level which interact through trade and primary factor flows. Consequently, the bottom-up approach is very demanding in terms of both computer resources and data compared to the top-down approach. As we are interested in the change of regional output prices but fail the data requirements of the fully-specified regional formulation, our approach of regional economic modelling is between these two extremes.

SwissTRANS distinguishes between the Alps and the plain to take account of the greater sensitivity of the former to transport-related pollution compared to the latter (figure 1). In each region, five types of agents are identified: industries, investors, households, governments, and foreigners. They interact through commodity flows and labour supply. However, bilateral trade flows between regions in domestic and imported goods are not explicitly represented. They are implicitly introduced assuming homogenous composites of regional commodities. The degree of mobility of regional goods and services is assumed to be control by an elasticity of substitution. In other words, lowering of a region-specific price, relative to the average, induces substitution in favour of that region. As a consequence, national domestic prices of good demand and import prices are equalized across regions. On the contrary, primary factors are taken to be mobile between sectors but not across regions which commands a different equilibrium rental rate associated with each primary factor in each region.

Figure 1: Definition of the Swiss Alps



2.2 Characterizing production sectors

Industries considered within each type of sectors are given in the following table.

Table 1: Industries considered within each type of sectors

Perfectly competitive sectors	Agriculture
	Food sectors
	Refined oil (fuel)
	Motor vehicles
	Manufacturing
	Other transport
	Services
Imperfectly competitive sectors	Road transport
	Rail transport

Perfectly competitive sectors

In all industries under perfect competition of the Swiss economy, agents are assumed to produce under constant returns to scale. They face markets that are perfectly competitive with free entry and exit. As a consequence, their price of output equals their marginal cost which makes profits impossible to earn for any activity.

Imperfectly competitive sectors

Transportation services in monopoly situation (supported by some restrictive practice as, for example, a governmental concession) are produced under increasing returns to scale at the firm level. More specifically, we assume the existence of setup costs of production and constant marginal costs[1]. When firms produce more output with the same fixed costs, there are rationalization gains as firms slide down their average cost curve. This specification requires that we obtain a measure of the extent of unrealized economies of scale. The cost disadvantage ratio (CDR) is customary used as an estimate of unrealized scale economies (de Melo and Tarr, 1992).

Monopoly pricing implies that firms maximizing their profits equate marginal cost to marginal revenues. In this case there are no pure profits or losses as the markup is determined such that it covers the fixed costs. However, the benchmark data show that both road and rail transportation sectors do not cover their fixed costs through optimal markups. Nevertheless, when we consider all the road transport revenues, the road fund realizes a pure profit due to taxes on fuel.

Industry transportation (both road and rail) supplies both passenger and freight services to other sectors of the economy and to households. One may think of passenger services provided to households while freight services destined to other sectors of the economy.

2.3 Modelling congestion

The model represents each region as a hypothetical one link system with homogeneous congestion conditions within each region but with heterogeneous congestion conditions across the two regions. The congestion function is based on the bottleneck model from Arnott, de Palma, and Lindsey (1993). Applied to our framework, it assumes that the route segment for peak period has a fixed capacity substantially smaller relative to traffic demand than for off-peak period. Only the road transport mode is subject to congestion. In each region a, we assume a unitary-elasticity relationship between the driving time and the volume of transport flow implying that a one percent increase in road transportation by any users produces a one percent decrease in the availability of road for all users. Mathematically, this is represented by the following congestion function:

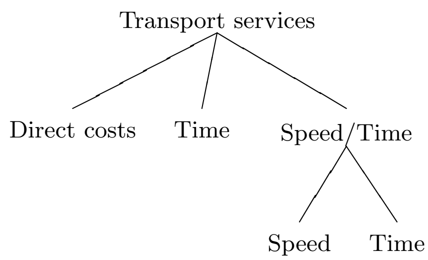
$$t_a \equiv \frac{1}{S_a} = \frac{\prod_u Z_{a,u}}{N_a\left(\bar{G}_a\right)} \tag{1}$$

where S_a is the speed, $Z_{a,u}$ is the quantity of road transportation services produced by user u (firms, households and transit), and N_a is the fixed road capacity. Transport capacity depends on the government's provision of road infrastructure, $\bar{G}_a$, which are assumed to fixed at the benchmark level.

The congestion function shows an increase in travel time as more transportation services are produced. In other words, as more people drive, the speed on the road goes down. The congestion function is introduced in the SwissTRANS model assuming that the supply of road speed is a public good available to both firms, households and transit. Road speed is substitutable with time meaning

[1]Graphically the average cost curve represents a rectangular hyperbole with average cost approaching asymptotic to marginal cost for high levels of output.

Figure 2: Congestion in transportation services



that when the speed falls, agents' own evaluation of speed increases inducing a substitution towards more time inputs to the provision of road transport. This is represented, in figure 2, on the lower level of the two-stage production function of transportation services. The upper level is a Leontief combination of this composite, direct costs and time cost of driving without congestion[2].

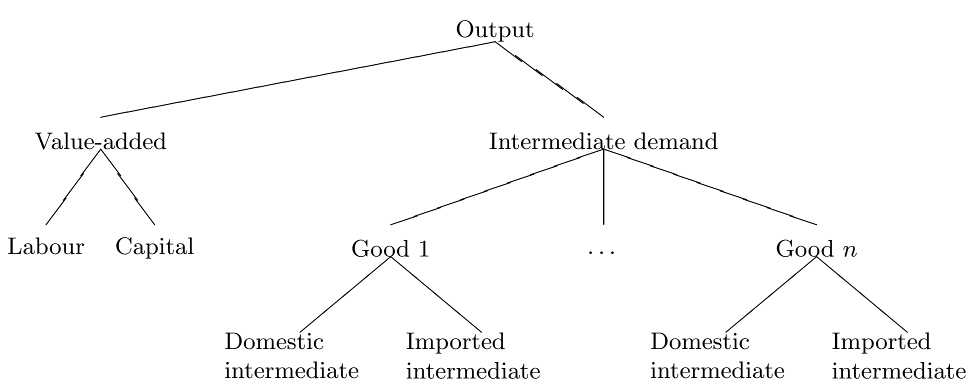
2.4 Structure of the SwissTRANS model

SwissTRANS is a comparative static computable general equilibrium model of Switzerland. Its general structure follows the Arrow-Debreu framework based on the neoclassical theory. It consists of industries and investors, households, foreigners and the national government.

2.4.1 Industries

The structure of production for each regional sector in perfect competition is depicted in figure 3. It provides a visual display of assumed constant returns-to-scale technologies.

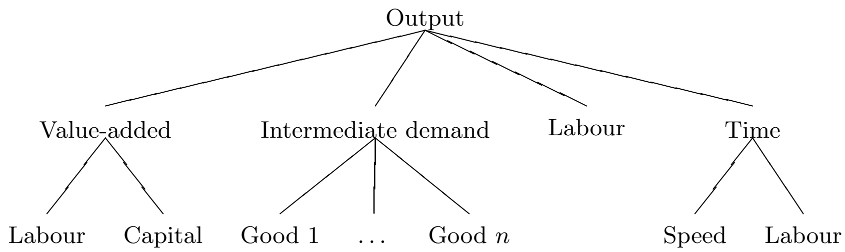
Figure 3: Regional production for sectors in perfect competition



Producers are assumed to maximize profits subject to their production technology represented by a three-stage production function. It is common to assume that the upper level is a Leontief combination of value-added and in-

[2]This representation of congestion originates from Tom Rutherford's CGE maquette on the GAMS mailing list in 1998.

Figure 4: Regional production for transportation services



termediate demand. There is thus no possibility for firms to substitute part of value-added with some intermediate inputs. On the intermediate level, all primary factors are combined using a constant elasticity of substitution (CES) function. Intermediate inputs on the other hand are used in fixed proportions (Leontief function). At the lower level, firms decide on the optimal mix of imported and domestic goods. This specification is known as the Armington approach according to Armington (1969).

The assumption of Leontief functions at the upper and intermediate levels implies that firms choose their optimal mix of primary factors (value-added) independently of the prices of intermediate inputs. Furthermore, intermediate demand is independent of both the prices of primary factors and the prices of intermediate inputs.

Regional sectors in imperfect competition concern the production of transportation services. Intermediate demand for transport services in other sectors may be considered as freight. As these services require time on the transportation mode itself, part of labour used in production is complementary to direct costs. The augmented production structure is shown in figure 4. In the case of congested transportation mode, a third complementary input is necessary to produce transport services. It is the additional time spent on the mode because of congestion which reduces the speed of travelling.

Industries in both perfect and imperfect competition are assumed to produce a single commodity. The good can however be destined for export or for local use, as represented in figure 5. The transformation of output into exports and domestic supply is governed by a constant elasticity of transformation (CET) function. It follows from the assumed input-output separability specification that the composition of inputs is independent of the composition of outputs.

Figure 5: Sectoral transformation in each region

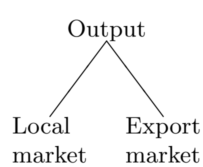
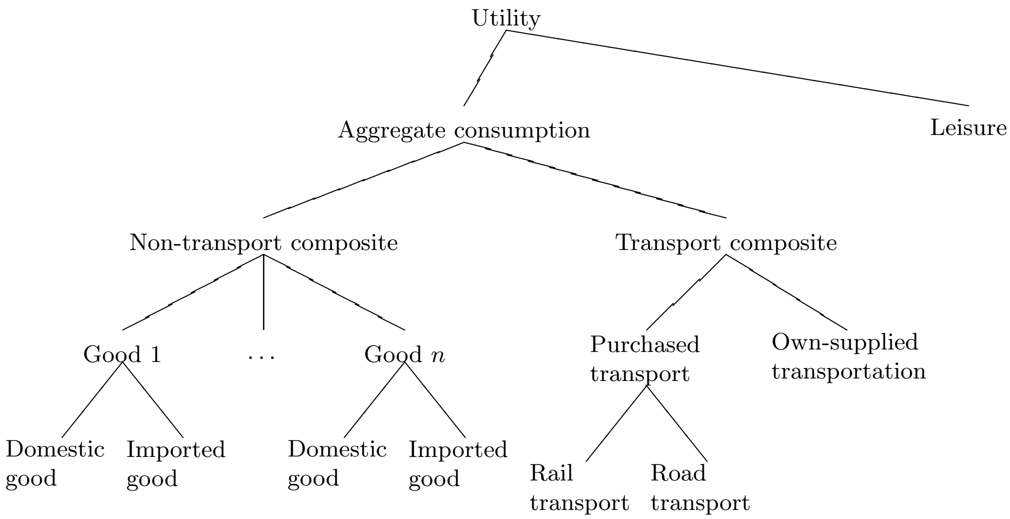


Figure 6: Utility for each regional household



2.4.2 Investors

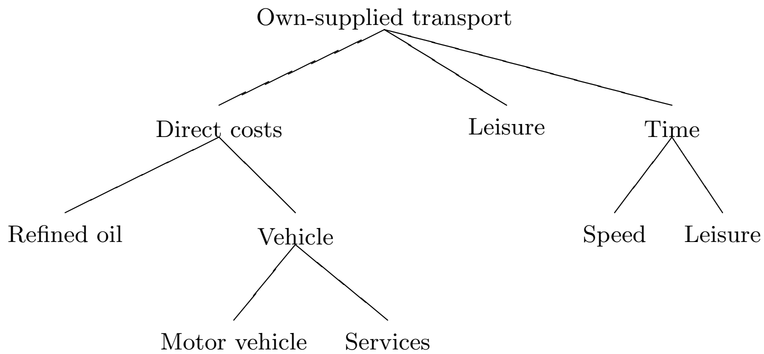
We assumed that investors behave in the same way as producers except to one difference. They do not use directly primary factors as inputs to capital formation. In other words, the structure of investment production is a particular case of the general production structure described above since investment output does not use primary factors. Investment output is thus assumed to represent a Leontief aggregation of market commodities. Each of these investment sector demand is defined by an Armington aggregation of domestic and imported inputs. The composition of investment sector inputs responds to relative prices. This defines a price index for investment composed by prices of the invested goods. Regarding the closure on investment, we assume that real aggregate investment is fixed at the base year level.

2.4.3 Households

Regional households are assumed to maximize an aggregated utility function subject to a budget constraint. The structure of consumer preferences in each region is represented in figure 6.

At the first stage, households are asked to make a trade-off between aggregate consumption (made possible by work) and leisure (time not allocated to work). They have thus to choose how much time they want to allocate between work and leisure. The former is considered as a source of disutility, and any time off work (leisure) as a source of utility. This specification allows us to endogenize the regional labour supply and thus to treat the labour tax as a distorting policy instrument. The second nest separates transportation services from other consumption goods. The non-transport composite is characterized by a trade-off across composite commodities, which allow for imperfect substitution between domestic and imported commodities in the final level. The transport composite makes the distinction between purchased transportation

Figure 7: Household-supplied transportation services



and own-supplied transportation. Purchased transport services (mainly passengers) combine rail transport with road transport, while household-supplied transportation concerns only private car transport. As in intermediate demand, rail and road transportation services are a composite of a domestic and an imported commodity.

Figure 7 illustrates the household-supplied transport nest. As in the transportation services produced by firms, own-supplied transportation services require direct costs and time. As the time available for households is embedded in leisure, part of it is used to drive on the road. The third input necessary to driving is a time composite capturing the congestion externality. As roads become congested, driving involves a larger leisure time spent on the road. Direct costs are aggregated from the consumption related to private cars of refined oil and a composite of motor vehicles (purchases of vehicles) and services (other operating costs) (Paltsev, Jacoby, Reilly, Viguier, and Babiker, 2004). Demand for these three commodities is an Armington aggregation of domestic and imported goods.

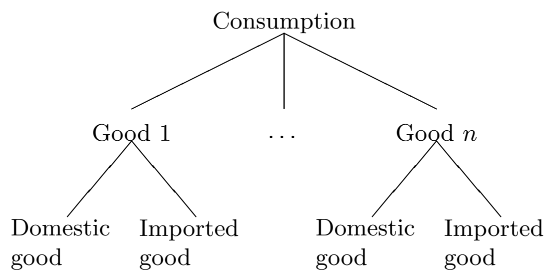
Primary factors are taken to be mobile between sectors but not across regions. In other words, perfect mobility of factors within each region means that migration occurs between sectors but not between regions. Consequently, there is an equilibrium rental rate associated with each primary factor for each region.

2.4.4 International trade

The idea behind the Armington approach to modelling import demand is to assume differentiated products. The assumption of product differentiation permits the model to match foreign trade with cross-hauling of trade (imports and exports of identical products) and avoids unrealistically strong specialization effects in response to exogenous changes in trade policy.

Given the fact that Switzerland is an open and small economy, world prices are treated as exogenous variables. Imports are imperfect substitutes for similar domestic commodities while exports and supply for the domestic market of a commodity are a joint product of domestic production. Transfers from and to

Figure 8: Public consumption in each region



the rest of the world are mainly composed of factor revenue and are fixed. At each period in time, the balance of the current account is imposed accounting for those transfers and an exogenously specified net capital outflow. The balance of payments equilibrium in simulations is obtained by permitting the real exchange rate to float.

Transit transportation is also part of the SwissTRANS model. It is defined as transportation services whose origination and destination are both abroad. Consequently they are not included in the calculation of the Swiss GDP as they are neither produced domestically nor imported from abroad to be consumed locally. Nevertheless, they are included in the model since they use the Swiss transportation networks and contribute to the production of Swiss external costs. We assume that the demand for transit transportation is represented by a constant elasticity function.

2.4.5 Government

Public consumption is characterized by the nested structure depicted in figure 8. There is indeed no possibility of substitution between sectoral commodities as they enter on a proportional basis in public consumption. The commodity composition of government consumption is thus exogenously determined. This reflects that the government allocates its budget between sectors independently from prices. However, substitution is introduced at the government demand level for both imported and domestically produced goods and services.

The level of real aggregate public consumption is assumed to be fixed at the base year level. The government income, on the other hand, is associated with taxes received from both direct and indirect taxation. Direct taxes are income tax on labour earnings and corporation tax on eligible capital earnings. Indirect taxes are (net) taxes less subsidies on production, import tariffs and taxes on consumption (VAT and excise duties). In a counterfactual scenario, the government budget is kept balanced assuming either lump-sum transfers between households and the government, or changes in the labour tax rate (see section 4.2).

3 Empirical Implementation

Empirical implementation of the SwissTRANS model requires three main types of data. The first type is an input-output table for Switzerland while the second type is appropriate values of second-order behavioural parameters, in particular elasticities of substitution. The last types of data are different kinds of shares allowing the regional disaggregation and the introduction of time in transport sectors.

3.1 Input-output table

The core input-output table is provided by the GTAP 6 database, which is based on the year 2001. The currency unit is the US dollar which is around 1.69 Swiss francs in 2001. Two adjustments are required to be able to use the data with the SwissTRANS model. The first is to distinguish between road (cars and buses) and railway transportation (trains and trams) in the land transport sector. The second adjustment is to extract the road infrastructure costs from the sector including public administration, defence, health and education[3]. For these two adjustments, shares of production are used to disaggregate both costs and revenues uniformly.

3.2 Behavioural parameters

Values for elasticities of substitution can not be observed from calibration to underlying data flows. They often result from econometric studies. The GTAP 6 database provides the source substitution or Armington elasticities (elasticities of substitution between domestic products and imports), and the factor substitution elasticities.

Regarding the elasticities of transformation between commodity produced for the domestic market and commodity destined for the export market, the GTAP 6 database does not give any information. As a consequence, the value is based on a similar model presented in Böhringer, Löschel, and Rutherford (2004). The same holds for elasticity of substitution for household-supplied transportation. In this case, we have drawn values from (Paltsev, Jacoby, Reilly, Viguier, and Babiker, 2004). The elasticity of substitution between aggregate consumption and leisure is drawn from (Wickart, Suter, and Nieuwkoop, 2002) as well as the own price elasticity for transit transportation.

An important behavioural parameter is the elasticity of substitution controlling the degree of mobility of goods and services between the Alpine region and the rest of Switzerland. We assume that both road and rail transportation services are much less mobile than the remaining commodities. This follows from the characteristic of this type of services which makes them to be highly differentiated products. A local trip in the Alpine region is not the same as a local trip in the rest of Switzerland, because the former is between Interlaken and Zermatt, whereas the latter is between Lausanne and Geneva.

[3]The rail infrastructure costs are already included in the railway transportation sector.

3.3 Additional data

The introduction of regions implies that we have to dispose of data for both regions in terms of production, investment, consumption, exports and public expenditure. Because of lack of data, we adopt a uniform approach across all the components of the GDP. Specifically we assume a uniform share based on the variable costs for the two transportation sectors[4] and based on GDP for all the remaining sectors.

Transportation services sectors are characterized by fixed costs, which are estimated by the cost disadvantage ratio. As we know the revenues generated by the mark up over marginal costs, we are able to determine the pure profits or losses.

The disaggregation of household transportation implies to know the shares of households expenditures allocated to their own-supplied transport services. These shares are based on Paltsev, Jacoby, Reilly, Viguier, and Babiker (2004). To account for the leisure component in the utility function, we assume a ratio of labour endowment to supply equal to 2.1 (Wickart, Suter, and Nieuwkoop, 2002).

Regarding the use of time in the production of transportation services, we assume that the market value of time spent in transportation is equal to 87% and 37% of the value of labour demand by firms for road and rail, respectively. For household-supplied transportation services, we assume that the market value of time spent in transportation is equal to 11% of the value of leisure consumed by households (Wickart, Suter, and Nieuwkoop, 2002).

Fraction of household-supplied transport time with congestion and fraction of transport time on transportation mode with congestion are both derived from Swiss statistical data and from (Suter and Lieb, 2006).

Speed valuation (marginal value of mode access) on produced transportation mode and for household-supplied transport is assumed to be equal to transport time costs with congestion.

4 Policy Scenarios

We propose a comparison on the effects in general equilibrium (with distorting pre-existing taxes) of two transport pricing policies: average cost versus marginal social cost. The first allows the budget equilibrium of the transport sector without the government intervention (potential source of distortions). The second makes it possible to increase the total welfare of the economy (less distorting policy instrument). The trade-off between these two transport pricing is the social loss (the average cost pricing) against the externality tax (the marginal social cost pricing).

We wonder about their reallocative effects within and redistributive effects between the two regions of the Swiss economy. Which of these two policies generates the higher regional welfare and total welfare ? Does differentiated

[4]The variable costs are approximated by the number of vehicle kilometres in the case of road and by the number of train kilometres in the case of rail.

Table 2: Macro Data in 2001 Benchmark (mio. of Swiss francs)

	Plain (P)	Alps (A)	Switzerland (CH)
Welfare (leisure incl.)	407'801	84'500	492'301
Welfare net of extern. costs	403'973	82'834	486'807
Aggregate consumption	235'141	48'650	283'790
Leisure	172'660	35'850	208'511
Real GDP	341'542	70'446	411'988
Consumption	212'592	43'971	256'563
Investment	67'246	13'773	81'020
Public expenditure	45'149	9'251	54'401
Exports	154'734	31'976	186'711
Imports	138'181	28'526	166'707

transport pricing for the Alps and the plain help to reduce transport-related pollution ?

Before we turn to the scenarios, we describe in few words the reference case which provides a benchmark which the different scenarios are applied to as counterfactual situations. It is followed by the two above-mentioned policy scenarios and two sensitivity scenarios.

4.1 The reference case

The calibration of a static model involves replicating an initial equilibrium which represents a benchmark for counterfactual scenarios. In the present case, the benchmark is the state of the Swiss economy for the year 2001.

4.1.1 The economy in Switzerland

Table 2 presents the main components of GDP in Switzerland whereas table 3 shows the disaggregation of production into the sectors considered in this study. As mentioned in section 3.3, production of transport services in the Alps are based on the share of infrastructure costs in this region, which amounts to 33% for both transportation modes. Regarding the remaining sectors, production in the Alps is based on the GDP and is equal to 17%.

Production is dominated in Switzerland by services (55%) and manufacturing (31%). Purchased transportation services represent only 4.6% of GDP. In terms of mode of transportation, road transport accounts for nearly three-quarter of purchased transportation (3.3% of GDP) which makes rail transport represent only one-quarter (1.3% of GDP).

4.1.2 The transport sector in Switzerland

The transport sector in Switzerland in terms of users is presented in table 4. The most important road user is the representative household consuming its own-supplied road transport (56% of road transportation). Time represents more and less the half of the production costs while direct costs are the remaining

Table 3: Production in 2001 Benchmark (mio. of Swiss francs)

	Plain (P)	Alps (A)	Switzerland (CH)
Agriculture	7'030	1'440	8'470
Food products	20'823	4'265	25'088
Petroleum, coal products	1'120	229	1'349
Motor vehicles and parts	17'193	3'521	20'714
Manufacturing	190'799	39'079	229'878
Road transport	19'755	4'634	24'389
Rail transport	7'127	2'129	9'256
Transport nec	8'367	1'714	10'080
Services	334'015	68'413	402'427

Table 4: Supply in 2001 Benchmark (mio. of Swiss francs)

	Plain (P)	Alps (A)	Switzerland (CH)
Road own-supplied transport	51'185	10'558	61'743
Road purchased transport	14'775	3'470	18'245
Road transit transport	20'983	4'928	25'911
Rail purchased transport	5'240	1'565	6'806
Rail transit transport	91	27	118

half. It also worthwhile to note that road transit represents approximately one-quarter of the total road traffic demand in Switzerland.

In terms of infrastructure-related charges, table 5 shows that rail purchased services has the highest markup over marginal costs among users. Track charges are the right instrument to use but nevertheless they are not high enough to cover the total infrastructure costs[5] (see table 7). On the other hand, the road sector has a very low coverage of its fixed costs with the transport-specific tax but still covers them with other transport-related taxes (e.g. other taxes in table 6 including annual vehicle tax and fuel tax).

Table 5: Markup over marginal cost in 2001 Benchmark (%)

	Plain (P)	Alps (A)	Switzerland (CH)
Road own-supplied transport	0.26	0.26	0.26
Road purchased transport	3.23	3.23	3.23
Road transit transport	0.92	0.92	0.92
Rail purchased transport	12.52	12.52	12.52
Rail transit transport	12.52	12.52	12.52

Markups for road purchased services are higher than for private cars and transit because they are mainly composed of heavy vehicle fees which better covers the infrastructure costs than the vignette.

Tables 6 and 7 present the road and rail accounts, respectively. These accounts are constructed using the UNITE methodology discussed in Link et al.

[5] More precisely, track charges are intended to cover only the variable part of the infrastructure costs, which we have assume to be 24% of the total infrastructure costs.

Table 6: Road Account in 2001 Benchmark (mio. of Swiss francs)

	Plain (P)	Alps (A)	Switzerland (CH)
Financial costs	5'671	1'330	7'001
Infrastructure costs	5'671	1'330	7'001
External costs	3'687	1'525	5'212
External accident costs	993	254	1'247
Air pollution	1'314	612	1'926
Global warming	964	206	1'170
Noise	416	453	869
Congestion time costs	860	149	1'009
Revenue	5'957	1'296	7'253
Infrastruct.-related taxes	771	177	948
Other taxes	5'186	1'119	6'305
Cost recovery ratio (%)	105	97	104

Table 7: Rail Account in 2001 Benchmark (mio. of Swiss francs)

	Plain (P)	Alps (A)	Switzerland (CH)
Financial costs	7'127	2'129	9'256
Infrastructure costs	3'125	934	4'059
Supplier operating costs	4'002	1'195	5'197
External costs	141	141	282
External accident costs	10	3	13
Air pollution	65	58	123
Noise	66	80	146
Revenue	4'512	1'348	5'859
Infrastruct.-related taxes	510	152	662
Other taxes	4'002	1'195	5'197
Cost recovery ratio (%)	63	63	63

(2000a) and applied to Switzerland in Link et al. (2000b).

In the benchmark, the financial cost coverage rate for Switzerland (ratio of revenue over financial costs) is above one for road transportation while it is nearly two-third in the case of rail transport. It means that the road sector generates more revenue than needed to cover its infrastructure costs, whereas the rail sector incurs a loss which has to be covered by the government budget.

4.1.3 The marginal external costs

The marginal external costs in terms of users are presented in tables 8 to 11. They are drawn from the deliverable 5 in the GRACE research project (Suter and Lieb, 2006).

As in production, the largest producer of road external costs is the representative household consuming its own-supplied road transport (table 8). However it generates proportionally more external costs than it produces transportation services (66% compared to 56%, respectively). In terms of congestion time costs (table 9), it is even higher as the share of own-supplied transport to total road user is 86%.

Table 8: Road External costs in 2001 Benchmark (mio. of Swiss francs)

	Plain (P)	Alps (A)	Switzerland (CH)
Own-supplied transport	2'509	923	3'432
External accident costs	850	214	1'064
Air pollution	693	305	998
Global warming	711	147	858
Noise	255	257	511
Purchased transport	889	455	1'344
External accident costs	108	30	138
Air pollution	469	232	701
Global warming	191	45	235
Noise	122	148	270
Transit transport	289	148	436
External accident costs	35	10	45
Air pollution	152	75	227
Global warming	62	14	76
Noise	39	48	88

Table 9: Road Additional costs in 2001 Benchmark (mio. of Swiss francs)

	Plain (P)	Alps (A)	Switzerland (CH)
Own-supplied transport	1'737	479	2'215
Infrastruct. marg. costs	983	361	1'344
Congestion time costs	753	118	871
Purchased transport	264	106	370
Infrastruct. marg. costs	183	83	266
Congestion time costs	81	23	104
Transit transport	86	34	120
Infrastruct. marg. costs	59	27	86
Congestion time costs	26	8	34

Table 10: Rail External costs in 2001 Benchmark (mio. of Swiss francs)

	Plain (P)	Alps (A)	Switzerland (CH)
Purchased transport	139	139	277
External accident costs	10	3	13
Air pollution	64	57	121
Noise	65	79	144
Transit transport	2	2	5
External accident costs	0	0	0
Air pollution	1	1	2
Noise	1	1	2

Table 11: Rail Additional costs in 2001 Benchmark (mio. of Swiss francs)

	Plain (P)	Alps (A)	Switzerland (CH)
Purchased transport	638	319	958
Infrastruct. marg. costs	638	319	958
Transit transport	11	6	17
Infrastruct. marg. costs	11	6	17

Table 12: Overview of the scenarios

Scenario	Pricing rule	Government budget neutrality rule
AC	Average cost: regionally non-differentiated ad-valorem markup over marginal cost and cost recovery per mode (i.e. road transport and rail transport)	Central case: labour income tax Alternative case: social security transfers
MSC.D	Marginal social cost: regionally differentiated ad-valorem markup over marginal cost (differentiation between the Alps and the rest of Switzerland)	Central case: labour income tax Alternative case: social security transfers
MSC.U	Marginal social cost: regionally uniform ad-valorem markup over marginal cost (no differentiation between the Alps and the rest of Switzerland)	Central case: labour income tax Alternative case: social security transfers
MC+	Marginal cost plus: internalisation of external costs on the top of the existing transport-related taxes and charges	Central case: labour income tax Alternative case: social security transfers

4.2 Overview of the scenarios

Policy scenarios represent possible strategies governments could adopt. We distinguish between two transport pricing policies[6]: average cost pricing and marginal social cost pricing. In addition we introduce two sensitivity scenarios which allow a better understanding of the policy scenarios. The first one is the marginal social cost pricing scenario but uniform across the Swiss regions. The second sensitivity scenario is the internalisation of external costs without abolishing the existing taxation.

All four policies will affect the government budget as the revenue from each tax instrument will change following the adjustment of prices in the new equilibrium. If the government budget is not balanced, then it is impossible to distinguish between a change in consumer welfare which is due to efficiency improvements and one which arise solely because the government is running a deficit. Therefore, in the long run welfare analysis is consistent only if the government budget is balanced. In this analysis we consider for each scenario two different recycling instruments by which the government achieves budget neutrality. The central instrument is the labour income tax as it is the most plausible to be used in reality. The alternative instrument is social security transfers, which we assume is a distortion-free lump sum transfer mechanism. As a consequence, the lump sum redistribution allows isolating the effect of the pricing scenarios on welfare as it does not have any impact on relative prices. In both recycling policies, we assume a proportional redistribution policy to either labour income in the case of the central instrument or to consumption in

[6]The instrument for representing transport pricing policy in the model is a markup over marginal costs (i.e. transport-specific tax over variable operating costs).

Table 13: Percent rate of Markup over marginal cost in Policy Scenarios

	AC -P	AC -A	AC -CH	MSC.D -P	MSC.D -A	MSC.D -CH
Road own-supplied transport	6.68	6.68	6.68	6.38	10.23	7.04
Road purchased transport	6.68	6.68	6.68	8.19	16.98	9.86
Road transit transport	6.68	6.68	6.68	6.92	10.95	7.68
Rail purchased transport	280.85	280.85	280.85	19.42	38.30	23.76
Rail transit transport	280.85	280.85	280.85	19.42	38.30	23.76

the case of the alternative instrument. An overview of the scenarios simulated in this study is given in table 12.

4.3 Average cost pricing

The first policy scenario introduces average cost (AC) pricing for the two transport sectors, namely the road and the rail sectors. AC pricing is defined here as covering the infrastructure costs at the national level with sector-specific revenue for each of the two transport sectors under imperfect competition. This means that each of the two transport sectors covers its own fixed costs in Switzerland (full earmarking) which implies that there is no cross-subsidization between transport modes.

The AC pricing scenario assumes specifically the following changes in policy instruments:

- All existing transport taxes in the two sectors are set equal to zero. For the road sector, it means that we abolish the annual vehicle tax, the fuel tax, the car import tax and the heavy vehicle fee as well as the vignette. For the rail sector, it implies the suppression of track charges;
- The profit related to the variable operating costs of road transport as well as the loss related to the variable operating costs of rail transport are put to zero; and
- The AC pricing is obtained in each of the two transport modes by a regionally undifferentiated ad-valorem markup (tax rate) over marginal costs (variable operating costs).

Columns 2 to 4 in table 13 reports the resulting markups in the policy scenarios where the labour income tax is used to achieve the government budget balance[7].

4.4 Marginal social cost pricing in Switzerland

4.4.1 Differentiated marginal social cost pricing in Switzerland

The second policy scenario concerns marginal social cost (MSC) pricing for both road and rail. The MSC pricing scenario is intended to make each transport

[7] Hereafter, A refers to the Alpine region, P to the rest of Switzerland (i.e. Plain) and CH to Switzerland.

user pay its marginal social cost. In other words, each different transport user pays not only for marginal operating and infrastructure costs but also for its marginal external costs such as accidents, congestion and environmental costs (air pollution, global warming and noise).

The MSC pricing scenario assumes in particular the following changes in policy instruments:

- All existing transport taxes in both the road and the rail sectors are set equal to zero;

- The profit related to the variable operating costs of road transport as well as the loss related to the variable operating costs of rail transport are put to zero; and

- The MSC pricing is introduced for each user in the two transport modes by a regionally differentiated ad-valorem markup (tax rate) over marginal costs (variable operating costs).

Columns 5 to 7 in table 13 report the resulting markups in the policy scenarios. They show the clearly different regime of taxation between the two regions. As the share of variable costs in the Alps are smaller than the share of external costs, this results in a marked differential in the tax rates between the Alps and the rest of Switzerland. Note that the high level of taxation in the Alps for road purchased services comes from trucks which are generating more external costs than private cars.

The MSC pricing is a Pigouvian tax that reflects the marginal external costs for each user. It is composed of an endogenous impact for congestion and of an exogenous impact for the remaining exterrnal effects. Therefore only congestion is really internalized through a feedback effect of congestion on transportation demand. Nevertheless, transport accidents, and environmental costs (air pollution, global warming and noise) have an impact on welfare through their respective exogenous marginal utility.

It should be stressed here that the MSC pricing scenario is not a Pigouvian optimal pricing scenario for two main reasons. The first is the lack of feedback effect of the accident and environmental externalities on producers and consumers decisions. More importantly, the second reason is that the level of taxation introduced in the simulations results in a sub-optimal solution for welfare as the Pigouvian tax does not respond to changes in quantities (in particular across regions).

4.4.2 Uniform marginal social cost pricing in Switzerland

The first sensitivity scenario is the MSC pricing scenario but applied uniformly across Switzerland. It assumes the government is not able to differentiate transportation services between the Alps and the rest of Switzerland and therefore imposes an identical MSC pricing in both regions. The same holds for the different users. The corresponding markups are given in columns 2 to 4 of table 14.

Table 14: Percent rate of Markup over marginal cost in Sensitivity Scenarios

	MSC.U -P	MSC.U -A	MSC.U -CH	MC+ -P	MC+ -A	MC+ -CH
Road own-supplied transport	7.67	7.67	7.67	4.91	7.59	5.36
Road purchased transport	7.67	7.67	7.67	6.89	14.47	8.33
Road transit transport	7.67	7.67	7.67	5.45	8.55	6.04
Rail purchased transport	23.76	23.76	23.76	3.46	11.59	5.33
Rail transit transport	23.76	23.76	23.76	3.46	11.59	5.33

Note that markup rates in the AC pricing scenario depend on the recycling instrument (i.e. labour tax or lump sum transfers). Nevertheless, as differences are relatively small, only markup rates the labour tax recycling instrument are reported here.

The non-differentiated MSC pricing scenario proposes to assess the potential advantages or disadvantage of the MSC pricing scenario differentiated across the Alps and the rest of Switzerland. It answers the question on the potential reduction of transport-related pollution in the Alps if users in this region are charged a higher rate than in the rest of Switzerland.

4.5 Existing taxation and internalisation of external costs

In the second sensitivity scenario, the objective is to evaluate the impacts on the economy when the government wants to charge users for external costs and congestion costs without lowering existing taxes and charges. This scenario has no theoretical justification. Nevertheless, it often appears in political discussions in which internalisation charges are proposed to be added on top of the existing taxation scheme. This scheme is thus considered as a politically feasible pricing scenario[8]. The result is a charge larger than the marginal external cost.

Specifically, this scenario assumes the following measures:

- All existing transport taxes in both the road and the rail sectors remain in place;
- The profit related to the variable operating costs of road transport as well as the loss related to the variable operating costs of rail transport are put to zero; and
- A regionally differentiated ad-valorem markup (tax rate) over marginal costs (variable operating costs) is introduced based on accidents, congestion and environmental costs (air pollution, global warming and noise).

The resulting markups for this sensitivity scenario are reported in columns 5 to 7 of table 14.

[8]The complete abolishment of fuel taxation present in the AC and MSC pricing scenarios is not considered as politically viable.

Table 15: Macro Results in Policy Scenarios with Labour tax (% deviation from benchmark)

	AC -P	AC -A	AC -CH	MSC.D -P	MSC.D -A	MSC.D -CH
Welfare (leisure incl.)	-0.34	-0.25	-0.33	0.53	0.08	0.45
Welfare net of extern. costs	-0.33	-0.14	-0.30	0.47	0.27	0.44
Aggregate consumption	-0.91	-1.00	-0.93	0.91	0.19	0.78
Leisure	0.44	0.78	0.50	0.01	-0.07	0.00
Real GDP	-0.80	-1.33	-0.89	0.08	-0.15	0.04
Consumption	-0.84	-0.83	-0.84	0.81	0.12	0.69
Exports	1.84	1.68	1.82	-0.60	-0.16	-0.52
Imports	2.75	3.91	2.95	0.37	0.38	0.37
Real Exchange rate	0.07	0.07	0.07	-0.23	-0.23	-0.23
Real price of Labour	-1.04	-1.36	-1.09	0.69	0.20	0.60
Real rental rate of Capital	-1.43	-1.76	-1.49	-0.52	0.45	-0.35

5 Results of the Simulations

The set of policy scenarios regarding the average cost and the marginal social cost pricing are simulated applying SwissTRANS[9]. We first introduce macroeconomic results while the subsequent sections present disaggregated results specific to the transport sectors. The final section reports the impact on production for the remaining sectors of the economy. Complementary results in terms of both the replacement instrument to balance the government budget and the sensitivity scenarios are reported in appendix A.

5.1 Macroeconomic impacts

The impacts of the two pricing scenarios on key macro variables are presented in table 15. The welfare measure is the most important indicator for assessing the overall impact of a proposed policy change. We distinguish two measures of welfare. The first measure is a function of aggregate consumption[10] and leisure (given on the third and fourth lines, respectively) while the second measure incorporates the negative external effects such as transport accidents and environmental costs (air pollution, global warming and noise). The former comes directly from the model itself[11] whereas the latter is computed on the base of transportation volumes resulting from the equilibrium.

Simulations of the two policy scenarios with the labour income tax as the

[9]The model's algebraic structure is formulated in a complementarity format, in which the general equilibrium of the economy is posed as a vector of market clearance, zero-profit and income balance equations (Mathiesen, 1985). It is numerically calibrated using the MPSGE subsystem (Rutherford, 1999) for GAMS (Brooke et al., 1998), and solved using the PATH solver (Dirkse and Ferris, 1995).

[10]Aggregate consumption is a composite of all consumption goods in addition of the time spent in household-supplied transportation and the speed necessary for driving on the road (measure of the congestion).

[11]In particular, we use an Hicksian money metric welfare index which corresponds to the Hicksian equivalent variation criterion. It allows us to know how much money consumers would need before a policy change to be as well off after the proposed policy change.

revenue-recycling instrument show that only the MSC pricing scenario is beneficial for Switzerland. The reason comes from the adverse impact of the AC pricing on rail transportation (table 17). This result clearly shows that balancing the financial part of the transport accounts should not be an objective per se as the accounts framework does not account for the loss of efficiency (due to increasing distortions in the economy) necessary to achieve that goal.

It is worthwhile to stress at this point that road transit is by far the main positive contributor to welfare for any scenario. Though road transit represents almost one-quarter of the total demand for road traffic in Switzerland, it contributes approximately to more than three-quarters in national welfare gains. Welfare gains from transit are basically a free lunch for Switzerland as domestic households benefit from foreign additional revenues without bearing the tax burden (pure income effect).

5.1.1 Average cost pricing

The macroeconomics impacts for the AC pricing scenario may be summarized as followed. As a result of the significant increase in rail transportation markups, the demand for primary factors decreases and hence their respective real price[12], which induces an increase in the demand for leisure. As marginal costs increase, domestic products are less competitive which implies an increase in imports. To restore the equilibrium in the balance of trade the real exchange rate increases which means that the Swiss franc depreciates. The depreciation of the real exchange rate encourages then exports. The real depreciation results in the larger increase in the demand for foreign exchange from imports than in the increase in supply of foreign exchange from exports, which together restore equilibrium in the balance of trade. The increase in rail transportation prices produces a higher living cost in Switzerland which implies a decrease in consumption. Overall the Swiss economy declines as translated by a negative real GDP.

From a regional point of view, there is no much difference between the Alpine region and the rest of Switzerland since the AC pricing scenario implies a uniform markup rate across the regions. Nevertheless, the welfare net of external costs is less negative in the Alpine region as the drastic reduction of rail transportation services allows cutting largely in the external costs.

The balancing of the government budget implies a decrease in the labour income tax in both scenarios mainly because of the transit revenue. The reduction is by 2.32% for the AC scenario while it is by 2.73% in the case of the differentiated MSC scenario. As a consequence, in the case of a redistribution to agents with social security transfers (table A-1), the negative change in welfare is amplified for the AC scenario whereas the positive change in welfare is diminished for the differentiated MSC scenario[13].

[12]Real prices in each region are defined as nominal prices deflated by the true-cost-of-living index in the corresponding region.

[13]This result follows from the implied assumption that the marginal cost of funds (MCF) for the labour income tax is greater than the MCF for the social security transfers (which is assumed to be one by definition).

5.1.2 Marginal social cost pricing

Turning to the differentiated MSC pricing scenario, one would expect that the internalisation of the external costs would make the households better off compared to the status quo. Although this is true in a partial equilibrium setting, this may not hold in a general equilibrium framework because of secondary effects (see section 4.4.1). This is however not the case in the present study as each region experiences a positive impact on welfare for the following reasons.

The high level of taxation in the Alps leads to a substantial decline in the production of transportation services, which results in a decline of the real wage and a increase in the rental rate of capital[14] (table A-1). It follows a shift of this production to the rest of Switzerland and thus inversely a rise in real wage together with a decline in the price of capital as relative net-of-tax production prices of transportation services raise in this region. When the revenue-recycling instrument is the labour income tax, the impact on real wage become positive in the Alpine region as the tax on labour income is reduced to keep the government budget balanced. Consequently the demand for leisure declines but aggregate consumption increases as the level of congestion is now lower. However the negative impact on the balance of trade outweighs the increase in consumption resulting in a negative real change in the Alpine GDP. In the rest of Switzerland, relative net-of-tax production prices of transportation services raise following the reallocation of these services from the Alps towards this region. Competitiveness relative to foreign markets thus declines leading to a drop in exports and an appreciation of the Swiss franc to restore equilibrium in the balance of trade. Nevertheless, the change in real GDP in this region is positive due to the significant increase in consumption.

The comparison of aggregate welfare between a uniform and a differentiated MSC pricing (tables 15 and A-4) shows that gains in terms of decreasing externals costs from different levels of taxation are sufficient enough to compensate for the efficiency loss resulting from the differentiated level of taxation between the Alpine region and the rest of Switzerland. As expected, in terms of regional impacts, it leads to a low positive impact on Alpine welfare with a substantial amelioration when adding the benefit of the reduction of the negative externalities (respectively 0.08 and 0.27 in table 15). On the other hand, the impact on welfare for the rest of Switzerland is high with a modest reduction when including the external effects (respectively 0.53 and 0.47 in table 15).

It should be noted at this point that redistribution policy matters a lot. The current underlying assumption is a proportional redistribution to either labour income or to consumption. When we introduce however redistribution concerns across both the Alps and the rest of Switzerland, regional welfare distribution may change substantially. In particular, the assumption of a uniform redistribution in the case of social security transfers results in a net welfare for

[14]This result is known as the Stolper-Samuelson Theorem, which is the proposition of the Heckscher-Ohlin Model that a decrease in the relative price of a good (here the net-of-tax production price of transportation services) lowers the real price of the factor used intensively in that industry (here labour is accounted for 77% in the road sector and 75% in the rail sector) and raises the real price of the other factor (here capital is accounted for 23% in the road sector and 25% in the rail sector).

Table 16: Real price of Supply in Policy Scenarios with Labour tax (% deviation from benchmark)

	AC -P	AC -A	AC -CH	MSC.D -P	MSC.D -A	MSC.D -CH
Road own-supplied transport	-2.26	-2.57	-2.32	-1.29	-0.21	-1.10
Road purchased transport	-3.93	-4.16	-3.97	-5.17	1.14	-4.32
Road transit transport	5.62	5.28	5.57	5.43	9.47	6.19
Rail purchased transport	202.33	201.36	202.16	2.30	16.18	3.97
Rail transit transport	205.15	204.19	204.98	4.64	19.16	7.92

the Alpine region twice as high as in the rest of Switzerland. National welfare is of course identical to a proportional redistribution policy.

Simulation of the pricing scenario consisting in adding external costs on top of the existing taxation (table A-4) shows no change in welfare for the Alpine region when the revenue-recycling instrument is the labour income tax. When social security transfers are used to balance the government budget, the impact is however negative. Consequently, raising road transport prices (table A-5) above marginal social costs may increase welfare, if the revenue from transport pricing is used to cut existing distortionary taxes[15].

5.2 Impacts on transport prices, transport demand and external costs

Given the financial cost coverage rates observed in the initial equilibrium, the AC pricing scenario implies a reduction in the overall taxation on road transport and a substantial increase in the overall taxation on rail transport. As a result, the money price of domestic car and truck transport falls, while that of train increases considerably (table 16). The price for road transit transport increases because transit cars and trucks do not pay the annual vehicle fees and are assumed not to refuel in Switzerland, which means that they do not benefit fully from the abolishment of existing taxes[16].

In terms of impacts on the transport demand (table 17), the AC pricing scenario leads to a significant drop in rail transport services and a small reduction in road transport services with the exception of road purchased transport which rises. The reason comes from the very high level of rail prices inducing a model shift from rail to road in purchased transport which reduces then the competitiveness of own-supplied transportation (see figure 6 for the nesting of the transport composite in the utility function).

Under the MSC pricing scenario, all existing taxes related to operating costs are abolished and each transport user pays its marginal social cost, which means that markups are different not only regionally but also with respect to transport users. The consequence of this policy in the Alpine region is an

[15]Similar results have also been derived in a partial equilibrium framework (Cretegny, Springer, and Suter, 2007).

[16]Our results suggest therefore a conservative view of the positive change in welfare as the demand for transit would not be as negative as it is in the present case and thus would imply an increase in the transit revenue.

Table 17: Volume of Supply in Policy Scenarios with Labour tax (% deviation from benchmark)

	AC -P	AC -A	AC -CH	MSC.D -P	MSC.D -A	MSC.D -CH
Road own-supplied transport	-1.58	-2.56	-1.75	1.67	0.38	1.45
Road purchased transport	11.29	10.66	11.17	18.21	-22.52	10.46
Road transit transport	-1.04	-1.03	-1.04	-1.07	-1.77	-1.21
Rail purchased transport	-78.87	-78.85	-78.86	6.56	-51.32	-6.75
Rail transit transport	-15.26	-15.26	-15.26	-0.73	-2.65	-1.17

increase in prices for both modes except own-supplied transport. The latter user sees a reduction in its price because the abolition of the annual vehicle fees and the fuel tax is enough for compensating the Pigouvian tax[17]. Similarly, in the rest of Switzerland, the money price of domestic car and truck transport falls. The opposite applies for rail transport as the existing taxation is low. It is also the case for road transit transport since they do not fully benefit from the abolishment of existing taxes.

The general increase in transport prices in the Alps reduces the demand for transport for all users but own-supplied transport which increases as its price declines. Following the shift in production towards the rest of Switzerland, the domestic demand for transport increases in this region. At the same time, there is a modal shift from rail to road as the latter is more competitive. The demand for transit transport declines for both modes since transit through Switzerland becomes more expansive.

At this point it is interesting to compare the MSC pricing scenario with the political scenario which consists in charging transport users for external costs and congestion costs without lowering existing taxes. The impact on national transport volumes of this latter policy[18] is a modal shift from road to rail transport as the price of road transportation is more expansive than the price of rail transportation (table A-6). Though this is the case at the regional level, there is also a shift of the transportation services from the Alps towards the rest of Switzerland. As a consequence, rail transport increases significantly in this region.

Tables 18 and 19 show how the policy scenarios affect the total marginal external costs of transport for each user. Given the shift from both rail transport and road own-supplied transport towards road purchased transport in the AC pricing scenario, the external and additional costs generated by the latter user increase while the ones resulting from the other transport users decline.

Regarding the MSC pricing scenario, the impacts on marginal external costs for each user is similar to the AC pricing scenario in the sense that changes in external costs are isomorphic to changes in transport volumes. In other words, a rise in transport volume implies an increase in external costs and conversely,

[17]The level of the price change is also sensitive to the fuel price elasticity. As we assume a lower bound of the long run elasticity, our results represent thus a conservative view of the positive change in welfare.

[18]This scenario corresponds to the current Swiss transport policy strategy which aims at the ferroutage of the transalpine traffic.

Table 18: Real value of External costs in Policy Scenarios with Labour tax (mio. of Swiss francs)

	AC -P	AC -A	AC -CH	MSC.D -P	MSC.D -A	MSC.D -CH
Road own-supplied transport	2'461	893	3'355	2'565	932	3'496
Road purchased transport	986	500	1'487	1'057	355	1'411
Road transit transport	285	145	430	287	146	433
Rail purchased transport	29	29	58	148	68	216
Rail transit transport	2	2	4	2	2	5

Table 19: Real value of Additional costs in Policy Scenarios with Labour tax (mio. of Swiss francs)

	AC -P	AC -A	AC -CH	MSC.D -P	MSC.D -A	MSC.D -CH
Road own-supplied transport	1'703	463	2'167	1'775	484	2'259
Road purchased transport	292	117	409	313	83	396
Road transit transport	84	34	118	85	34	119
Rail purchased transport	134	67	202	684	156	840
Rail transit transport	9	5	14	11	5	16

a decline in the demand for transport lowers the external costs. This is also true for the additional costs such as congestion time costs.

5.3 Impacts on transport account figures

Transport accounts are an important monitoring instrument as they allow summarising all financial as well as non-financial transport costs and revenues into a simple table. However they are not suitable for a correct cost-benefit analysis since they do not include all elements necessary to the determination of social welfare. This point can be illustrated by the fact that the AC pricing scenario would be a better policy in terms of cost recovery compared to the MSC pricing scenario as the aggregated cost recovery ratio on the road and rail modes for the former is by definition one whereas it is only 0.89 for the latter. Our measure of welfare indicates however a negative performance for the AC pricing scenario and a positive impact for the AC pricing scenario.

The AC pricing scenario ensures a financial cost coverage ratio of one only for Switzerland as a whole. The consequence for road is a cross-financing of the Alpine region's infrastructure costs by the rest of Switzerland. This comes from the fact that the Alpine share of road own-supplied transport is lower than the one of purchased and transit transport. As Alpine shares for rail are identical among users, the cost recovery ratio is one for each of the regions.

The impact of the AC pricing scenario on the costs and revenues for road transportation results from two opposite effects. On the one hand, road purchased transport raises but on the other hand the use of private cars decreases. This translates into a reduction in infrastructure costs as people tend to travel more in buses than in private cars, and into an increase of external costs as trucks are substituted to rail transportation. It is also interesting to note that

Table 20: Road Account in Policy Scenarios with Labour tax (mio. of Swiss francs)

	AC -P	AC -A	AC -CH	MSC.D -P	MSC.D -A	MSC.D -CH
Financial costs	5'284	1'235	6'519	5'184	1'177	6'360
Infrastructure costs	5'284	1'235	6'519	5'184	1'177	6'360
External costs	3'732	1'538	5'272	3'908	1'433	5'341
External accident costs	988	250	1'238	1'032	249	1'281
Air pollution	1'350	624	1'975	1'417	563	1'980
Global warming	970	205	1'176	1'015	198	1'213
Noise	424	459	884	444	423	866
Congestion time costs	854	147	1'001	892	145	1'037
Revenue	5'359	1'160	6'519	5'666	1'870	7'535
Infrastruct.-related taxes	5'359	1'160	6'519	5'666	1'870	7'535
Cost recovery ratio (%)	101	94	100	109	159	118

Table 21: Rail Account in Policy Scenarios with Labour tax (mio. of Swiss francs)

	AC -P	AC -A	AC -CH	MSC.D -P	MSC.D -A	MSC.D -CH
Financial costs	3'359	1'000	4'360	7'229	1'361	8'590
Infrastructure costs	2'520	750	3'271	3'084	796	3'880
Supplier operating costs	839	250	1'089	4'144	565	4'710
External costs	31	31	62	151	70	221
External accident costs	2	1	3	11	1	12
Air pollution	14	13	27	70	29	98
Noise	15	18	32	71	40	110
Revenue	3'359	1'001	4'360	4'962	789	5'752
Infrastruct.-related taxes	2'520	751	3'271	818	224	1'042
Other taxes	839	250	1'089	4'144	565	4'710
Cost recovery ratio (%)	100	100	100	69	58	67

both external accident costs and congestion time costs decrease while other environmental costs increase. The reason comes from the marginal cost per vehicle-kilometre, which is larger for passengers than for freight in the case of accident and congestion and inversely for the other environmental externalities.

Regarding the rail account, the higher prices lead to a rise in infrastructure-related taxes but also to a significant drop in financial costs due to the considerable decline in demand for rail transport.

Turning to the MSC pricing scenario, the road account shows a decline in external costs and congestion costs for the Alpine region while it reports a rise in these costs for the rest of Switzerland. Changes in external costs and congestion costs are similar for the rail account. However, because of the modal shift from rail to road occurring in the rest of Switzerland, the national impact differs accordingly. In other words, external costs and congestion time costs decline at the national level for rail transport while they increase for road transport.

The rationale for this unanticipated result is that changes in national prices imply a secondary burden which significantly alters the economic implications of the primary regional policy. In other words, applying higher transport taxes in the Alpine region increases not only the alpine price of transportation but also the national domestic price. As a result part of the tax burden is shifted to the rest of Switzerland through the demand for transport. In addition the shift in the provision of transport services from the Alpine region towards the rest of Switzerland implies that the Pigouvian taxes rates do not correspond any longer to the external costs caused by transport users. This is true in particular for road transport which explains why external costs and congestion costs increase in the MSC pricing scenario.

Concerns of policy makers for external costs and congestion cost can motivate a deviation from theory-based MSC pricing if compensation policy instrument is aimed at reducing pre-existing distortions (table A-4). Net welfare is in this case positive and external costs as well as congestion costs decline in Switzerland for both rail and road transport modes. The introduction of environmental taxes without abolishing the current taxation scheme (in particular the fuel tax) is similar indeed to cross-subsidizing the railway sector by road transport.

5.4 Sectoral effects

As a result of the defined pattern of different pricing scenarios, applied general equilibrium models are able to identify expanding and contracting sectors as well as the magnitudes of these changes. Under the assumption that total employment and aggregated capital is constant within each region, a mixture of expansions and contractions at the industry level in employment and capital occurs in each region.

The AC pricing scenario reduces efficiency in sectors affected by rail transport taxes[19], which contracts the demand for labour and capital, and hence the output of final goods in the corresponding sectors. As primary factors are mobile across industries, wages and rental rates of capital decline which leads to a reallocation of these factors towards the more efficient sectors. This implies lowering their marginal costs and thus an expansion of their production.

Regarding the MSC pricing scenario, the relative high level of taxation in the Alps (compared to the rest of Switzerland) on both the road and rail modes does not affect the remaining sectors in this region. The reallocation of primary factors implies thus a significant decline in production only for these two sectors. As transport taxes in the rest of Switzerland are relatively lower than in the Alps, part of the production of transportation services moves which increases real wages and reduces return to capital as demand is used intensively in these productions. Since existing transport taxes are abolished, production of road transport services experiences the largest increase, which expands in turn the other transportation modes and the food sector[20]. The petroleum sector expands due to the increase in own-supplied transport, which demands

[19] Rail transport is obviously part of the affected sectors but other industries such as transport nec (water and air transport), motor vehicles, foods products and agriculture are also included as their respective share of rail transport in production is not negligible.

[20] Ttransport nec and food products use respectively 14% and 7% of road transport as input in their production.

Table 22: Volume of Production in Policy Scenarios with Labour tax (% deviation from benchmark)

	AC -P	AC -A	AC -CH	MSC.D -P	MSC.D -A	MSC.D -CH
Agriculture	-2.85	-2.71	-2.83	-0.04	1.05	0.15
Food products	-4.80	-4.73	-4.79	0.23	2.11	0.55
Petroleum, coal products	2.89	2.88	2.89	9.15	9.11	9.15
Motor vehicles and parts	-3.48	-3.39	-3.46	-1.66	-0.27	-1.42
Manufacturing	3.13	3.40	3.18	-1.64	1.18	-1.16
Road transport	8.10	7.61	8.01	13.25	-16.36	7.62
Rail transport	-52.47	-52.46	-52.47	4.36	-34.13	-4.49
Transport nec	-10.15	-9.98	-10.12	0.44	6.33	1.44
Services	-0.28	-0.12	-0.25	-0.57	1.71	-0.18

accounts for 34% of the aggregate demand for petroleum.

6 Conclusion

Reforming transport policy plays an important role in current political discussions as policy makers face increasing unsolved environmental issues. Simulation of different transport pricing scenarios in an economy-wide perspective suggests the following policy recommendations:

Environmental policies are beneficial for both the Alpine region and the rest of Switzerland A change from the current pricing regime in transport towards a marginal social cost pricing scheme is beneficial for both the Alpine region and the rest of Switzerland. Though the impact is rather limited in terms of welfare, the policy debate should be oriented in this direction. Our results suggest for example that a transport pricing policy aiming at charging users for external costs without lowering existing taxation may also be welfare improving as long as the recycling of transport tax revenues is used to reduce distortions of existing taxes.

Regional transport and redistribution policies matter The differentiation in the case of MSC pricing is justified with the argument of differences in external costs in the Alps and in the rest of Switzerland. Though the welfare loss is significant for the Alpine region, we find that differentiation of tax rates across both regions compared to a uniform taxation does improve national welfare, but not significantly. Nevertheless, an appropriate redistribution policy may increase existing welfare gains in the Alpine region without harming too much the rest of Switzerland.

Cost recovery considerations are negative for all regions in Switzerland Average cost pricing is usually justified when the intervention of the government in balancing its budget creates more distortions than the pricing itself. Our negative estimates of social welfare show clearly that this may not be applied to transportation in Switzerland and therefore cost recovery in transportation should not be an objective per se.

Additional transport revenues should aim at reducing current distortionary taxes Changes in transport charges and taxes cause changes in revenues raised in the transport sector. As expected, the recycling of transport revenues towards lowering the distortions of existing taxes such as the labour income tax is welfare improving. Though this effect is rather limited in the case of AC and MSC pricing scenarios because of low additional revenues, it does significantly and positively alter the conclusions in the case of the politically-feasible transport policy as it generates substantial additional revenues.

Appropriate pricing of transit transport contributes significantly to the Swiss welfare Due to the geographical position of Switzerland, road transit represents a significant share of total traffic demand. It is therefore by far the main positive contributor to welfare gains in any scenario under consideration as domestic households benefit from foreign additional revenues without bearing the tax burden.

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A Complementary Results

A.1 Policy scenarios with lump sum transfers

Table A-1: Macro Results in Policy Scenarios with Lump-sum tax (% deviation from benchmark)

	AC -P	AC -A	AC -CH	MSC.D -P	MSC.D -A	MSC.D -CH
Welfare (leisure incl.)	-0.36	-0.27	-0.34	0.50	0.05	0.42
Welfare net of extern. costs	-0.35	-0.15	-0.32	0.45	0.25	0.41
Aggregate consumption	-1.05	-1.14	-1.07	0.72	0.00	0.60
Leisure	0.59	0.93	0.65	0.19	0.11	0.18
Real GDP	-0.90	-1.43	-0.99	-0.05	-0.28	-0.08
Consumption	-1.00	-0.99	-1.00	0.61	-0.08	0.49
Exports	1.72	1.56	1.69	-0.72	-0.28	-0.64
Imports	2.61	3.76	2.81	0.24	0.25	0.24
Real Exchange rate	0.28	0.28	0.28	0.03	0.03	0.03
Real price of Labour	-1.26	-1.58	-1.32	0.41	-0.08	0.32
Real rental rate of Capital	-1.29	-1.61	-1.34	-0.35	0.62	-0.18

Table A-2: Real price of Supply in Policy Scenarios with Lump-sum tax (% deviation from benchmark)

	AC -P	AC -A	AC -CH	MSC.D -P	MSC.D -A	MSC.D -CH
Road own-supplied transport	-2.26	-2.57	-2.31	-1.30	-0.22	-1.12
Road purchased transport	-3.71	-3.93	-3.74	-4.88	1.45	-4.03
Road transit transport	5.86	5.52	5.80	5.70	9.75	6.47
Rail purchased transport	200.93	199.97	200.76	2.58	16.50	4.26
Rail transit transport	203.73	202.79	203.57	4.91	19.47	8.20

Table A-3: Volume of Supply in Policy Scenarios with Lump-sum tax (% deviation from benchmark)

	AC -P	AC -A	AC -CH	MSC.D -P	MSC.D -A	MSC.D -CH
Road own-supplied transport	-1.58	-2.56	-1.75	1.65	0.35	1.43
Road purchased transport	11.07	10.46	10.96	17.90	-22.72	10.18
Road transit transport	-1.04	-1.04	-1.04	-1.07	-1.77	-1.21
Rail purchased transport	-78.63	-78.62	-78.63	6.36	-51.43	-6.93
Rail transit transport	-15.17	-15.17	-15.17	-0.73	-2.65	-1.17

A.2 Sensitivity scenarios with labour tax

Table A-4: Macro Results in Sensitivity Scenarios with Labour tax (% deviation from benchmark)

	MSC.U -P	MSC.U -A	MSC.U -CH	MC+ -P	MC+ -A	MC+ -CH
Welfare (leisure incl.)	0.47	0.47	0.47	0.35	0.00	0.29
Welfare net of extern. costs	0.43	0.41	0.43	0.36	0.24	0.34
Aggregate consumption	0.81	0.80	0.81	0.59	0.06	0.50
Leisure	0.00	0.03	0.00	0.02	-0.08	0.00
Real GDP	0.09	0.10	0.09	0.24	0.01	0.20
Consumption	0.77	0.78	0.77	0.91	0.28	0.80
Exports	-0.56	-0.56	-0.56	-0.13	0.22	-0.07
Imports	0.33	0.33	0.33	0.67	0.65	0.67
Real Exchange rate	-0.39	-0.39	-0.39	-1.43	-1.43	-1.43
Real price of Labour	0.63	0.59	0.62	0.44	0.11	0.39
Real rental rate of Capital	-0.45	-0.48	-0.46	-1.37	-0.68	-1.25

Table A-5: Real price of Supply in Sensitivity Scenarios with Labour tax (% deviation from benchmark)

	MSC.U -P	MSC.U -A	MSC.U -CH	MC+ -P	MC+ -A	MC+ -CH
Road own-supplied transport	-0.42	-0.20	-0.38	3.57	4.38	3.71
Road purchased transport	-5.93	-5.80	-5.91	1.89	8.16	2.78
Road transit transport	6.02	5.97	6.01	2.90	5.98	3.48
Rail purchased transport	5.30	5.27	5.30	-8.20	-2.13	-7.22
Rail transit transport	7.79	7.76	7.79	-8.26	-2.05	-6.85

Table A-6: Volume of Supply in Sensitivity Scenarios with Labour tax (% deviation from benchmark)

	MSC.U -P	MSC.U -A	MSC.U -CH	MC+ -P	MC+ -A	MC+ -CH
Road own-supplied transport	1.07	0.89	1.04	-2.42	-3.17	-2.55
Road purchased transport	14.64	13.26	14.37	-2.82	-31.89	-8.35
Road transit transport	-1.21	-1.20	-1.21	-0.84	-1.38	-0.94
Rail purchased transport	-9.19	-9.18	-9.19	23.75	-20.39	13.60
Rail transit transport	-1.20	-1.20	-1.20	1.10	0.11	0.87

A.3 Sensitivity scenarios with lump sum transfers

Table A-7: Macro Results in Sensitivity Scenarios with Lump-sum tax (% deviation from benchmark)

	MSC.U -P	MSC.U -A	MSC.U -CH	MC+ -P	MC+ -A	MC+ -CH
Welfare (leisure incl.)	0.43	0.44	0.43	0.25	-0.10	0.19
Welfare net of extern. costs	0.40	0.38	0.39	0.27	0.15	0.25
Aggregate consumption	0.60	0.58	0.60	-0.05	-0.57	-0.14
Leisure	0.21	0.24	0.21	0.65	0.56	0.64
Real GDP	-0.05	-0.05	-0.05	-0.19	-0.43	-0.23
Consumption	0.54	0.54	0.54	0.21	-0.42	0.11
Exports	-0.70	-0.69	-0.70	-0.54	-0.20	-0.48
Imports	0.18	0.18	0.18	0.20	0.19	0.20
Real Exchange rate	-0.09	-0.09	-0.09	-0.56	-0.56	-0.56
Real price of Labour	0.30	0.26	0.29	-0.53	-0.86	-0.59
Real rental rate of Capital	-0.26	-0.29	-0.27	-0.80	-0.12	-0.69

Table A-8: Real price of Supply in Sensitivity Scenarios with Lump-sum tax (% deviation from benchmark)

	MSC.U -P	MSC.U -A	MSC.U -CH	MC+ -P	MC+ -A	MC+ -CH
Road own-supplied transport	-0.43	-0.22	-0.40	3.60	4.43	3.74
Road purchased transport	-5.60	-5.47	-5.57	2.95	9.29	3.85
Road transit transport	6.34	6.29	6.33	3.81	6.92	4.40
Rail purchased transport	5.64	5.61	5.64	-7.32	-1.20	-6.34
Rail transit transport	8.12	8.09	8.12	-7.43	-1.17	-6.01

Table A-9: Volume of Supply in Sensitivity Scenarios with Lump-sum tax (% deviation from benchmark)

	MSC.U -P	MSC.U -A	MSC.U -CH	MC+ -P	MC+ -A	MC+ -CH
Road own-supplied transport	1.05	0.87	1.02	-2.54	-3.32	-2.68
Road purchased transport	14.28	12.95	14.03	-3.62	-32.48	-9.11
Road transit transport	-1.21	-1.20	-1.21	-0.84	-1.38	-0.94
Rail purchased transport	-9.39	-9.38	-9.39	22.89	-20.95	12.81
Rail transit transport	-1.20	-1.20	-1.20	1.10	0.11	0.87