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Effects from consistent internalization of external effects from transport and manufacturing – a CGE analysis for Sweden

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Abstract: This paper uses a static, small open-economy computable General Equilibrium (CGE) model of the Swedish economy to study the effects of consistent internalization of external effects from transport and manufacturing. We look at eight policy scenarios: first a fully implemented Social Marginal Cost Pricing (SMCP) in manufacturing, sea and air transport, road transport, and rail transport; and then SMCP in these sectors separately or in various combinations. We evaluate effects on, among others, national and global emission reductions, GDP, government budget, and social welfare. The results show that the fully implemented SMCP in all sectors generates the highest social welfare surplus, largest emission reduction and largest government net revenue. When this option is not feasible, society still could benefit from correcting prices in or more sectors. Correcting prices only for rail transport generates very small social welfare surplus, emission reduction and government revenue; while correcting prices only for road transport generates much larger effects in all aspects. Taking into consideration that sea and air modes are regulated not only by domestic legislation, the findings from this study suggest that the second-best policy scenario could be to correct prices for the rail, road and manufacturing sectors.

Keywords: social marginal cost, externalities, transport taxation, CO_2 taxation, general equilibrium.

JEL Classification: C68; H23; R48

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1 Introduction

Freight transport grows worldwide and contributes significantly to the increase of global green-house gas (GHG) emissions. Policy instruments such as fuel taxes, distance-based transport charges (km-taxes), road and track user charges, port and sea route charges, etc. are used and/or considered in many countries as means to reduce GHG emissions and other externalities from transport. On the other hand CO_2 emissions from manufacturing are also charged through various instruments such as the EU Emission Trading System, energy and electricity taxes, carbon dioxide (CO_2) taxes, etc. However, the mechanisms, interactions, and effects of these instruments are not obvious to understand because of the complexity of the dynamic and interactions between different sectors of an economy.

A policy instrument can affect emission levels from both transport and manufacturing directly and indirectly no matter which sector this instrument is implemented on, because transport is one of the key inputs of production. What's more, the shifts in transport demand from policy reforms affect the cost of energy (and/or electricity) economy wide (not just in the transport sector), which could also affect manufacturing production level.

Hence the supply side-oriented transport sector models that are used in national infrastructure planning (for instance, the Swedish-Norwegian Samgods model) are not sufficient, and a general equilibrium model is necessary, to understand the question – how do these instruments that are designed to internalize externalities from transport and manufacturing affect emissions, the macroeconomic variables, transport demand, social welfare, and government revenue; and to help to find a cost-efficient GHG emission reduction policy.

Previous economy-wide computable CGE models used for climate policy analysis often lack some of the detail needed for analyzing important features of transport pricing in small open economies (like most EU countries), either because transport is not described with enough detail (separating different modes of transport) or because foreign trade is not modeled in a realistic way. The combination of both these features is essential to recognize the potential effects of SMCP. This paper enriches a CGE model (SAINT4) coded for the Swedish economy by disaggregating the transport sector, and uses this model to study the effects of SMCP. Eight policy scenarios are studied:

1) remove tax subsidies for manufacturing industry
2) remove tax subsidies for sea and air transport

3) increase infrastructure charges for road transport
4) increase infrastructure charges for rail transport
5) combine 1), 2), 3) and 4)
6) combine 2), 3), and 4)
7) combine 1), 3), and 4)
8) combine 3) and 4)

The results show that the most efficient policy is to correct prices in all sectors; this generates the largest welfare effects, emission reductions, and yields the largest tax revenue. Correcting prices only in rail transport generates small government revenue, emission reduction effects and social welfare effects; while correcting prices only in road transport generates larger effects in all perspectives. When combining correcting prices of several sectors or transport modes, the more sectors or transport modes involved, the better off the society is.

The rest of the paper is organized as follow: chapter 2 introduces the background, chapter 3 presents the CGE model and the results, and chapter 4 concludes the study.

2 Background

Transport accounts for 13.8 percent of the annual global GHG emissions (WRI, 2005), and 26 percent of global CO_2 emissions. In Sweden, transport is the only sector that fails to show any substantial reduction of CO_2 emissions in any year between 1990 until 2005 (the decrease of total CO_2 emissions in Sweden during this period is close to 7 percent). On the contrary, transport sector's CO_2 emission is more than 10 percent higher in 2005 than in 1990, and has grown from being 32 percent of Sweden's total CO_2 emissions in 1990 to 38 percent in 2005. The main explanation for the increasing emissions is a dramatic increase in road haulage (Vägverket, 2008a).

The EU has adopted a dual approach to tackle CO_2 emission externalities, EU ETS and emission taxes. EU ETS covers emissions from the emission intense industry such as energy generating installations, iron and steel works, and factories making pulp, paper, glass, etc. The CO_2 emissions from the other sectors are subject to carbon taxes. For the transport sector, the carbon tax is within the frame of energy tax. The tax is a combination of carbon parity and taxes to compensate other externalities. At the same time, there are several other transport policy instruments such as congestion taxes, infrastructure charges, etc., together with fuel

taxes, covering SMC from transport such as congestion, noise, accident, operating costs and wear and tear of infrastructure. Table 1 shows how each sector is subjected to the policy instruments mentioned above.

Table 1 Climate and transport policy instruments used for different sectors in Sweden.

	EU ETS industry		non EU ETS industry		Transport				Households
	Energy generating industry	Other EU ETS industry	Manufactured goods	Services	Road	Rail	Sea	Air	
EU ETS	X	X							
Fuel tax			L	H	H	H			H
Electricity tax			L	H	H	L	H	H	H
Infrastructure usage charge						L			

Note: X indicates that EU ETS is implemented, L indicates that a lower tax-rate is used while H indicates that a higher tax-rate is used.

The heat and electricity generation industries are subject to EU ETS but not carbon taxes. Fuel tax rates are differentiated across sectors. Road transport, rail transport, households, and services are subject to fuel tax at a higher rate, manufacturing is subject to a lower fuel tax rate, while sea transport and air transport are exempted from fuel tax. Electricity tax rates are differentiated across sectors as well. Manufacture and rail transport pay at a lower electricity tax level, while road transport, sea transport, air transport, services and households are charged at a higher electricity tax level. (REF!!)

It has been shown that the most efficient tax system is a system that equalizes marginal costs for society, with uniform tax rates across sectors and without tax exemption (Bruvoll and Larsen 2004, Johansson 2006). In a recent report on the consequences of raising track use charges, The Swedish Transportation Administration (2011) (STA) calculates the cost of externalities, other than noise and congestion, from road and rail transport and the current rates of internalization from existing taxes and charges. STA finds the internalization degree to be 101, 50, 58, and 18 percent, for cars, trucks, passenger trains, and freight trains, respectively. Based on estimates of average operation costs[3], this implies that full internalization of truck and train operations would in both cases require a 25 percent increase of the operation cost. We will therefore study the effects of removing tax exemptions from manufacturing, sea and air transport, and increasing charges for road and rail by 25 percent.

[3] From personal communication with Lena Wieweg, VTI.

3 CGE-analysis

3.1 The model

The model used in this study is a static, small open-economy Computable General Equilibrium (CGE) called SAINT4, calibrated with a Swedish Social Accounting Matrix from 2005 (Bohlin 2010a). Since the focus of our study is on transportation we have a more disaggregated transport sector than in previous versions of this model, while energy inputs are more aggregated. This version of the model includes 18 industries producing 27 commodities. SAINT is based upon the small open economy assumptions: Sweden is thus assumed to be able to import and export unlimited amounts at fixed world market prices. International trade is modelled with the Armington/CET assumptions (Armington 1969), i.e. imports are assumed to be imperfect substitutes for domestic production and exporting is assumed to be an imperfect substitute for selling domestically. Labour supply is assumed constant regardless of the real wage.

In all simulations that we conduct with this model, internal and external equilibrium are achieved by adapting the household's marginal propensity to save. Government real consumption is fixed, as well as all tax rates that are not subject to the policy. Therefore government saving will change. From the change of government saving we are able to evaluate the ability of the different reforms to raise revenue. In the balance of payments, foreign saving is fixed. Investments are also fixed in quantities, meaning that household savings are adjusted as much as needed to finance investments when prices of investments goods and government saving are changing. This is the Ricardian equivalence assumption, i.e. when government saving increases households do not need to save that much and will increase consumption. The increase in household consumption and the increase in government saving are therefore two sides of the same coin. EV (add def here!!) of household consumption could be used as a single welfare measure of the reforms since that also includes the increase in government saving.

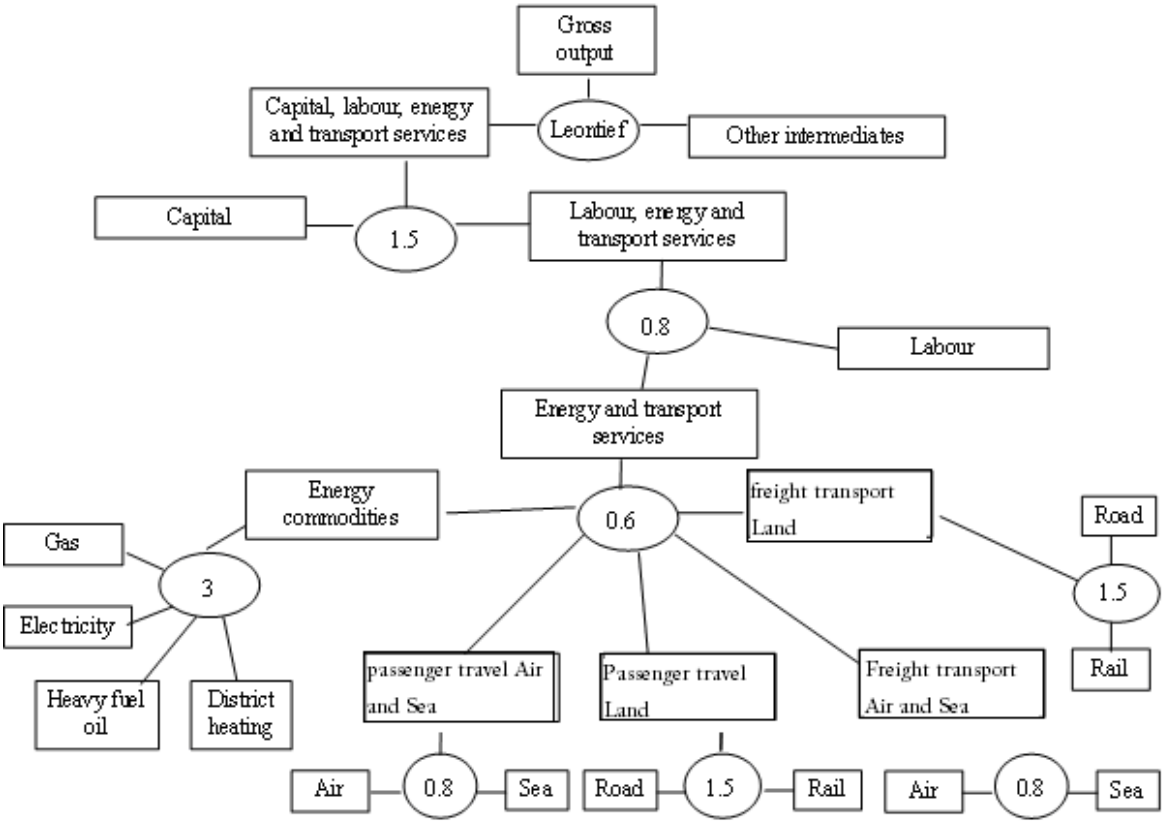
[4] SAINT ha a special way of modelling taxes and trade margins that makes it suitable for analyses of unit taxes and similar policy instruments for details se Bohlin 2010a.

The main motivation for holding foreign savings and domestic investment fixed is to simplify evaluation of the welfare effects. If the accumulation of foreign and domestic assets all welfare effects will come through changes in household consumption and emissions. A drawback of this is that we cannot analyse the ability of the Swedish economy to attract foreign capital.

3.1.1 Production functions

The production functions in the model are nested CES functions (Figure 1). At the top level output is a combination of capital, labour, energy, transport services and other intermediate goods. Other intermediates consist of all intermediate goods except energy and transport services and are assumed to be used in fixed proportions to output, i.e., under Leontief technology. Transports and energy commodities are divided into five commodity groups. The first group consists of *energy commodities*, the second of person transports by air or sea, the third of person transports by rail or road, the fourth of freight transport by air or sea, and the fifth of freight transports by rail or road.

Figure 1 Nest structure of the production functions.



The numbers in the ellipses refer to the elasticity of substitution between each aggregate.

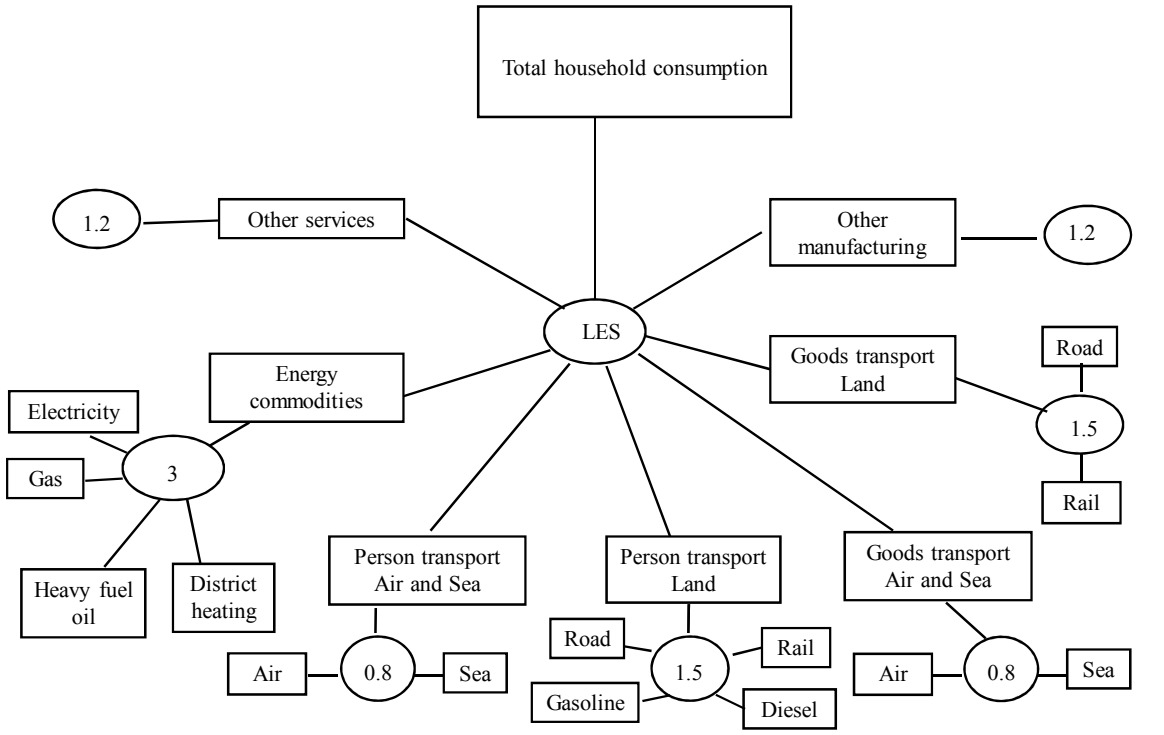
Choosing a set of reasonable elasticities for the CGE model cannot be based solely on econometric estimates, as these are derived from historical data and specific contexts. There are also severe problems of endogeneity when estimating elasticities. In Figure 2.1 the numbers refer to the elasticities of substitution and are assumed to be the same in all industries at the referred level. The following assumptions regarding substitution possibilities in the model have been made: Labour and energy are assumed to be easy to substitute with capital in the long run. In the long run it should be even easier to substitute between different kinds of heating systems. However, it is assumed to be more difficult to substitute between labour and energy. In a literature review, Viert et al. (2010) find empirical estimates over the elasticity of substitution between rail and other transport modes within a wide range between 0.5 and 4. According to these authors the most reliable studies are found in a more narrow interval between 0.9 and 1.7. We further assume it to be easier to substitute between rail and road than between the other transport modes and therefore use 1.5 for that elasticity. Finally we set the elasticity to 0.6 between different groups of transports and 0.8 between air and sea, assuming that it is more difficult to substitute between these modes. Since air and sea transports are rarely used for short distance transports. Moreover, there are larger differences between air and sea transports in terms of time and cost per tonne then between road and rail transports.

3.1.2 Household consumption

There is one representative household in the model. Consumer behaviour is described in Figure 2. It is modelled as a LES-CES (add Def here!!) nested system with a LES system at the top aggregating together seven commodity groups. Within these seven aggregates substitution is modelled with CES equations. Since the elasticity of substitution between the six different commodity groups is probably fairly low, the Frisch parameter has been set to achieve a relatively high proportion of subsidiary consumption[5].

[5] In a LES system some parts of the consumption of every commodity are fixed, the so called habit or subsidiary consumption, while the rest of the consumption have fixed proportions of the part of the expenditure that is not used for subsidiary consumption. (Deaton, A & Muellbauer, J, 1980) The Frisch parameter determines the share of subsidiary consumption.

Figure 2 Nest structure of the household demand functions.



The numbers in the ellipses refers to the elasticity of substitution between each aggregate. The commodities in other services and other manufacturing are not specified in the figure

3.1.3 Modelling emission trading and carbon emission

The price of CO_2 permits is exogenously given. This follows from the small open economy assumption that the domestic economy cannot influence world market prices. Unlike the previous version of the model[6] we here assume that the initial distribution of permits does influence behaviour in firms. This version of the model is thus more close to the real EU ETS system, where exiting plants do not keep their permits and entrants may receive permits. The values of the distributed permits are taken into account when capital are reallocated between industries, that is for decisions about exit and entry.

Carbon emissions from domestic production are calculated from the changes in the use of diesel, gasoline, fuel oil and gas. [7] Total domestic emissions of CO_2 are equal to 38 million tonnes in the base model, i.e., about 60 percent of actual emissions. The divergence could be explained by errors in data and the fact that not all sources of CO_2 are taken into account.

[6] Bohlin 2010a.
[7] For details about the calculation of carbon emissions see Bohlin 2010b.

Since emission of CO_2 is calculated from taxes actually paid, tax evasion and firm-specific tax reductions may explain part of the divergence[8].

To calculate direct carbon leakage a global model is needed. Since the reallocation of production, which the tax exemptions are supposed to prevent, has an impact on indirect leakages only, the results will be unaffected by the fact that direct carbon leakage is ignored. The impact on world market prices of fossil fuels from an increase in the production of energy-intense goods would be the same regardless of in what part of the world the production is increased.

To calculate indirect carbon leakages through international trading commodities not included in the EU ETS, it is assumed that foreign consumption of different commodities is not affected by developments in Sweden. Therefore, the changes in net trade of different commodities are used as a measure of the imposed change in foreign production. This can be considered as an upper bound of the change in foreign production under the assumptions that all adjustments in foreign countries are on the production side. By making assumptions about technologies abroad, the emissions changes can be calculated due to a change in net trade. In our study, Swedish technology is assumed for all non EU ETS-commodities. We include both direct emissions in the production of the good and indirect emission from the production of intermediate inputs.

For the commodities included in EU ETS, we assume that carbon leakage is equal to 100 percent. That would be the case if reduced production in Sweden leads to a similar increase from firms within the European Union that buy the allowances that the Swedish firms can sell.[9] Total emissions are calculated as the sum of domestic emissions, carbon leakage from EU ETS industries and carbon leakage from non-EU ETS commodities.

3.2 Policy Scenarios

[8] We study the industry specific reductions of energy taxes; within each industry there are also some firms getting even higher reductions due to extra energy intensity in their production.

[9] This way of modelling assumes that there is no policy response due to changes in the price of the permits. If cost efficiency is an issue when designing climate policy, policymakers would be more willing to decrease the total quota if the price of the permits is reduced compared to the Pigovian taxes used in other sectors. In that case carbon leakage in EU ETS industries would be less than 100 percent since a reduction in the permit price will lead to reductions of the total quota.

Table 2 describes the current energy tax rates in Sweden. These are used as the base scenario.

Table 2 Unit tax rates on energy in base model

Tax item	Agric. fishing and mining	Manu-facturing	Electricity and gas	Transports				Households & Services
				rail	road	Water	Air	
Jet fuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel oil, SEK[10]/litre	0.55	0.55	1.20	3.40	3.40	0.00	0.00	3.40
Gasoline, SEK/litre	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Diesel, SEK/litre	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88
GAS, SEK/litre	0,41	0,41	0,50	2.19	2.19	2.19	2.19	2.19
Electricity, SEK /kWh	0.005	0.005	0.24	0.03	0.24	0.24	0.24	0.24

Source: Own calculations.

The policy scenarios are shown in Table 3. Scenarios 1, 2, 3 and 4 are used to evaluate the effect of four policy instruments separately: removing tax exemption from the manufacturing sector; removing the tax exemption from sea and air transport; increase of road infrastructure charges; and increase of rail infrastructure charges. Scenario 5 is used to study the general equilibrium first-best scheme, which charges SMC to all sectors including manufacturing sector and all transport modes. Scenario 6 includes the first-best transport tax scheme, which combines tax increases in the sea, air, road and rail sectors. Scenario 7 is used to study the effect of combining scenarios 1, 3 and 4 together. Finally, scenario 8 includes a second-best transport tax scheme, where road and rail sectors are charged according to their SMCs.
The tax changes for transport modes are intended to reflect potential changes as part of a tax reform intended for full internalization of the external cost of transport. As described in Chapter 2, the full internalization of truck and train operations would in both cases require a 25 percent increase of the operation cost. Therefore this is the magnitude of the tax increases used for these two modes. Notice that noise and congestion costs are excluded, which means that the increase required for full internalization is underestimated, probably in particular for rail traffic.

Table 3 Scenario description.

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7	Scenario 8
Removing tax exemptions on fossil fuel for **primary se**ctors, manufacturing electricity and gas	×				×		×	

[10] 1 SEK = 0.1 EUR.

Removing tax exemptions on fossil fuel for **sea and air** transports	×			×	×		
Increasing **road** infrastructure charge to SMC level		×		×	×	×	×
Increasing **rail** infrastructure charge to SMC level			×	×	×	×	×

Table 4 shows the domestic, global emission reduction effects and the amount of carbon leakage of each scenario. Table 5 shows the effects of these scenarios on the variables such as GDP, equivalent variation (EV), gross real wage, and capital return change.
Table 6 is a Cost-Benefit accounting list comparing welfare gains and losses for each scenario; i.e., including changes of the cost of externalities. Table 7 shows the effects of these scenarios on government revenues.
Table 8 compares Table 6 to Table 4 to calculate the costs for society for each unit of emission reduction.
Table 9 shows the effects of these policy scenarios on transport performance.

The results show that the first-best scenario policy, i.e., scenario 5, generates the largest social welfare. Even though accounting the relatively large carbon leakage both to EU ETS industries and through trade to non-EU ETS commodities, scenario 5 still generates the largest global emission reduction effects among all eight policy scenarios, due to the very large domestic emission reductions (a reduction of 7200 thousand tones CO_2 emissions, or 19 percent of the domestic emission reductions). Scenario 5 also generates relatively large government revenue.

The results indicate that society benefits by correcting prices from one sector/ transport mode, leaving the price distortions in other sectors/ transport modes, except in the case of rail charges. Table 4 shows that all scenarios except scenario 4 generate positive social welfare. In the Swedish context, since Sea and Air pricing policy cannot be changed only by domestic decisions, the second-best policy is then scenario 7, correcting prices of manufacturing, road and rail transport. This generates the second largest social economic surplus, a rather large emission reduction effect, and relatively large government revenue.

In all the policy scenarios EV is reduced (Table 5). Scenario 2 has the lowest domestic emission reduction cost (0.27 SEK EV for per kg CO_2 reduction); and scenario 1 has the lowest global emission reduction costs among all scenarios (1.23 SEK EV for per kg CO_2 reduction).

Scenario 4 represents a recent policy proposal: to increase track-use charges for rail to reduce externalities and generate revenue within this sector. We can use scenarios 4, 3, 8 and 7 to see the differences of effects between only increasing the charges for rail (scenario 4), only increasing the charges for road (scenario 3), increasing charges for both road and rail (scenario 8), or an alternative that also removes the tax subsidies for manufacturing (scenario 7). We find that combining road and rail infrastructure charge (scenario 8) yields a slightly larger emission reduction effect than correcting prices only for road (scenario 3), but a much larger emission reduction effect than correcting prices only for rail (scenario 4). And moreover, the cost in terms of consumer surplus lost per CO_2 reduction is considerably higher in the latter alternative. Scenario 7 has the largest effects on reducing transport work in all modes compare to scenario 8.

Table 4 Effects on CO_2 emission reduction (thousand tones).

CO_2 emissions	**Base**	**Scenarios**							
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Domestic emission	37847	-4300	-1491	-1719	-38	-7200	-2849	-5887	-1765
Carbon leakage from EU ETS industries		2817	-143	311	82	2857	299	2906	381
Carbon leakage through trade in non EU ETS commodities.		-628	1346	235	-57	884	1079	-143	198
Impact on global emissions		-2111	-288	-1173	-13	-3458	-1471	-3124	-1186

Table 5 effects on macroeconomic variables.

Economic variables	Base	Scenarios							
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Billion SEK	Changes from base in %							
National income. deflated by CPI	2742	-0.45	-0.11	-0.39	-0.10	-1.06	-0.59	-0.94	-0.49
GDP. Deflated by GDP deflator	2756	-0.16	-0.05	-0.13	-0.01	-0.35	-0.19	-0.31	-0.15
Equivalent Variation	1353								
Change EV / household consumption		-0.19	-0.03	-0.16	-0.04	-0.44	-0.23	-0.39	-0.18
Gross real wage		-0.71	-0.19	-1.41	-0.26	-2.55	-1.84	-2.36	-1.67
Capital return		-0.52	-0.22	-1.03	-0.19	-1.95	-1.40	-1.74	-1.22

Note: CPI is a price index with the cost shares in the base model household's consumption as weights while GDP deflator is the price index of domestic production in the model.

Table 6 Effects on social welfare (billion SEK).

Variable	Scenarios							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
EV	-2.60	-0.40	-2.12	-0.48	-5.95	-3.08	-5.34	-2.48
Consumer surplus total	-2.60	-0.40	-2.12	-0.48	-5.95	-3.08	-5.34	-2.48
Less infrastructure externalities[11]	0.04	0.03	0.22	0.22	0.51	0.47	0.49	0.46
Increased traffic safety[12]	0.10	0.19	1.28	-0.03	1.52	1.39	1.37	1.27
Less CO_2 emissions[13]	4.30	1.49	1.72	0.04	7.20	2.85	5.89	1.77
Externalities, total	4.44	1.71	3.22	0.23	9.23	4.71	7.75	3.50
Total social economic surplus	1.84	1.31	1.10	-0.25	3.28	1.63	2.41	1.02

Note: The value of less infrastructure damage and increased traffic safety are calculated using the traffic work changes for the rail and road transport (both passenger and freight). And the value of less CO_2 emissions is calculated using the total domestic emission reductions that are reported in.

[11] Operation, maintenance and reinvestment costs are included in infrastructure externalities. 0.0258 SEK/tonne-km and 0.0263 SEK/passenger-km are used for rail freight and passenger infrastructure externalities calculation. 0.0537 SEK/tonne-km and 0 SEK/passenger-km are used for road freight and passenger infrastructure externalities calculation. (Source: own calculation based on Trafikverket 2011).

[12] 0.0020 SEK/tonne-km and 0.0074 SEK/passenger-km are used for rail freight and passenger infrastructure externalities calculation. 0.0215 SEK/tonne-km and 0. SEK/passenger-km are used for road freight and passenger infrastructure externalities calculation. (Source: own calculation based on Trafikverket 2011).

[13] Recommended Swedish valuation of 1 SEK/kg CO_2 (Trafikverket 2011) is used.

Table 7 Effects on public costs and revenues (billion SEK).

Variable	Scenarios							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Commodity tax revenue change	3.02	1.33	18.29	2.65	25.02	22.38	23.85	21.19
Other tax revenue change	-7.23	-2.09	-12.83	-2.42	-24.58	-17.16	-22.52	-15.31
Government consumption change	3.93	1.08	5.23	1.30	11.52	7.48	10.48	6.57
Public costs and revenues, total	-0.28	0.33	10.69	1.53	11.97	12.70	11.80	12.44

Table 8 Cost of per unit of emission reduction in EV terms (SEK).

Variable	Scenarios							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
EV / Domestic emission reduction	0.61	0.27	1.23	12.40	0.83	1.08	0.91	1.41
EV / Global emission reduction	1.23	1.38	1.81	37.16	1.72	2.09	1.71	2.09

Table 9 Changes in transport work (percentage).

Variable	Scenarios							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Rail – passenger	-1.75	0.12	3.69	-28.52	-26.86	-25.79	-26.85	-25.77
Rail – freight	-2.42	0.21	5.01	-27.74	-25.46	-23.88	-25.48	-23.89
Road - passenger	-0.77	-1.51	-9.84	0.46	-11.40	-10.39	-10.25	-9.44
Road – freight	-0.95	-1.31	-12.55	0.62	-13.82	-12.76	-12.87	-11.97
Sea - passenger	3.34	-20.41	-7.40	0.30	-23.32	-24.09	-4.99	-7.19
Sea – freight	5.88	-19.93	-11.98	0.24	-24.91	-24.03	-10.27	-12.04
Air - passenger	-0.19	-3.81	-2.31	-0.25	-6.46	-6.07	-2.83	-2.57
Air – freight	-0.32	-1.52	-3.54	-0.37	-5.64	-5.07	-4.34	-3.92

4 Conclusion

In this paper, the effects from more efficient pricing of externalities from manufacturing and freight transport on emission reduction, macro-economy variables, social welfare and government budget have been studied. The first-best policy scenario (correcting externalities from manufacturing sector and all transport modes in transport sector) generates the highest social welfare surplus, emission reduction, government net revenue. Correcting prices on only the rail market and not others generates a small social welfare surplus, a small emission reduction effect, and little revenue. The net revenue accounts for 58 percent of the total revenue collected from increasing rail charges. Taking into consideration that sea and air modes are not regulated only by Swedish domestic decisions, the findings for this study suggest that the second-best policy scenario is to correct prices for the rail, road and manufacturing sectors. The results of this paper show that a pricing system can have large effect on transport demand at relatively lower cost. Before drive in the large scale of new infrastructure, it is worthwhile to study carefully the options of optimizing pricing system. A detailed regional implication with a spatial CGE model is needed.

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