Outcomes of a Swedish Kilometre Tax.

An Analysis of Economic Effects and Effects on NOx Emissions[Ψ]

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Summary in Swedish

Konjunkturinstitutet (KI) har analyserat konsekvenser av en svensk kilometerskatt ur ett övergripande samhällsekonomiskt perspektiv. Resultaten visar att effekterna på den ekonomiska tillväxten blir 0,1 till 0,3 procent lägre sett över hela perioden 2006-2020. Undersökningen visar också att en kilometerskatt medför en strukturomvandling som innebär att verksamheter där lastbilstransporter står för en stor del av produktionskostnaderna missgynnas medan de som gynnas är sådana sektorer där kostnadsandelen för lastbilstransporter är liten och/eller sådana sektorer som tillverkar högt förädlade varor. Analysen visar också att kilometerskatten leder till minskade utsläpp av kväveoxider (NOx) och att utsläppen minskar mer än BNP i procentuella termer, d.v.s. en frånkoppling (s.k. decoupling) mellan tillväxt och utsläpp. Resultaten indikerar att decoupling är starkare vid lägre kilometerskattesatser och om tekniskt utveckling mot renare motorer kan förväntas. Utsläppsminskningarna av NOx sker dels inom tillverkningsindustrin som en följd av att produktionen minskar och därmed också transportbehovet, dels inom transportsektorn där godstransporter minskar på väg samtidigt som de ökar inom sjöfarten. Utsläppsminskningarna, om man bortser från att lastbilsflottan blir renare fram till 2020, uppgår till mellan 630 och 1260 ton, vilket endast utgör ett litet bidrag till uppfyllandet av det nationella målet som är att minska NOx-utsläppen till 148 000 ton år 2010 jämfört med de cirka 205 000 ton som Sverige totalt släppte ut år 2005. Lastbilsflottan kan dock förväntas bli renare, dels som en följd av normal föryngring, och dels som en effekt av att en kilometerskatt stimulerar till tidigareläggning av fordonsinköp men också som en effekt av att renare lastbilar används. Dessa effekter är antagligen avsevärt större än den direkta effekten av byte till andra transportslag. När vi även räknar med att kilometerskatten leder till en betydande modernisering av lastbilsparken kan man nå upp till nio gånger så stor reduktion av de totala NOx-utsläppen.

BAKGRUND

Bakgrunden till KI:s studie är dels det principförslag om införande av en svensk kilometerskatt för tunga lastfordon som läggs fram i Vägtrafikskatteutredningens slutbetänkande *Skatt på väg* (SOU 2004:63), och dels den oro som finns för att viss industri kommer att missgynnas om kilometerskatten införs. Denna oro har specifikt nämnts i den transportpolitiska propositionen *Moderna transporter* (Prop. 2005/06:160) som ett argument emot införande av kilometerskatt, och har föranlett två olika regeringsuppdrag. Det första *Kilometerskatt för lastbilar. Effekter på näringar och regioner* (SIKA Rapport 2007:2) avslutades mars 2007 och det andra (Regeringsbeslut 2007-09-13; Fi2007/2023) påbörjades i september 2007 och skall vara färdigt 15 december 2007.

Enligt Vägtrafikskatteutredningen kan en kilometerskatt motiveras av att den bättre tydliggör och prissätter de samhällsekonomiska kostnader, som lastbilstransporter ger upphov till i form av utsläpp (av kolmonoxid, kolväten, kväveoxider och partiklar), vägdeformation, buller och olyckor, än befintlig styrning via fordonsskatt och dieselskatt. Genom kilometerskatten stärks därmed motiven till att leta efter alternativa transportlösningar som medför lägre externa kostnader. Det kan ske genom ökad användning av lastbilar som har låga utsläpp och som sliter mindre på vägbanan, samt genom en ökad användning av andra transportslag. I ett bredare transportpolitiskt perspektiv utgör en kilometerskatt, enligt Vägtrafikskatteutredningen, också ett sätt att bidra till en större konkurrensneutralitet för gods på väg i Sverige, genom en rättvis konkurrens mellan svenska och utländska åkare.

Föreliggande studies huvudsakliga resultat baseras på en analys med KI:s allmän jämviktsmodell EMEC (Environmental Medium term EConomic), vilken nyligen utvecklats (Östblom & Berg, 2006) för att bättre än tidigare kunna analysera transportpolitiska styrmedel såsom exempelvis en kilometerskatt. Resultat från EMEC kompletterar också resultat från partiella jämviktsanalyser (Hammar et al 2008; Swedish EPA 2007) av konsekvenser av kilometerskattens införande. De viktigaste kompletteringarna utgörs av (1) en kvantifiering av utsläppsförändringar (en delmängd av de samhälleliga intäkterna), (2) effekter på ekonomin som helhet av olika genomsnittliga kilometerskattesatser och (3) en uppskattning av strukturförändringarnas omfattning och storlek.

Det finns få tidigare studier som analyserat ett införande av en kilometerskatt ur ett allmän jämviktsperspektiv. Tidigare forskning pekar på att en kilometerskatt har både direkta och indirekta effekter på ekonomin De senare är svåra att fånga i partiella analyser där en eller ett flera sektorer analyseras utan att beakta att delmarknader kan påverka varandra. Detta motiverar också att tidigare partiella analyser kompletteras med en analys där interdependensen mellan olika sektorer och marknader beaktas.

SYFTE OCH RESULTAT

Syftet är att ur ett allmän jämviktsperspektiv undersöka makroekonomiska effekter, storleken av strukturförändringar och hur utsläppen av kväveoxider[3] påverkas av en kilometerskatt för tunga lastbilar, samt att jämföra resultaten med tidigare studier av ett eventuellt införande av en svensk kilometerskatt.

Effekter på lång sikt, mellan år 2006 och år 2020, av tre olika nivåer på en eventuell kilometerskatt har analyserats. Scenariet med en hög kilometerskatt om 2,86 kronor per fordonskilometer motsvarar den skada (dvs. de marginella externa skadekostnaderna) som lastbilsflottan bedöms ge upphov till år 2002. I det andra scenariot uppgår kilometerskatten till 1,43 kronor per fordonskilometer och motsvarar skadan som bedöms uppkomma med 2005 års lastbilsflotta. Den lägsta analyserade nivån om 1,00 kronor per fordonskilometer motsvarar skadan som (den ännu renare) lastbilsflottan bedöms ge år 2010. Det skall betonas att resultaten från EMEC inte är att betrakta som prognoser, utan som beräkningsutfall vid olika genomsnittliga nivåer på kilometerskatt jämfört med ett basscenario. Basscenariot sammanfaller med det som använts i Kontrollstation 2008 (Östblom, 2007).

Ett införande av kilometerskatt har små <u>makroekonomiska effekter</u> (se figur 3). Vid en hög nivå på kilometerskatten, sett till hela den analyserade perioden om 14 år, minskar BNP med cirka 0,3 % jämfört med basscenariot, export och import minskar med drygt 1 %, investeringar minskar med cirka 1,7 %, och privat konsumtion ökar med 0,2 %. Om den lägre kilometerskattenivån blir verklighet så halveras ovanstående makroekonomiska förändringar. På en årlig basis är dessa effekter mindre än en tiondel av den totala långsiktiga effekten.

Beträffande <u>strukturförändringar</u> (se figur 4) kan noteras att kilometerskatten påverkar de 27 olika sektorerna i varierande omfattning. Påverkan på förädlingsvärdet[4], som mått på strukturförändringar, varierar och de fem sektorer där den negativa påverkan är störst är gruvor inklusive återvinning[5], metallindustrin utom järn, kemisk basindustri utom läkemedel och hygienprodukter, massa- och papper samt skogsbruket. Alla dessa sektorer kännetecknas också av ett relativt stort beroende av godstransporter på väg av relativt lågt förädlade produkter. I procentuella termer står dessa sektorer år 2020 för knappt 10 % av hela näringslivets totala förädlingsvärde. Den del av tillverkningsindustrin som producerar relativt förädlade varor (SNI 28-36 – teknikföretagen, dvs. metallvaruindustrin, maskinindustrin, elektro-, teleprodukter och instrumentindustrin, transportmedelsindustrin, samt möbelvaruindustrin), och som ökar sitt förädlingsvärde med drygt 0,6 % som en följd ett relativt förbättrat konkurrensläge vid införande av en kilometerskatt, står för 12 % av näringslivets totala förädlingsvärde år 2020 (se figur 6). Servicesektorn som står för nästan 40 % av förädlingsvärdet i näringslivet minskar med 0,3 % (se figur 6). För att förstå storleken av struktur-

[3] Kväveoxider bidrar till försurning och övergödning. Det är inte möjligt att inom ramen för EMEC analysera effekter på alla de externa effekter som skall internaliseras av kilometerskatten.

[4] Förädlingsvärdet definieras som sektorns produktionsvärde minus värdet av sektorns förbrukning.

[5] Den stora procentuella negativa påverkan för aggregatet "gruvor inkl återvinning" förklaras till stor del av att återvinningsindustrin är vägtransportintensiv.

förändringarna kan förändringen i förädlingsvärde uttryckas i hur många års ”normal tillväxt” som förloras vid införande av kilometerskatten. Effekten på det totala förädlingsvärdet, sett över hela perioden, är mellan -0,17 % och -0,38 % beroende på kilometerskattenivå (se figur 4). Det kan jämföras med den genomsnittliga ökningen i förädlingsvärde på 2,41 % per år (se tabell 2), dvs. kilometerskatten innebär att man förlorar mellan en och två månaders tillväxt i ekonomin. Motsvarande jämförelse på sektorsnivå visar dock att det kan ta längre tid att neutralisera effekten av kilometerskatten (för massa och pappersindustrin, mellan 8 och 21 månaders normal tillväxt), men också att tillväxten påskyndas för andra industrier (för sjötransporter, mellan 1,5 och fyra månader). Fler sektorer missgynnas genom förlorad tillväxt än de som gynnas av snabbare tillväxt. Vid en hög kilometerskattenivå förlorar de flesta sektorer (16 st) mindre än ett års tillväxt, och de resterande sju (av de 27) analyserade sektorerna vinner i förädlingsvärde motsvarande en halv månad till fyra månaders tillväxt. Vid en låg kilometerskattenivå halveras, grovt sett, effekterna på förädlingsvärde och fördröjning i tillväxt.

I det senaste regeringsuppdraget nämns speciellt att produktions- och sysselsättningseffekter för skogsbruket skall analyseras. En fördel med föreliggande allmän jämviktsanalys är att hela ekonomin analyseras inom ett konsistent ekonomiskt ramverk, vilket bland annat innebär att resultaten från EMEC beaktar det faktum att marknaderna för olika skogsprodukter (timmer, massa och papper, trävaruprodukter, biobränslen) påverkar varandra. Resultaten visar att skogsbrukets förädlingsvärde minskar med 1,0 % till 2,5 % beroende på kilometerskattenivå (figur 4). Det lägre förädlingsvärdet inom skogsbruket kan jämföras med att förädlingsvärdet ”normalt” stiger med 1,65 % per år, dvs. det tar mellan drygt ett halvår till cirka ett och ett halvt år att hämta igen det förlorade förädlingsvärdet inom skogsbruket. Antalet arbetade timmar minskar inom skogsbruket med 0,4 % till 1,3 % (figur 5). Att effekten är mindre för arbetade timmar än för förädlingsvärde beror på att sysselsättningen i hela ekonomin inte antas förändras vid ett införande av kilometerskatt. Anpassningen i ekonomin sker då genom att arbetsproduktiviteten minskar, vilket motverkar sysselsättningsminskningar.

Att utsläppen av kväveoxider (se figur 7 och tabell 7) minskar förklaras dels av en överflyttning av godstransporter från lastbil till sjöfart och dels av att behovet av transporter minskar till följd av lägre produktionen i vägtransportintensiva branscher minskar. När man bortser från effekterna av en renare lastbilsflottan uppgår utsläppsminskningarna till mellan 630 och 1260 ton år 2020. Bidraget till uppfyllandet av miljömålet om utsläpp av högst 148 000 ton kväveoxider 2010 är därför förhållandevis litet och kommer dessutom för sent. Att utsläppsminskningar av kväveoxider är relativt små är möjligen något förvånande. En del av förklaringen är att lastbilsflottan redan är relativt ren och att det samtidigt sker en tillväxt inom godstrafiken mellan 2006 och 2020. Om det antas att lastbilsflottan kontinuerligt förnyas och att byte till lastbilar med lägre specifika NOx-utsläpp sker, innebär det att utsläppen minskar ytterligare. Vilken betydelse en kilometerskatt har för att minska utsläppen genom en snabbare föryngring av lastbilflottan är svårt att kvantifiera. Det står emellertid ganska klart att en snabbare teknisk utveckling av motorernas utsläppsegenskaper i kombination med att nyare och renare lastbilar kommer i trafik kan generera stora utsläppsminskningar.

Resultaten från allmän jämviktsanalysen med EMEC har också jämförts med andra studier som analyserar ett eventuellt införande av kilometerskatt. För det första bör nämnas att enkla slutsatser om effekten på en viss industri är svåra att göra, eftersom användning av olika metoder och data spelar roll för resultaten. Det kan exempelvis noteras att effekterna på produktion i allmänhet blir större när kilometerskatten analyseras i ett allmän jämviktssammanhang än vid partiella analyser av industriers efterfrågan på vägtransporter. Detta ”resultat” är väntat eftersom spridningseffekterna genom hela ekonomin finns med i EMEC men inte i den partiella jämviksmodell som använts av Naturvårdsverket (Swedish EPA, 2007), och tjänar som påminnelse att kvantifieringar alltid görs givet metod och data. För det andra, utöver användande av olika metoder och data, så används också olika sektorsindelningar. Det innebär ytterligare hinder för direkta jämförelser. För det tredje, kan det konstateras att resultaten, trots nämnda skillnader, i huvudsak går i samma riktning. Sektorer där vägtransportkostnaden står för en relativt stor del av de totala transportkostnaderna och/eller där transporter i huvudsak utgörs av lågt förädlade varor, påverkas mer än andra sektorer.

SLUTSATSER OCH KONSEKVENSER FÖR POLITIKEN

Sammanfattningsvis visar resultaten från KI:s allmän jämviktsmodell (EMEC) att en kilometerskatt ger mätbara effekter på makroekonomiska variabler, att den ger upphov till strukturförändringar, samt att den stimulerar till minskningar av kväveoxidutsläppen. Effekterna ökar med nivån på kilometerskatt. Effekterna på samhällsekonomin mätt som effekter på BNP bedöms dock som liten. Även utsläppsminskningar som en följd av substitution från lastbilstransporter och minskad produktion i ekonomin får bedömas som modesta, i alla fall sett som bidrag till uppfyllande av det nationella målet för utsläpp av kväveoxider. De största effekterna av kilometerskatten är antagligen påverkan på strukturförändringar. Vid jämförelse med en partiell analys av ett eventuellt införande av en kilometerskatt kan resultaten allmänt sett sägas ligga i linje med varandra, men att det är svårt att dra säkra slutsatser pga. att studierna använder sig av olika sektorsindelningar, metoder och data. Beträffande konsekvenser för politiken bör följande uppmärksammas:

För det första, de små makroekonomiska effekterna kan tolkas som att även om en kilometerskatt är ett ekonomiövergripande styrmedel som påverkar stora delar av ekonomin, så kommer den knappt att inverka alls på Sveriges framtida BNP-tillväxt . De produktivitetsförluster som uppkommer inom ramen för analysen sker som en följd av omflyttning av arbetskraft till sektorer med lägre kapitalintensitet, vilket då innebär en lägre arbetsproduktivitet.

För det andra, de sektorer där man är orolig för kilometerskattens konsekvenser är också de sektorer som påverkas mest. I termer av procentuella förändringar i förädlingsvärde så påverkas fler sektorer negativt än positivt; den negativa effekten är i genomsnitt större än den positiva. För den mest drabbade sektorn motsvarar den negativa påverkan tre års ”normal” tillväxt i förädlingsvärde vid en hög kilometerskatt och drygt ett års ”normal” tillväxt vid en låg kilometerskatt (gruvindustrin, inkl återvinningsindustrin). Ökningen i förädlingsvärde för den mest gynnade sektorn motsvarar fyra månaders ”normal” tillväxt vid en hög kilometerskatt och cirka 1,5 månads ”normal” tillväxt vid en låg kilometerskatt (sjötransporter). En förändring av relativpriser påverkar besluten i en ekonomi, och för de sektorer som påverkas mest kan omställningen vara kostsam. I de fall omställningen medför att företag läggs ned på orter där alternativ sysselsättning saknas innebär detta högre omställningskostnader. Varken allmän jämviktsanalysen eller den partiella analysen som vi jämfört med, kvantifierar kostnaderna för omställning i ekonomin eller i de olika sektorerna.

För det tredje, resultaten pekar på att utsläppsminskningar av kväveoxider är relativt små när vi inte räknar med en föryngring av lastbilsflottan. Om lastbilsflottan under den analyserade perioden till stor del antas bestå av fordon som åtminstone uppfyller Euro 4 blir ytterligare minskningar av specifika kväveoxidutsläpp svårare att göra, eftersom de tekniska möjligheterna att minska specifika kväveoxidutsläpp avtar i takt med en allt renare fordonsflotta. Hur fordonsflottan exakt ser ut år 2020 och vilka utsläppsmål som då gäller avseende kväveoxider råder dock stor osäkerhet kring. Men i det fall som den tekniskt möjliga utsläppsnivån för specifika kväveoxidutsläpp är nådd har en Euro-klassdifferentierad kilometerskatt mycket begränsade möjligheter att minska dessa utsläpp. I ett sådant fall är det i huvudsak den trafikdämpande effekten av en kilometerskatt som genererar utsläppsminskningar, möjligen i kombination med högre fyllnadsgrad på lastbilarna. Att utsläppen från lastbilstransporter inte minskar ytterligare behöver inte vara samhällsekonomiskt fel. En effektiv utformning av skatter som syftar till att korrigera externaliteter innebär att de skall sättas på en nivå som motsvarar den marginella kostnaden av den externa effekten. I fallet kväveoxider från lastbilstransporter innebär detta att utsläppen kommer att hamna på ”rätt” nivå ur samhällsekonomisk synvinkel *givet att den Euro-klassdifferentierade skatten avspeglar de marginella externa skadekostnaderna*. Skillnaden med eller utan kilometerskatt blir då att lastbilstransporterna betalar ”rätt pris” för de kväveoxidutsläpp som genereras. För att nå utsläppsmålet om 148 000 ton kväveoxider verkar det dock behövas ytterligare åtgärder, även i andra delar av ekonomin. I det fall som kilometerskatten kan förväntas påskynda en föryngring av den lastbilsflotta som används i Sverige kan dock reduktionen av NOx-utsläppen vara avsevärda. Om kilometerskatten leder till en betydande modernisering (motsvarande att den genomsnittliga lastbilen uppfyller Euro 4 i stället för Euro 3) av lastbilsparken kan man nå upp till nio gånger så stor reduktion av de totala NOx-utsläppen.

För det fjärde, med tanke på att en viss överflyttning av gods från väg till sjöfart kan förväntas som en följd av en kilometerskatt bör det beaktas att sjöfarten i stor utsträckning använder dieselolja med avsevärt högre svavelhalt än den som används av vägfordon. Detta kan få den icke önskvärda effekten att svavelutsläppen totalt sett ökar i ekonomin, vilket föranleder åtgärder för att minska svavelutsläpp från sjöfarten. Åtgärder för att minska svavelutsläpp från sjöfarten, inte minst från den internationella, är motiverade oberoende av en eventuell kilometerskatt, men förstärks till följd av den förväntade överflyttningen av transporter.

För det femte, de brister och osäkerheter som finns avseende inköpta transporttjänster och transporter utförda i egen regi (s.k. inhouse-transporter) finns i såväl företagsstatistiken som i nationalräkenskaperna. I analysen har vi försökt att beakta dessa dataproblem, men sannolikt kan ytterligare förbättringar göras i detta avseende. För framtida utvärderingar av förd transportpolitik är det angeläget att den officiella statistiken bättre än idag redovisar omfattningen av inhouse-transporter.

Abstract

By using an applied general equilibrium model of the Swedish economy, this paper examines how an introduction of a kilometre tax will affect economic growth (GDP), industry structure and emission levels of nitrogen oxides (NOx). According to our findings, the GDP will decrease by 0.1-0.3 per cent and NOx emissions by 0.4-0.8 per cent (assuming fixed emissions coefficients) during the 2006-2020 period. Thus, we find that economic growth and NOx emissions decouple due to an introduction of a kilometre tax. The projected reductions of NOx emissions are, however, minor relative to the Swedish objective for 2010. Road transports will overall be substituted by sea and rail transports and industry structure will change in favour of industries less dependent on heavy road transports. The emissions reductions will, however, be substantively larger if the kilometre tax also ends up inducing technological development able to expedite the adoption of cleaner vehicles. Consequently, this would reinforce the decoupling effect. Furthermore, we compare our findings with the results of others, who used partial equilibrium or bottom-up approaches to study the effects of a Swedish kilometre tax. The effects on production are more significant in the applied general equilibrium framework, but structural changes point in the same direction for all the studies compared.

JEL Classification Numbers: C68, D20, H23, R48

Key words: static general equilibrium model, EMEC, partial equilibrium model, bottom-up models, kilometre tax, transport policy, environmental policy.

Introduction

There is an ongoing policy discussion on the pricing of transport at the European level (European Commission, 2001). Distance-based pricing schemes for heavy goods vehicles have been introduced in some countries[6] and are discussed in others, e.g. Sweden.[7] A kilometre tax implemented in Sweden at 'full' internalisation has the potential, depending on the cost share for transports and the substitution possibilities, to drastically increase production costs for road transport intensive industries. By using an applied general equilibrium model, this paper examines the economic effects and effects on NOx emissions of a Swedish kilometre tax levied on heavy goods vehicles.[8] We find it motivated to examine effects on NOx emissions since Sweden has an ambitious NOx emission goal. The kilometre tax is differentiated by Euro-class NOx emission limits,[9] and the general equilibrium model applied here is suited for analysing changes in NOx emissions. We also compare our findings with those of studies using other modelling approaches. The paper is motivated by the general policy relevance of analysing economic and environmental effects of introducing a kilometre tax and the lack of such analyses in an applied general equilibrium context, where we account, directly as well as indirectly via interrelated markets, for the interaction between the tax introduced and the prevailing prices and taxes. A decoupling of economic activity and road transport NOx emissions is a desirable thing from a policy perspective. The question of whether or not the introduction of a kilometre tax would bring about such a decoupling is addressed in the paper, along with the question of how the decoupling would be affected by a kilometre-tax induced modernisation of the vehicle fleet. The comparisons of results from different modelling approaches improve our understanding of how to evaluate research results for policy purposes, and further motivate the paper.

The introduction of taxes in the transport sector is typically motivated by a mix of allocative efficiency purposes and fiscal reasons in line with Pigouvian taxes (Pigou, 1920) and Ramsey taxation (Ramsey, 1927; Mirrlees, 1971; Diamond and Mirrlees, 1971), respectively. Since a kilometre tax, if differentiated according to the proposal (SOU 2004:63), internalises externalities not sufficiently accounted for in market prices including taxes, it qualifies well as a Pigouvian tax. According to the suggested tax differentiation, the relevant externalities to be internalised are primarily emissions to the air (NOx, particulate matters, hydrocarbons, carbon monoxide), noise, accidents and road deformation which are all correlated with transport distance. The kilometre tax will, hence, correspond much closer to the sources of these external effects compared to the present system of a vehicle tax (yearly tax without any relation to distance) and a diesel tax (perfect for internalising carbon dioxide emissions). A standard characteristic of market-based policy instruments is that they provide strong incentives for technological development, i.e. such policies are typically dynamically efficient. However, there can still be negative effects, largely depending on so-called tax interactions (e.g. Goulder, 1998) after an introduction of a kilometre tax. A major concern from a Swedish perspective is the effects on production, i.e. higher relative production costs due to an introduction of a kilometre tax will decrease production in Sweden but increase production in countries less ambitious in regulating the externalities related to transport. An increase in transport price can have direct effects on the demand for transport and indirect effects on the demand for transported products. In this sense, transport can be seen as a derived demand, implying that goods production presupposes transports.

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[6] See ARE (2002) for a description of the Swiss Heavy Vehicle Fee, and Suter and Walter (2001) for how it fits theoretical concepts and pricing principles. See Toll Collect (2005) for the German system, ASFINAG (2005) for the Austrian system, and MYTO CZ (2007) for the Czech Republic.

[7] See HM Treasury (2003 & 2004) for the UK, and for Sweden see SOU 2004:63 and Government Bill 2005/06:160.

[8] CGE modelling has been used by applied economists for a long time and is increasingly influential in policy making. A thorough review of the field is given by Dixon and Paramenter (1996) and an excellent guiding in how to construct a CGE-model is presented by Dixon et al. (1992). The use of CGE models is a well established tool for environmental policy analysis as reviewed by Bergman (2005). For a model of EU countries, see e.g. European Commission (1995), and for Swedish models see Östblom (1999), Hill (2001) and Johnsson (2003).

[9] See OJEC (2000) for emission limit values of different Euro classes.

Demand for road freight by heavy goods vehicles has been surveyed by Oum et al. (1992) and Graham and Glaister (2002), who also point to the importance of accounting for firms' output decisions. Empirical studies analysing the effect of a kilometre tax in Sweden can roughly be divided into studies using: (1) applied general equilibrium models, (2) partial equilibrium models, and (3) bottom-up approaches.[10]

To account for interactive effects between sectors and markets, a computable general equilibrium model (CGE) is appropriate.[11] The Environmental Medium term EConomic (EMEC) model (see Östblom, 1999; Östblom & Berg, 2006 for documentation) used here is a static CGE model of the Swedish economy for analysing the interaction between the economy and the environment, based on the physical environmental and national accounts produced by Statistics Sweden.[12] The recent development of EMEC such that it models transport services in some detail (Östblom & Berg, 2006) is central for the present study and allows for an analysis of economic effects on central macro variables, production sectors and NOx emissions.[13] The Swedish Environmental Protection Agency (SEPA) has in a partial equilibrium framework analysed the effects on production and input factor demand in the manufacturing industry following an introduction of a kilometre tax in Sweden (SEPA, 2007).[14] These effects on production can, hence, be compared with the corresponding effects reported in the EMEC results. In the Samgods 'bottom-up' model (SIKA, 2000, 2004, 2007a&b), detailed data on transport cost categories for different transport modes are used in order to calculate total transport costs. The transport costs form the basis for determining how the allocation of transports is affected by a change in relative transport prices due to e.g. a kilometre tax. These calculations are used as inputs in EMEC. In a similar approach, Johansson et al. (2003) calculate the kilometre tax effect on freight transport NOx emissions by using information on how a tax will affect the cost structures of various products.[15]

The paper is structured as follows. The following section presents the applied general equilibrium model used here for analysing the effects of introducing a Swedish kilometre tax. Thereafter we present new empirical findings of our analysis. These results are then compared with the results from other modelling approaches, and the causes for differences and similarities in empirical results are discussed. The paper ends with a concluding discussion, including the policy implications of our findings.

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[10] Other approaches are also possible, such as e.g. Salter analysis, which studies how profit margins are affected by increased costs, e.g. by introduction of a kilometre tax at plant level. The primary benefit of this type of analysis is that it gives information about plant level effects and whether they apply only to a few plants or to the total industry subsector.

[11] CGE modelling of transport demand was performed by e.g. Kremers et al. (2002), Steininger (2002), Johnsson (2003) and Nilsson (2004).

[12] The model was used for the first time in the 1999/2000 Swedish Medium Term survey (MTS) (reported in SOU 2000:7) and then in the 2003/04 MTS (reported in SOU 2004:19). It was used also to analyse the economic implications of the Kyoto agreement on CO_2 restrictions (reported in SOU 2000:23 and by Nilsson (2002)), the economic effects of EU's system of emission trading on Sweden (reported in SOU 2005:10, SOU 2003:60 and by Östblom (2003a), (2003b), (2004a)) and Sweden's climate strategy reported for Kontrollstation 2004 by Östblom (2004b). Sulphur abatement cost functions were introduced in the model by Östblom (2002). Also, a feedback effect on health and labour productivity of nitrogen oxide pollution was introduced by Östblom and Samakovlis (2007).

[13] Johnsson (2003) developed a CGE model that accounts for structural changes, modal shifts and fiscal effects, and analysing the effects of introducing a kilometre tax on road wear and deterioration, he found that a kilometre tax differentiated with respect to vehicle weight and axles would decrease road wear, primarily due to a decrease in long-distance heavy trucking, somewhat due to modal shifts and less due to use of less damaging trucks.

[14] Hammar et al. (2008), also in a partial equilibrium framework, analyse in more detail the effects on the Swedish forest industry.

[15] They use econometric models to get a representation of the distribution of Euro classes in the truck fleet, STAN (Strategic Transportation Analysis, a model for multimodal, multiproduct transportation systems) to model traffic volumes and allocation on different roads, and the EMV model to calculate emissions (see Hammarström and Karlsson, 1998, for details).

An applied general equilibrium analysis

EMEC is a static CGE model with 27 industries, 33 composite commodities and a public sector producing a single commodity. Produced goods and services are exported and used together with imports to create composite commodities for domestic use. Composite commodities are used as inputs by industries and for capital formation. In addition, households consume composite commodities and there are 26 consumer goods. A full description of EMEC is given by Östblom and Berg (2006), but definitions of production sectors and commodities are also given here in the appendix.

To capture the economic effects of a kilometre tax within a CGE framework, the transport demand of households and firms must be modelled with the option of adjusting to the changes of transportation costs. The present version of EMEC exhibits such adjustment mechanisms when households and firms choose among a number of transportation modes for work trips and leisure trips, as well as firm transportations of inputs and outputs.

The flows of commodities relate to production and consumption of commodities in the economy, and thus economic activity brings about demand for carriers of commodity flows. Production demands materials and energy inputs, which are substitutes for labour and capital in the model. Firms are cost minimising in the choice of labour, capital, energy, materials and various transport modes for producing outputs. In the model, thus, firms adapt to price changes due to e.g. a kilometre tax when choosing among a number of transport modes for the commodity flows. The firms' production function and the equations of the firms' transport demand are presented in the following sections.

The use of energy by firms and households is subject to an energy tax and pollution taxes.[16] Consumer goods are also subject to a value-added tax as well as other indirect taxes. The use of labour is subject to social security fees and households pay income tax on labour income. Firms and households react to prices, including taxes, and adjust their input mix or their bundle of consumer goods by substituting away from the relatively dearer input or good.

Production function

Firms' production requires primary factors (capital and two kinds of labour) as well as inputs of materials, transports and energy. The use of fuel inputs in current production emits e.g. nitrogen oxides (NO_x) to the air.

The representative firm is assumed to choose an optimal mix of two types of labour and an optimal mix of energy in three stages. The firm, then, decides upon the mix of labour and physical capital in the creation of value added as well as the mix of energy and material in the creation of energy-material input. The various outputs and inputs must be transported, and the firm chooses an optimal transport solution (which allows for the use of several transport modes) in two steps. An optimal mix of value added and energy-material input is chosen at the highest level, to produce the firm's output.

Gross output, Q, is produced by means of value added, Y, and an energy-material aggregate, Z, at the highest level of aggregation. At each succeeding level, the inputs of skilled and unskilled labour, $L(\cdot)$, capital, K, various energy carriers, $E(\cdot)$, materials, M, transports, TP with transport modes $TM1$, $TM2$ and $TM3$, and freights, FR with freight modes $FM1$, $FM2$, $FM3$ and $FM4$, are aggregated in the same manner by CES or Leontief functions. The nested structure of production, expanded for transports, is shown in Figure 1 and the corresponding sector production function is:[17]

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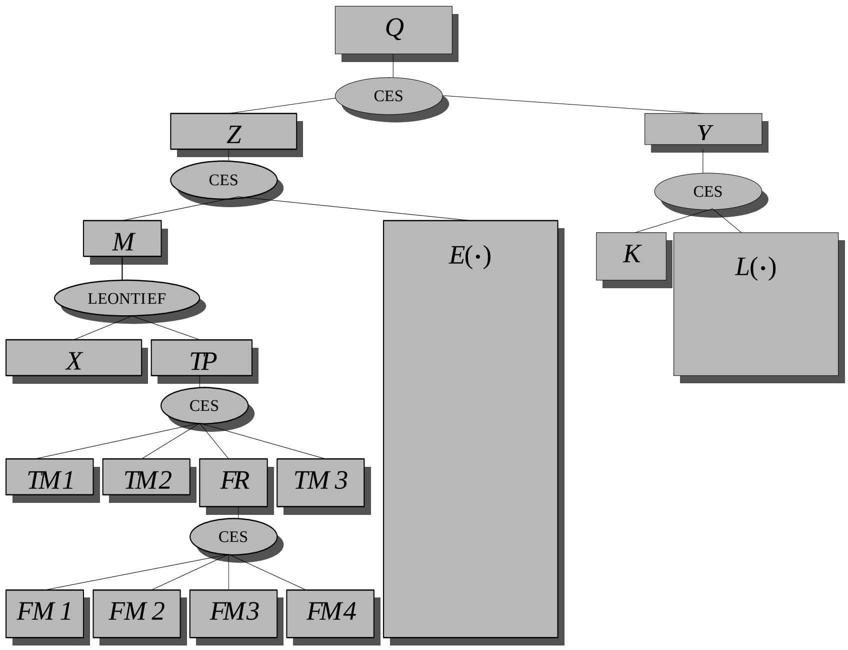
[16] Also, the levels of various emissions can be bounded in the model to give the corresponding shadow prices of emission.

[17] The transport modes are passenger transports, air transports and small truck transports. The freights modes are train transports, sea transports, large truck transports and medium truck transports.

$$Q = f\left(Y\left(K, L(\cdot)^{CES}\right)^{CES}, Z\left(E(\cdot)^{CES}, M\left(X(\cdot), TP\left(TM1, TM2, TM3, FR\left(FM1,\ldots, FM4\right)^{CES}\right)^{CES}\right)^{LEONTIEF}\right)^{CES}\right)^{CES}.$$

Figure 1. The nested production function in *EMEC* expanded for transports.



Transport demand

The CES production function has a dual cost function, and differentiation of the minimum cost per unit of output *Q* yields demand equations for value added *Y* and the energy-material aggregate *Z*. Likewise, differentiation of the minimum cost per unit of material-energy composite *Z* gives sectoral demands for materials *M* and energy *E*. The intermediate demand of various material *X* and transports *TP* are Leontief aggregates, which are defined as shares of total use of materials *M*. Differentiation of the minimum cost per unit of aggregate transport *TP* gives sectoral demand for transport services by transport modes *TM1*, *TM2, TM3* and freights *FR*. Sectoral demands for the freight modes *FM1*, *FM2, FM3* and *FM4* are given by differentiation of the minimum cost per unit of freight transport *FR*. Furthermore, let *FM1* and *FM2* be large truck transports and medium truck transports, respectively. Then their sectoral demands will be a function of the freight mode prices PDS_{FM1}, PDS_{FM2}, the aggregate freight transport price *PFR* and the demand of freight transports *FR*. The price *PFR* is a CES aggregate of all freight mode prices PDS_{FM1}, PDS_{FM2}, PDS_{FM3} and PDS_{FM4}.

$$FM1 = \psi_{FM1}\left(PDS_{FM1}, PFR\right)\cdot FR$$
$$FM2 = \psi_{FM2}\left(PDS_{FM2}, PFR\right)\cdot FR$$

Commodity taxes levied on the inputs of production include VAT, other indirect commodity taxes and subsidies, energy tax, carbon tax, sulphur tax and a kilometre tax for medium and large truck transports. The tax on energy, environmental taxes and the kilometre tax are based on quantities, while the net of VAT, other indirect commodity taxes and subsidies are ad valorem. The prices of medium truck transports and large truck transports (PDS_{FM1} and PDS_{FM2} respectively) including taxes are given by:

$$PDS_{FM1} = PD_{FM1} \cdot \left(1 + itp_{FM1}\right) + itpKM_{FM1}$$
$$PDS_{FM2} = PD_{FM2} \cdot \left(1 + itp_{FM2}\right) + itpKM_{FM2}$$,

where itp_{FM1} and itp_{FM2} are the ad valorem net tax and $itpKM_{FM1}$ and $itpKM_{FM2}$ are the kilometre tax on medium truck transports and large truck transports, respectively. PD_{FM1} and PD_{FM1} are domestic prices before taxes.

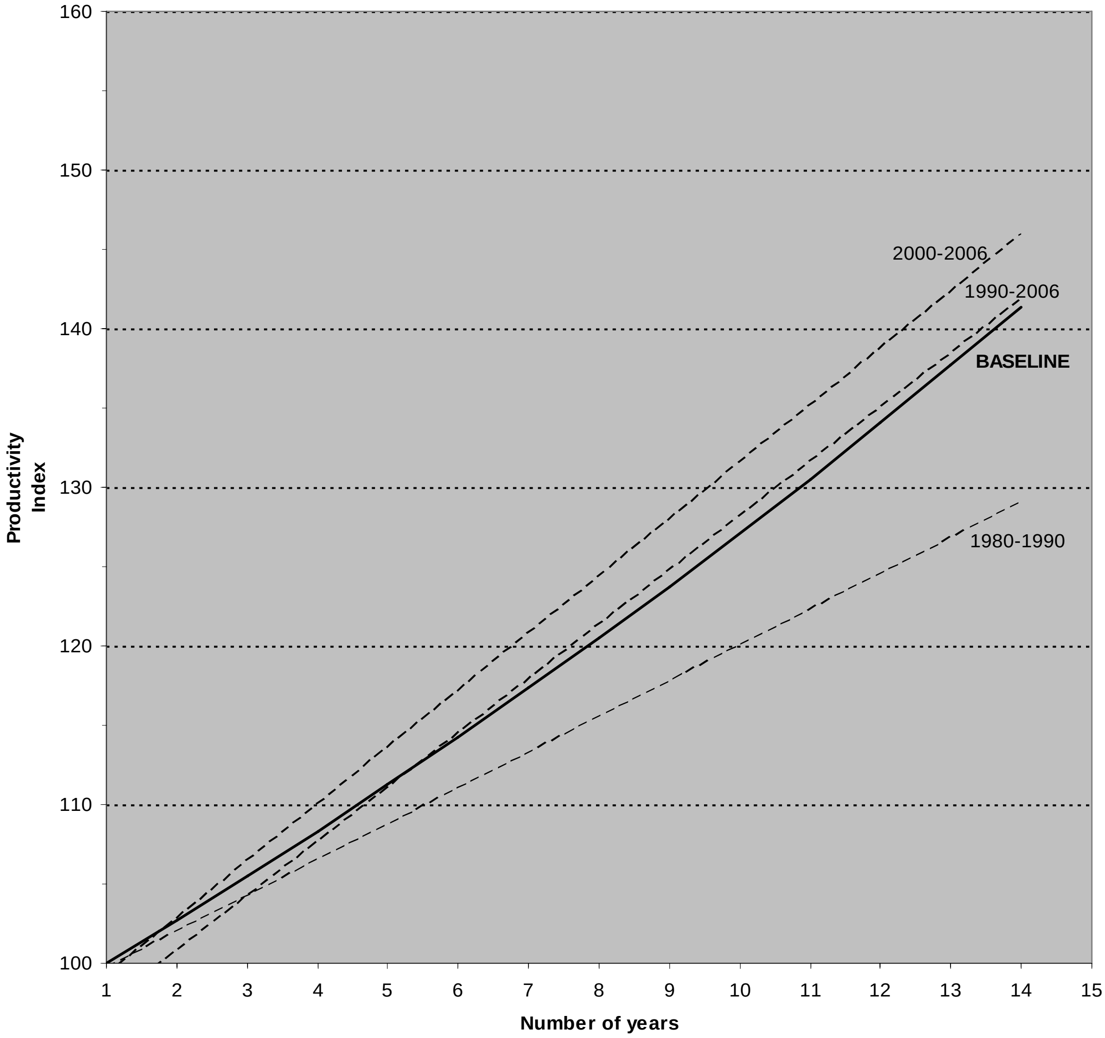
A kilometre tax on truck transports would then make these freight transports dearer relative to other freight transports and induce a substitution away from truck transports. It would also increase the aggregate prices of freights, transports and materials and thus induce substitution away from these inputs, although to a much smaller extent as the tax impact will reduce with the level of aggregation.

Baseline scenario

The baseline scenario of the present study for the 2006-2020 period is based on the 2002-2015 and 2015-2025 economic projections reported to Checkpoint 2008 (Kontrollstation 2008) by the National Institute of Economic Research (Konjunkturinstitutet) in Östblom (2007). According to the productivity trends depicted in Figure 2, the industry productivity growth in the baseline scenario comes close to the 1990-2006 trend, but is well above that observed for the 1980s. It can also be seen that productivity grew at a historically very high rate during the years 2000-2006, but that the trend is assumed to turn into a more likely productivity growth for the remaining years to 2020 in the baseline scenario (BASELINE).

The baseline scenario describes a stronger economic development than observed for the 1990-2006 period because of higher employment, but also a stronger economic development than in the 1980s because of increased productivity in industry (SCB, 2002). The yearly percentage rate of GDP growth is 2.4 in the baseline scenario while it is 2.2 in 1980-1990 and 1990-2006 as shown by the figures in Table 1.

Figure 2. Productivity growth in the baseline scenario and trends in productivity growth for the 1980-1990, 1990-2006 and 2000-2006 periods. Index.



Source: The Swedish National Accounts and EMEC.

Exports are assumed to grow at an annual rate of 4.4 per cent in the 2006-2020 period, which is close to the rate of growth during the 1980s but lower than that of the 1990-2006 period when exports grew unusually strongly from a historical perspective as shown by the figures in Table 1. Imports grow at a somewhat higher yearly rate 4.6 per cent than exports, giving a more balanced development of foreign trade than during 1990-2006 when the Swedish economy showed huge trade surpluses. This development of foreign trade gives more room for the expansion of domestic markets, and private consumption, assumed to grow at an annual rate of 2.6 per cent in 2006-2020, will take an increasing share of economic growth compared to the its weak development during the periods 1980-1990 and 1990-2006. Public expenditures will grow at a modest rate compared to GDP, while the growth rate of investments will be well above the 1990-2006 growth rate.

Table 1. GDP expenditure and employment 1980-2020.

Percentage changes per year

	1980-1990	1990-2006	2006-2020
GDP	2.2	2.2	2.4
Private consumption	1.7	1.6	2.6
Public expenditures	1.7	0.9	0.7
Investments	3.8	1.4	3.9
Exports	4.3	6.9	4.4
Imports	3.8	4.9	4.6
Employment (hours worked)	1.0	-0.3	0.1

Source: The Swedish National Accounts and EMEC.

Assumptions about the development of the exogenous variables productivity, world market prices and world market growth for Swedish products differ among the various production sectors for the 2006-2020 period. As a result, the baseline scenario will exhibit structural changes as shown in Table 2 by the different growth rates of value added and employment for various sectors. Also, the use of fossil fuels differs among sectors and thus the rates of change in NOx emissions vary among sectors in the baseline scenario. We observe that the Engineering sector has the highest growth rates for value added and employment. The Drug industry and the Chemical industry also have high growth rates for value added and employment, while these rates develop below the industry average for the Pulp and paper industry. The growth rates of the Iron and steel industry and the Non-iron metal industry develop close to the industry average for value added but well above the industry average for employment. Construction has high growth rates for value added as well as for employment. The assumed increase in the prices of emission allowances and electricity leads to substitution away from electricity and towards district heating, produced by biofuel-supplied hot water plants, for the warming of houses and premises.

Table 2. Value added, employment and NOx emissions in the baseline scenario 2006 – 2020. Percentage changes per year.

Sector	Value added	Employment	NOx
Agriculture	1.54	-1.16	0.67
Fishery	1.37	-0.16	0.63
Forestry	1.65	-0.94	0.88
Mining	1.59	-1.25	1.05
Mineral products	1.76	-0.99	0.96
Pulp and paper mills	1.74	-0.05	1.80
Drug industries	3.30	1.28	2.42
Other chemical industries	3.33	1.12	3.79
Iron & steel industries	2.73	1.29	2.18
Non-iron metal industries	2.69	1.55	3.02
Engineering	5.21	2.73	2.56
Other industries	1.70	-0.89	1.33
Petroleum refineries	2.12	0.97	1.78
Electricity supply	1.62	-0.73	1.34
Hot water supply	2.77	1.70	2.65
Gas distribution	1.96	0.36	1.99
Water and sewage	2.44	0.90	1.67
Construction	3.66	1.86	2.90
Rail road transports	1.77	0.68	1.08
Road passenger transports	1.53	0.52	0.89
Road goods transports	2.58	1.60	2.08
Sea transports	2.16	-0.32	2.12
Air transports	1.94	-1.18	0.96
Other transports	2.33	-0.16	1.52
Services	2.61	-0.33	1.49
Real estate	2.09	0.91	1.57
Total	2.41	0.09	1.79

Basic assumptions in the policy scenarios

The baseline scenario includes all current (2007) energy and emission taxes but excludes the kilometre tax included in the three policy scenarios KI NV, SIKA1 and SIKA2. [18] In KI NV we apply the 2.86 SEK/vehiclekm tax rate used by Hammar et al. (2008) and by SEPA (2007) in its medium tax alternative. The SIKA1 tax rate of 1.43 SEK/vehiclekm was used by SIKA (2007b) for the alternative assuming a 2005 vehicle fleet, whereas the SIKA2 tax rate of 1.00 SEK/vehiclekm was used for an alternative assuming a 2010 vehicle fleet. In the complementary policy scenario SIKA2Comp, we assume the kilometre tax to induce a modernisation of the vehicle fleet, which will reduce NOx emissions by 23 per cent by 2020

[18] All tax rates used in the scenarios originate from the work conducted at SIKA (Swedish Institute for Transport and Communications Analysis), an agency that is responsible to the Ministry of Industry, Employment and Communications in Sweden. The marginal external costs for heavy goods transport estimated by the agency were also the central basis when developing the preliminary proposal of a kilometre tax reported by the Swedish Road Tax Commission (SOU 2004:63). The KI NV tax rates correspond to a vehicle fleet in 2002, and the two SIKA scenarios reflect that the vehicle fleet is expected to modernise over time, which implies cleaner vehicles and lower external costs.

compared to the SIKA2 vehicle fleet.[19] Also, for all scenarios we assume an emission allowance price of €15 per tonne CO_2 and a corresponding electricity price of 0.34 SEK/KWh in 2020. As shown in Table 3, the kilometre tax rate differs among the scenarios for large trucks (total weight > 32 tonnes), medium trucks (3.5 tonnes < total weight < 32 tonnes) and all trucks. The tax rates for all trucks are given by the three different studies referred to below and are here applied within the same general equilibrium model to analyse effects of the proposed Swedish kilometre tax on the economy and on emissions. The tax rates for all trucks were transformed into different tax rates for large and medium trucks by use of marginal costs and distances driven for trucks of various Euro classes and weights given in SIKA (2007a).

Table 3. Kilometre tax for the policy scenarios.

Scenario	**Km tax** (SEK/vehiclekm)		
	All trucks	**Large trucks** > 32 tonnes	**Medium trucks** 3.5-32 tonnes
KI NV	2.86	3.46	1.47
SIKA1	1.43	1.54	1.17
SIKA2	1.00	1.09	0.80

These kilometre tax rates were applied to all truck transports carried out by transporting companies. Since truck transports carried out 'in house' are not priced at the market in the model, the kilometre tax was transformed into a corresponding tax on diesel fuel for 'in house' transports as shown in Table 4.[20]

Table 4. Corresponding diesel tax for in-house transports.

Scenario	**Diesel tax** (SEK/litre)	
	Large trucks > 32 tonnes	**Medium trucks** 3.5-32 tonnes
KI NV	7.27	3.34
SIKA1	3.37	2.85
SIKA2	2.38	1.95

[19] The distribution of vehicles across Euro classes estimated by SIKA (2007b) for 2010 gives a kilometre tax rate which is 23 per cent lower than for the 2005 vehicle fleet, and correspondingly less NOx will be emitted by the 2010 vehicle fleet, which is estimated to be of Euro-class 4 on average. The 2005 vehicle fleet is Euro-class 3 on average and according to OJEC (2000), the limit value of NOx for Euro-class 4 is 30 per cent lower than for Euro-class 3.

[20] The transformation of the kilometre tax into an equivalent cost increase in terms of diesel is made due to the lack of data for a proper modelling of in-house transports. For the same reason, the modernisation approach could not be adopted for in-house transports. To estimate the magnitude of in-house transports, Johnsson (2003) developed satellite accounts for transportation and showed that whether in-house transports are modelled or not affects the results of CGE modelling. Hence, it is motivated to account for these transports. In practice, if the kilometre tax is implemented, then all trucks above 3.5 tonnes, irrespective of where the cost for road transports ends up in the National Accounts, will pay the kilometre tax.

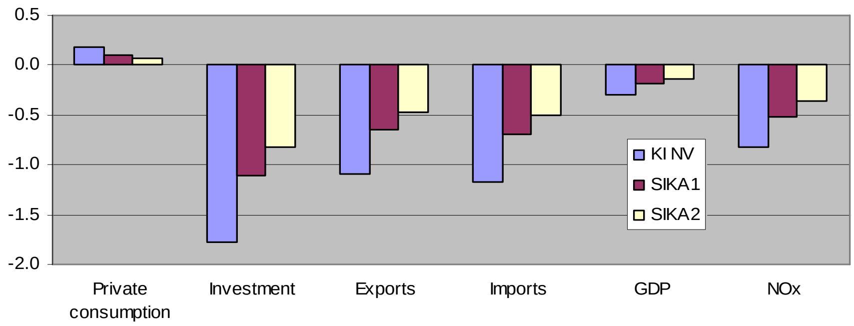
Results

Firms and households are assumed to adjust fully to price changes in an applied general equilibrium framework. The time required for these adjustments to occur in the real economy could vary, but lies assumingly in the span of 10-20 years. The adjustment period here is from 2006 to 2020, but the reported results do not consider that the adjustment process could involve inertia, which increases adjustment cost and thus also affects structural changes. An applied general equilibrium analysis, however, has the advantage of capturing all the adjustment effects which arise due to the interdependence of the production system, i.e. it accounts not only for direct effects in a sector but also for all the indirect effects arising due to the adjustment processes of all other sectors.

The outcomes of a kilometre tax for the Swedish economy are illustrated here by relating macroeconomic development, structural changes and NOx emissions of the policy scenarios to corresponding variables of the baseline scenario. It must be pointed out that the variables reported here for the various scenarios are not to be taken as economic forecasts with different kilometre tax rates for 2020 but should be evaluated in relation to the baseline scenario and used as measures of the economic impact of introducing a kilometre tax in Sweden.

Figure 3. Expenditure of GDP for policy scenarios 2020.

Differences compared to baseline 2020 in per cent.



The macro economic impact of introducing a kilometre tax is illustrated by comparing the expenditure of GDP for the policy scenarios with those for the baseline scenario, as shown in Figure 3. For all scenarios, the GDP will be 0.1-0.3 per cent lower than in the baseline scenario in 2020. The more we raise the kilometre tax, the more economic growth is affected, as more transports will be substituted with production factors that were dearer than transports before the kilometre tax was introduced. This is clear from Figure 3 by comparing the policy scenarios KI NV, SIKA1 and SIKA2, where KI NV has the highest and SIKA2 the lowest kilometre tax rate.[21] The increase in production costs makes Swedish exports dearer on the world market in the policy scenarios, and the higher the kilometre tax rate, the more exports decrease as shown in Figure 3. Furthermore, as an effect of the exogenous condition set up for the trade balance in the model, imports decrease when exports decrease. Import and export decrease at the same magnitude as an effect of unchanged terms of trade and the trade balance condition. This situation also leaves gross savings unaffected by the trade balance, but as investments decrease, gross savings will take a smaller part of GDP and more income can be spent on goods and services, increasing private consumption. Investments decrease due to less demand for capital investments in production as capital intensive production will be more affected by the kilometre tax than less capital intensive production.

A decline in economic growth also tends to decrease NOx emissions as economic activity slows down. When emissions decrease more than economic growth, we observe a decoupling between economic activity and NOx emissions. This is also what happens with an introduction of the kilometre tax

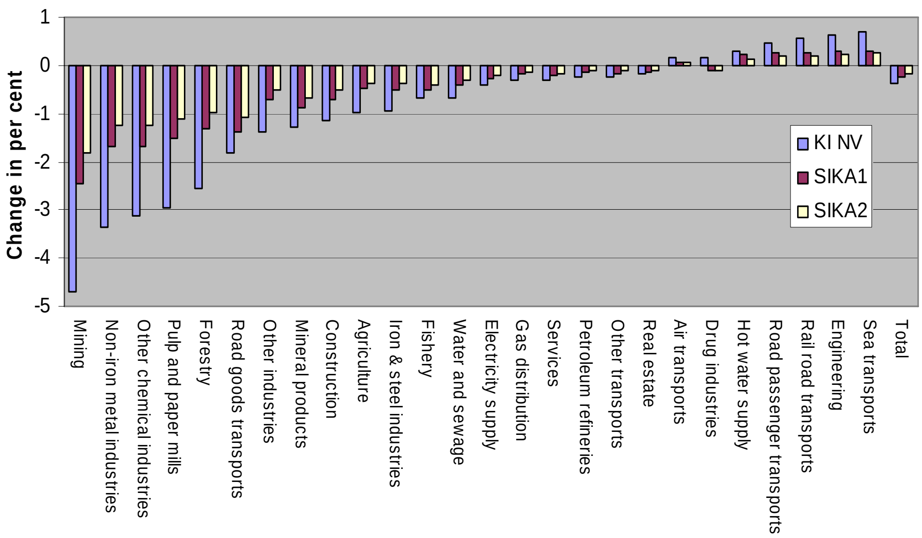
[21] The results of the policy scenario SIKA2Comp coincide with those of the policy scenario SIKA2 except for NOx emissions which decrease by 3.7 per cent.

according to our analysis as shown in Figure 3. The higher the kilometre tax rate, the lower the level of NOx emissions, but also the stronger the decline in economic growth as can be seen in the figure. This is due to less use of road transports and a decline in growth of emission intensive production. Road transports are used less because of substitution by other transport modes and a decline of industries using road transports intensively. For the policy scenario KI NV, which is noted for having the highest kilometre tax rate, the reduction in the level of NOx emissions is about 0.8 per cent, whereas the decline in economic growth is about 0.3 per cent compared to the baseline scenario in 2020. The corresponding figures for SIKA2, with the lowest kilometre tax rate, are about 0.4 and 0.1 per cent. The decoupling effect is, hence, stronger for low than for high kilometre tax rates according to our analysis. An explanation to this is that the measures taken at a high kilometre tax rate induce higher costs to the economy per unit of reduced NOx emissions than the measures taken at a low kilometre tax rate. When the kilometre tax also induces a modernisation of the vehicle fleet, as in SIKA2Comp, the decoupling effect is significantly reinforced, as indicated by the 3.7 per cent reduction of NOx emissions for this scenario compared to SIKA2. The costs of reducing NOx emissions will, hence, in terms of GDP losses be much lower when considering the truck fleet modernisation.[22]

Turning to how the industry structure will be affected by a kilometre tax, measured by changes in the value added of various industry sectors (Figure 4) or by changes in the hours worked in various industry sectors (Figure 5), we observe some interesting features. First, we note the same pattern of structural changes for all three policy scenarios but with differences in the magnitude of changes, indicating that a high tax rate, as in KI NV, causes more structural change than a low tax rate, as in SIKA2. This is true regardless of whether structural change is measured by changes in value added or by changes in hours worked, although we note more significant changes in value added.

Figure 4. Value added for policy scenarios 2020.

Differences compared to baseline 2020 in per cent.



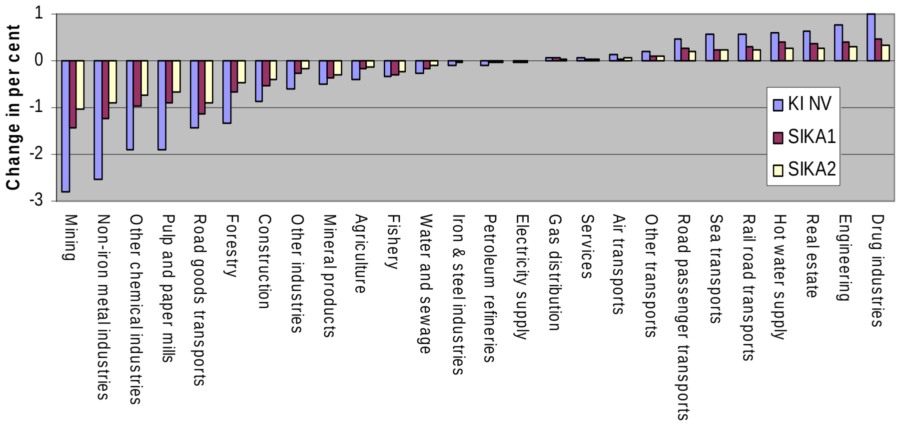
As we assume that all labour is always employed in the scenarios, the economy's labour productivity must decrease in response to production losses in order to counteract the decrease in employment that otherwise would follow, and likewise it reinforces the increase in employment following a production gain. When comparing the changes in value added shown in Figure 4 with the changes in hours worked in Figure 5, we thus observe smaller changes in hours worked than in value added for declining industries but greater changes in hours worked than in value added for growing industries.

[22] The costs of reducing NOx emissions will be nine times lower than in SIKA2.

Sector production costs are affected by an introduction of a kilometre tax directly because of increased costs of transporting the firms' inputs and outputs by road, and indirectly by the increased costs of material inputs from other sectors that also experience increased costs of road transports. Moreover, the road transport sector is affected twofold by increased transport costs as firms will substitute road transports with other transports and the fact that less transports will be demanded by declining transport intensive sectors.

Figure 5. Employment for policy scenarios 2020.

Differences for hours worked compared to baseline 2020 in per cent.

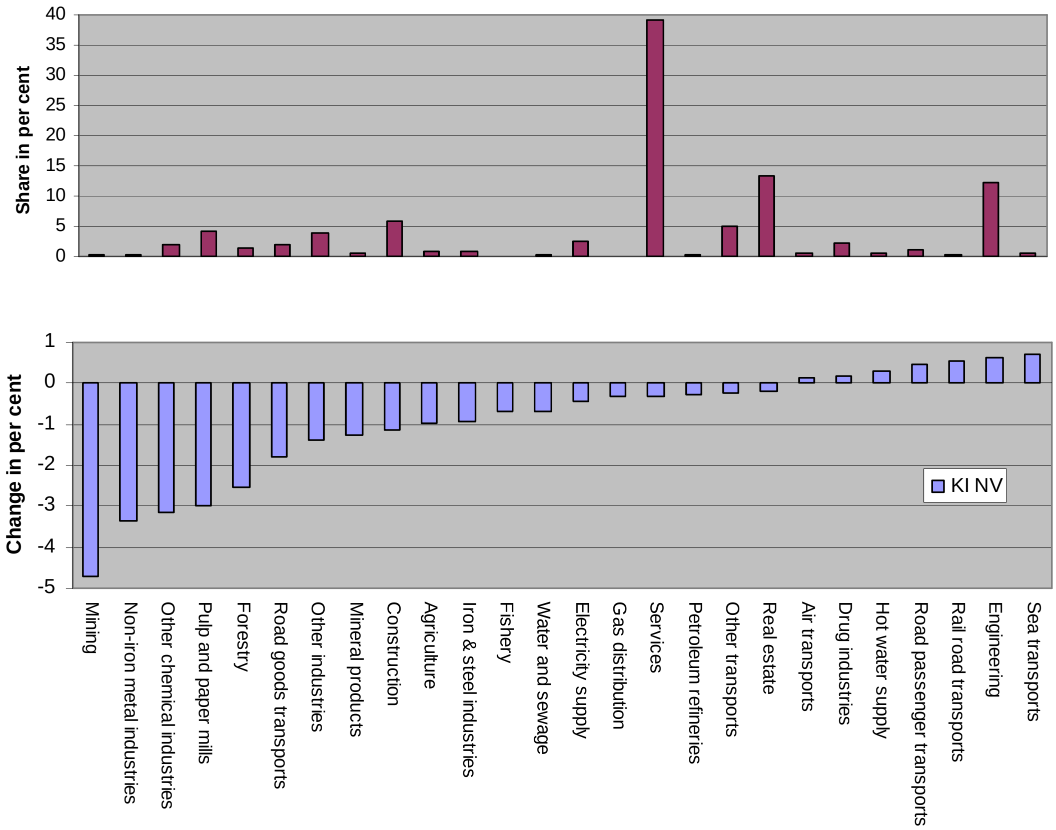


Among the sectors struck hardest by a kilometre tax (as shown by Figures 4 and 5), we find road transports whose services are substituted with services of the gaining sectors railroad transports and sea transports. However, there are a few other sectors with even higher rates of decline than road transports. The Mining industry's bottom rank is explained by our sector classification, where Mining includes the road-transport intensive Recycling industry. The fact that the Non-iron metal industry ranks second lowest is to a great extent an effect of its use of material inputs delivered by the Mining and Recycling industry. The third and fourth lowest positions are held by the Chemical industry and the Pulp and Paper industry due to their large cost shares for road transports of material inputs and outputs. At the highest positions we find transport modes which compete with road transports, but also the Engineering industry which has a very low cost share for road transports. The declines of value added noted for the various industry sectors could be put in relation to the yearly percentage growth rates shown in Table 2 for the baseline scenario. For the Mining industry, then, the noted declines in value added would at most correspond to the loss of three years of economic growth due to the kilometre tax rate applied in KI NV. We note declines in value added of the Pulp and paper industry corresponding to somewhat less than two years of economic growth for KI NV, and to somewhat less than one year of economic growth for SIKA2.

Despite the fact that the value added of most industries declines at a higher rate than the growth rates of gaining industries, the value added of total industry decreases at a very modest percentage rate. The reason for this is that the shares of declining sectors in the total value added of industry are much smaller than the corresponding shares of growing sectors as shown in Figure 6. The value added share for the gaining Engineering industry is about 12 per cent, whereas the corresponding shares of industries at the five bottom positions add up to less than 10 per cent of value added. The largest shares of value added are taken by Services and Real estate, both noted for very small declines in value added.

Figure 6. Production structure and value added 2020.

Shares of value added and differences compared to baseline in per cent for the KI NV scenario.



Fossil fuels are combusted in the production of goods and services either as motor fuels or heating oils. While the kilometre tax will have a direct effect on the use of diesel oil for road transports, it will leave the use of fossil fuels for other purposes unaffected in a direct sense. We should therefore expect reduced emissions to the air, e.g. NOx emissions, to follow from less use of road transports. Yet, the substitution away from road transports towards other transport modes implies increases in emissions from fossil fuels in other transport modes. Also, structural change will affect the NOx emissions. The declining sectors will decrease the emissions while the gaining sectors will increase the emissions. Furthermore, the total effect of all the structural changes on NOx emissions depends also on the intensity in use of fossil fuels in declining and gaining sectors and on the relative magnitudes of these sectors.

Figure 7. NOx emissions for policy scenarios 2020.

Differences in NOx emissions compared to baseline 2020 in per cent.

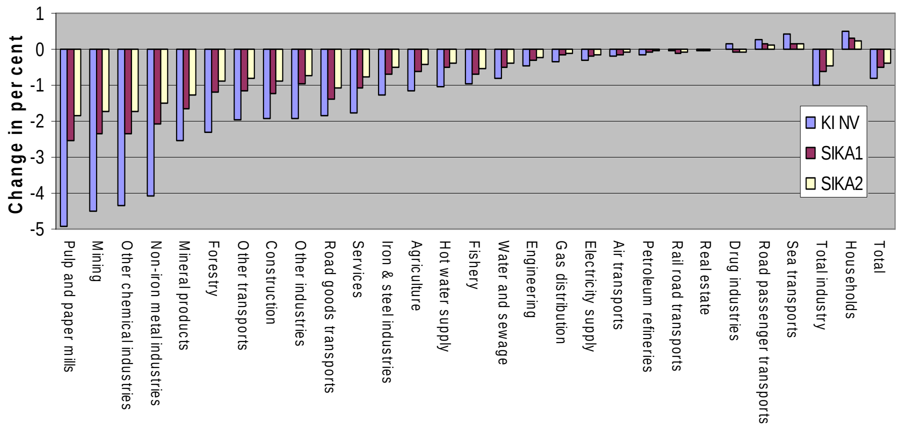


Figure 7 shows the total effects of kilometre-tax induced structural changes on NOx emissions for the different policy scenarios. We observe that the decline of road transports reduces NOx emissions while the substitution towards sea transports increases NOx emissions. The sectors which decline in value added, according to Figure 4, include many sectors with a fossil fuel intensive production, e.g. Pulp and paper, Iron and steel, Mining, and Mineral products, and thus NOx emissions will decrease in these sectors. Sectors gaining from the structural change also reduce their NOx emissions since they reduce their use of in-house transports, which become dearer due to the kilometre tax. The total effect on the industry's NOx emissions is a decrease of at most one per cent in KI NV, due to less demand for road transports but also due to the structural decline of other fossil fuel intensive sectors. Obviously, many of the fossil-fuel intensive sectors also have an intensive use of road transports, and hence a kilometre tax has a strong indirect effect in the direction of reduced NOx emissions. In case the kilometre tax induces a modernisation of the vehicle fleet, the total industry's NOx emissions decrease by a full four per cent in SIKA2Comp, compared to a reduction of somewhat less than a half per cent in SIKA2. The emissions reduction of almost 31 per cent in road transports will account for 95 per cent of the total industry's emissions reduction in SIKA2Comp compared to about 50 per cent without modernisation (as in SIKA2).

Comparison with previous empirical studies

In Table 5, we schematically present the quantified effects of an introduction of a Swedish kilometre tax according to existing studies that apply different modelling approaches. It should be noted that the models used in the studies might be applied in many different ways and incorporate more or other aspects than those reported in the table.

Table 5. Coverage of quantified effects from different modelling approaches.

	EMEC - CGE model	*SEPA (2007) – partial equilibrium model*	*SIKA (2007a&b) – Bottom up model*
Data	National Accounts data and environmental accounts data for the Swedish economy.	Data on the use of input factors, production, costs and profits at plant level for the Swedish manufacturing industry 1990-2001.	Twelve categories of goods produced in Sweden. Detailed use of operative costs for transport, accounting for value of time and punctuality/security of delivery, use of infrastructure network with 30,000 links and 10,000 nodes.
Macro variables	Private consumption, investment, exports and imports, and GDP.	No	No
Structural changes and/or effects on production	Yes	Yes	No, only effects on transport costs for different categories of goods are analysed.
Transport	Demand for total transport can change, as can the distribution between modes, as a result of changes in transport mode prices.	Demand for road transport can change as a result of changes in road transport price. Substitution to other transport solutions not covered.	Total transport demand assumed to be constant, but distribution between modes is implicitly accounted for via changes in generalised transport costs. Transports abroad for sea and rail are covered to some extent.
NOx emissions	Yes	No	No

Data

The various data used by the different modelling approaches are not of the same kind, differ in aggregation level and relate to different periods of time. EMEC is calibrated for the year 2002, but uses data on 2007 energy taxes. The partial equilibrium model applied in SEPA (2007) uses firm level data for the 1990-2001 period corresponding to roughly 80,000 observations. In these models, a kilometre tax translates directly and fully into an upward price change in heavy road transports. Other prices are assumed to be unchanged. This may be realistic in some cases and less realistic in others. For example, significant increases in the road transport price might affect the labour market since increased transportation costs may affect labour demand, which in turn may affect the labour market and wage rates. This type of general equilibrium effect is not accounted for in the partial equilibrium framework. However, the use of detailed data on actual behaviour is naturally a great advantage of these models. Turning to SIKA (2007a&b), its use of detailed cost data for available transport solutions allows for an analysis of possible behavioural response within the transport sector at a relatively detailed level. Transport demand is, however, exogenously given and assumed to be constant irrespective of its distribution over transport modes. The transport demand for different modes and transport solutions is sensitive to cost changes, and a kilometre tax translates directly and fully into an upward price change in heavy road transports. The kilometre tax is differentiated between Euro classes and total laden weight, which is a much richer representation of the design of the kilometre tax compared to the other approaches.

Macro variables

One of the main advantages with CGE analyses is that effects on macro variables are handled in a theoretically consistent way. Other modelling approaches assume these effects to be either non-existing or exogenously given, which can be reasonable in many cases, but less so the more stringent and 'economy wide' a policy change is.

The results from EMEC give the macro economic effects shown in Figure 3. It should be noted that these figures refer to the whole 2006-2020 period, i.e., the yearly effects on the economy are much smaller. An interpretation of the results is that even though a kilometre tax is an economy-wide policy with measurable general equilibrium effects, the effects on macro variables are relatively small in the long run when the economy has adjusted to a new equilibrium. This in turn implies that other methodological approaches that do not account for general equilibrium effects miss the overall effects on the economy. Although these effects are relatively small for the policy scenarios analysed here, general equilibrium effects in terms of structural changes could as already reported potentially be significant and can not be caught by other methodological approaches.

Structural changes and effects on production

Structural changes are often of important policy concern, since they typically imply adjustment costs (e.g. in the form of structural unemployment). Table 6 below displays effects on production in various industries according to the present EMEC study and SEPA (2007), and we then discuss similarities and differences between the studies.[23] Rather than including all sectors, the table focuses on those where we find significant negative effects on production in at least one study. Before going into detail, it can be noted that the classifications of production sectors differ between the two studies, which constitutes an important reservation against making direct comparisons. The fact that both direct and indirect effects on production are accounted for in the EMEC study while only direct effects are measured in SEPA (2007) serves as a potentially important explanation for the differences found in the results of the studies. The fact that comparisons are made between changes in value added for EMEC and changes in gross production for SEPA (2007) also warrants caution. Moreover, it is important to remember that the results from both EMEC and SEPA (2007) are to be considered as long run effects on production; i.e. until the economy has adjusted to a new (general) equilibrium (EMEC) or until the capital stock has fully adjusted (SEPA, 2007). The long run can for both studies be interpreted as the year 2020. The adjustment costs that may arise between 2006 and 2020 are not included in either of the analyses.

We find it useful to discuss: (1) to what extent differences in the sector classifications also explain the differences found in results; (2) in which way the results are similar in spite of the differences in method and data; and (3) interpretations of contradictory results.

[23] The reason for not including SIKA (2007a&b) is simply that the model results do not include effects on production in the different sectors, but 'only' how the generalised transport cost changes as a result of a kilometre tax.

Table 6. Effects on production.

EMEC [1]			SEPA (2007) [1]		
Sector	Effects on value added, %	NACE	Sector	Effects on gross production %	NACE
Agriculture	-1.0	01	--	--	--
Forestry	-2.5	02	--	--	--
Mining and recycling	-4.7	13	Mining of iron ores and non-ferrous metal ores, except uranium and thorium ores	-0.1	131-132
		10-11, 14	Mining and quarrying except iron	+0.9	10-11,14
		37	Recycling of metal waste and scrap, and non-metal waste and scrap[2]	-1.8	37
Other industries	-1.4	15-20	Manufacture of food products, beverage and tobacco industry	-0.5	15-16
			Manufacture of textiles and textile products, and leather	-0.1	17-19
			Manufacture of wood and wood products	-1.4	201-205
Pulp and paper mills	-3.0	21	Manufacture of pulp, paper and paper products	-1.0	2111-2124
		22	Publishing and printing	-0.1	22
Chemical industry	-3.1	24-25 excl 244,245	Manufacture of rubber and plastic products	-0.3	251- 252
Drug industries	+0.2	244,245	Manufacture of coke, refined petroleum products and nuclear fuel; chemicals, chemical products and man-made fibres	-0.1	231-233, 24
Petroleum refineries	-0.3	23			
Manufacture of other non-metallic mineral products	-1.3	26	Manufacture of other non-metallic mineral products	-2.5	26
Iron and steel industries	-0.9	271-273	Manufacture of basic metals and fabricated metal products	0	27-28
Non-iron metal industries	-3.4	274-275			
Engineering	+0.6	28-36	Manufacture of machinery and equipment n.e.c. [2]	-0.1	29
			Manufacture of electrical and optical equipment [2]	-0.4	30-33
Construction	-1.1	45	--	--	--
Road transports of goods	-1.8	6024	--	--	--

[1] EMEC figures based on KI NV are compared to the baseline scenario (cf. Figure 4 on value added). Figures for SEPA based on the high tax scenario implying a 23 % increase in the road transport price after adjustment in capital stock (Appendix 2, p.56-80, based on changes in production). The '--' implies that the study does not uncover effects on that sector.

[2] In EMEC, 'Engineering' includes NACE 28-36, where value added increases. Note that NACE 37 is included in mining in EMEC. Value for NACE 37 for SEPA is taken from Figure 7 in SEPA (2007, p. 28).

Let us begin with sector coverage, where the advantage of EMEC is that it includes all sectors of the economy (NACE 01-95) and not 'only' the manufacturing industry (i.e. NACE 10-37). The general equilibrium approach of EMEC accounts for the indirect effects of adjustments in all sectors of the economy as well as for the direct effects of a kilometre tax on industry production, while the approach of SEPA (2007) accounts only for the direct effects on industry production. When introducing a kilometre tax it is of policy concern to estimate the magnitude of the effect on forestry (NACE 02) in a general equilibrium context, since the market for forest products is closely linked to production in the Forest industry (NACE 20-22). The negative production effects on Forestry are comparable with those in the Pulp and paper industry and the Wood industry when expressed as percentage changes of value added. It is also clear from Table 6 that when we turn to the manufacturing industry (NACE 10-37), we find identical sector classifications in the studies only for Manufacture of other non-metallic mineral products (NACE 26). Hence, when trying to synthesise and draw general conclusions regarding the production effects on particular industries, the sector classifications used need to be considered.

Next, in what ways can we say that the results from the two methodological approaches point in one direction? As can be seen in Table 6, basically the same sectors are 'in the list' for both studies, indicating that the results of the studies point in the same direction regarding the sectors showing production losses due to an introduction of a kilometre tax. Bearing in mind that sector classifications and production measures differ between studies, the results point particularly strongly in the same direction for the sectors 'Other industries'[24] and 'Pulp and paper industry' regarding production changes. While the direction of change in production is the same, the size of the effect is typically larger in EMEC than in SEPA (2007). An explanation to this stylised fact is that both approaches allow for substitution of production factors when relative prices change (determining the direction of production changes). An explanation to the larger effects in EMEC is the interdependence of production sectors modelled in EMEC but not in SEPA (2007).

Finally, there are some seemingly contradictory results shown in Table 6, especially for the Mining and recycling industry, Non-iron metal industries, Chemical industries, Manufacture of other non-metallic mineral products, and Engineering. The production of Mining and recycling (NACE 10-11, 13-14, 37) is hurt the most in EMEC, while the production effect of this sector is small (NACE 131-132) or even slightly positive (NACE 10,11,14) in SEPA (2007). However, while recycling is classified in the Mining sector in EMEC it constitutes a separate sector in SEPA (2007), and as recycling typically is transport intensive, its production can be expected to be relatively strongly affected by a kilometre tax (cf Figure 7 in SEPA, 2007, p. 28). A similar contradiction is found for Non-iron metal industries, where large production effects are found in the EMEC results but not in the partial equilibrium analysis. This observation is due to an indirect effect on production as the Non-iron metal industry to a great extent uses material inputs delivered by the Mining and recycling industry. The large negative magnitude of production effects noted for the Chemical industry in the EMEC results is explained by the difference in sector classifications compared to SEPA (2007). The production of pharmaceuticals (NACE 244) and soaps and perfumes (NACE 245) is excluded in the EMEC classification of Chemical industry, but instead constitutes the separate sector 'Drug industries' (this sector increases its production in terms of value added, cf. Figure 4). The Chemical industry in EMEC thus produces goods with small value added shares in relation to products of the Drug industry, and this fact makes the Chemical industry in EMEC more sensitive to transport price changes than the corresponding industry studied in SEPA (2007). For Manufacture of other non-metallic mineral products, differences in the effects on production could possibly be of methodological character, as the studies use corresponding sector classifications in this case. The dominant subsector here is the cement industry, which transports large volumes of goods with small value added shares. As long as there are technical possibilities to switch to less road transport intensive solutions at a low marginal cost, the effects of a kilometre tax on production will be low for the cement industry. EMEC models substitution towards other transport modes in a general equilibrium context, and therefore the

[24] 'Other industries' corresponds to the Manufacture of wood and wood products, Manufacture of food, beverage and tobacco products, and Manufacture of textiles and textile products, and leather in SEPA (2007).

negative effects on production tend to be smaller for the cement industry there than in the analysis of SEPA (2007). Lastly we turn to the Engineering sector (NACE 28-36) which is very heterogeneous in EMEC and largely characterised by production of goods with high value added shares, and hence the sector is not hurt by increased road transport prices due to an introduction of a kilometre tax. The sector even increases its production, indicating that transport prices are relatively unimportant for competitiveness and that the sector gains from lower costs of other inputs such as labour and capital, i.e. a typical general equilibrium effect. Engineering has a more detailed representation in SEPA (2007), and we observe both small increases (NACE 34-36) and relatively large decreases in production (NACE 30-33 and 37) for the sector.

Transport

The SIKA (2007a&b), SEPA (2007) and EMEC analyses of the economic effects of changes in road transport costs following an introduction of a kilometre tax can be viewed as complementary. The purpose in the study by SEPA (2007) and in our study (EMEC) is to compare the economic effects of different kilometre tax rates, which are given exogenously from the calculations made by SIKA (2007a&b), while the calculation of changes in generalised transport costs following from the different kilometre tax rates is the main purpose of the study by SIKA (2007b).

The calculations of transport cost changes made by SIKA (2007a&b) use detailed information on the Swedish transport network for freight transports and detailed values of operative costs including a value of time. The detailed information in transport costs is used to calculate changes in the distribution of transports between modes. The fact that transports abroad made by Swedish transporters are covered to some extent for sea transports and rail transports adds to the rich and detailed transport cost representation found in SIKA (2007a&b). The total increase in transport costs is 3.1 per cent for SIKA1 and 2.0 per cent for SIKA2. The highest transport cost increases are found for food (6.3 %), followed by products with a large value added share (4.1 %), round wood (3.5 %), and agricultural products (2.8 %). [25]

In SEPA (2007) the transport cost increase is weighed by the share of total road transports in each sector. Hence, the resulting effects on transport volumes are due to the effects on road transports only. However, road transports cannot be substituted by other transport modes in this analysis. The typical result here is that the demand for road transport tends to decrease. In EMEC, the change in transport demand includes effects of introducing a kilometre tax on all transport modes, and as expected we observe (Figure 4) a substitution away from road transports and towards sea and rail transports. The road transport sector will decline by 1.8 per cent compared to the baseline scenario in 2020, due to the effects of the kilometre tax rate introduced in KI NV.

SEPA (2007) also studies changes in the manufacturing industry's road transport demand, and finds a 5.5 per cent decrease for a transport price increase of 23 per cent. As pointed out by the author, the calculation is based on a statistically insignificant elasticity estimate and, thus, we should be cautious when comparing results.

Emissions

The EMEC results suggest that the introduction of a kilometre tax will, assuming no modernisation of the vehicle fleet, reduce NOx emissions by 0.4-0.8 per cent compared to the baseline scenario in 2020 as shown below in Table 7. This figure can be compared to the environmental objective of 148 000 tonnes in 2010 and the prognosis for NOx emissions of 168 000 tonnes in 2010 and 158 000 tonnes in 2020 (SEPA, 2006). An emission reduction of 0.4-0.8 per cent amounts to 630-1260 tonnes in relation to the emission

[25] Percentage figures are for SIKA2. Products with a large value added share are typically found in the Engineering industry.

level of 158 000 tonnes. Hence, the kilometre tax will in this perspective contribute marginally to reaching the objective, as the level of NOx emissions was 205 000 tonnes in 2005. The direct contribution from the freight transport sectors (road, rail and sea) amounts to a reduction of NOx emissions by 380-610 tonnes. Hence, roughly half of the total emission reduction originates from a decline of the freight transport sector, accounting for the fact that NOx emissions increase for sea transports. Note, however, that the rest of the emission reduction is caused by declining production, and thereby also less combustion of fossil fuels, in industry sectors other than transports.

Also, Johansson et al. (2003) analysed in a bottom-up approach the effect of a kilometre tax on NOx emitted by the freight transporting sector, and their results are compared with those of EMEC in Table 7.[26] Johansson et al. (2003) also accounted for a modernisation of the truck fleet for vehicles larger than 3.5 tonnes,[27] and found that the NOx emissions of freight transport will decrease by 1300-2500 tonnes by 2010. This large reduction, which exceeds that reported in the EMEC results, could partly be explained by their use of 2001 as a base year, when NOx emissions totalled 223 000 tonnes.

Table 7. Effects on NOx emissions.

	EMEC (from Figure 7) [1]	*EMEC (SIKA2Comp)* [2]	*Johansson et al. (2003)*
Period studied	2006-2020	2006-2020	2001- 2010
Tax level, SEK/km	1.00-2.86	1.00	0.46-2.14
Reduction in NOx emissions in the whole economy	0.4-0.8 % corresponding to 630-1260 tonnes of about 158 000 tonnes	3.7 % corresponding to 5800 tonnes of about 158 000 tonnes	Indirect effects on the whole economy not accounted for.
Reduction in NOx emissions from freight transport	0.9-1.5 % corresponding to 380-610 tonnes of about 41 300 tonnes [3]	13.4 % corresponding to 5550 tonnes of about 41 300 tonnes [3]	4-8% or about 1300-2500 tonnes [4]

[1] All effects are compared to a baseline scenario without a kilometre tax.

[2] All effects are compared to a baseline scenario without a kilometre tax. Emission coefficients reflect a less NOx intensive truck fleet.

[3] Calculation of change in NOx emissions from freight transport is based upon Swedish figures for 2005 reported to the Convention on Long-range Transboundary Air Pollution (LRTAP) for heavy duty vehicles, railways, and national navigation, adjusted according to a prognosis of NOx emissions in 2020 of 158 000 tonnes.

[4] Change in NOx emissions from freight transport is based upon emissions in EMV in 2001.

The NOx emissions reduction is, however, underestimated in the EMEC results as emissions coefficients are fixed during the period studied. The complementary results of EMEC (SIKA2Comp) presented in Table 7 build on the assumption of a less NOx-intensive truck fleet in 2020 due to an assumed turnover into higher Euro classes. The emissions intensity of the 2020 truck fleet is assumed to decrease by 23 per cent in SIKA2Comp, which corresponds to a switch from Euro 3 to Euro 4. This change implies large NOx emissions reductions by 2020, amounting to roughly 5500 tonnes compared to the baseline scenario. *If* the reduction in emissions intensity can be assumed to reflect the incentive of the kilometre tax to develop and use cleaner vehicles (i.e. in addition to 'normal upgrading' of newer and cleaner vehicles), this clearly is a much stronger argument in favour of a kilometre tax than the direct effect assuming no change in truck fleet. It should be stressed, however, that it is extremely difficult to quantify the effect of an economic incentive on technological development.

[26] NOx emissions reductions are not analysed in SEPA (2007) and SIKA (2007a&b). The results in Johansson et al. (2003) indicate that relatively short annual distances are sufficient to justify purchasing a truck with a higher Euro class. The authors also analyse the shifts to other modes resulting from a kilometre tax. In relative terms, the potential for modal shifts from HGVs to rail and sea transport is, according to Johansson et al. (2003), greatest for agricultural, steel, pulp and paper, and 'other industrial products'.

[27] NOx emissions vary with Euro class, and an introduction of a Euro-class differentiated kilometre tax can therefore be expected to imply lower emissions, at least per kilometre.

Concluding remarks and policy implications

This paper presents an applied general equilibrium analysis of introducing a kilometre tax in Sweden and gives new evidence on effects on the economy and the environment. We also provide a comparison with partial equilibrium techniques and bottom-up models; the latter comparison to sort out differences and similarities and to be able to draw some (relatively) certain conclusions on the effects of a kilometre tax.

- Macro economic effects are relatively modest, e.g. GDP decreases by 0.1-0.3 per cent compared to the baseline scenario in 2020.
- We find general equilibrium effects on production changes in the fact that the structural changes observed for the applied general equilibrium analysis (EMEC) are more significant than those observed for the partial equilibrium analysis (SEPA, 2007). This is due to a tax interaction effect between production sectors, accounted for by the interdependence modelled in the general equilibrium framework.
- Structural changes occur in the partial equilibrium analysis as well as in the general equilibrium analysis but are difficult to compare due to the existing differences between sector classifications used in the analyses. Still, it is fair to say that road transports will overall be substituted by sea and rail transports and that the industry structure will change in favour of industries less dependent on heavy road transports.
- A kilometre tax will contribute to attain the Swedish NOx emissions goal. The direct contribution, assuming that the tax will have no effect on modernisation of the truck fleet, is small and will come too late to be effective for attaining the goal by 2010. We also find that NOx emissions from sea transports will increase as a result of modal shifts, but that the net effect from all transport modes implies reductions in NOx emissions. The contribution of a kilometre tax to emissions reductions in the long run, however, can be large given an optimistic view of its effect on technological development and adoption of cleaner vehicles. The costs of reducing NOx emissions will in terms of GDP losses be much lower when considering the truck fleet modernisation.
- We find a decoupling between economic activity and road transport NOx emissions that is more prominent with low than with high kilometre tax rates. The interpretation of this is that the measures taken at low kilometre tax rates to reduce NOx emissions are less expensive than those taken at high rates. Naturally, the decoupling effect becomes much stronger when the kilometre tax also induces a modernisation of the vehicle fleet.

Regarding policy implications we want to stress the following:

- A full accounting of the primary social benefits of a kilometre tax should include more externalities than NOx emissions alone, e.g. carbon monoxide emissions, particulates, noise, less road deformation. Also, we should consider secondary social benefits such as decreased carbon dioxide emissions and neutrality in taxation between domestic and foreign heavy road freight traffic in Sweden. The introduction of a kilometre tax could also contribute to the attainment of other environmental objectives, meaning that smaller proportions of other policy instruments would be needed.
- It should be noted, however, that the introduction of a kilometre tax could also give a rationale for additional policy measures. For example, the substitution of road transports by sea transports implies more combustion of high sulphur oils used by sea carriers. The Swedish environmental objective of no acidification hence motivates additional policy measures addressing the emissions of sea carriers.
- While the incentive created by a kilometre tax to develop and use cleaner vehicles most likely does exist, its size is uncertain. It is nevertheless fair to say that a market-based policy such as a kilometre tax would provide incentives for technological development among truck producers due to an increased demand for trucks that are environmentally friendly and less damaging to roads. This effect will most probably be of more significance once many countries adopt similar taxes and/or have the same ambition in internalising the external effects from heavy goods transports.

Appendix

Classification of private production sectors

Production sector in EMEC	NACE Rev.1*	Sector label in the Swedish National Accounts
1. Agriculture	01	Agriculture and hunting
2. Fishery	05	Fishing
3. Forestry	02	Forestry and logging
4. Mining	13	Metal ore mining
	10-11,14	Other mining and quarrying
	37	Recycling
5. Other industries	15,16	Manufacture of food, beverage and tobacco
	17-19	Textile industries
	20	Manufacture of wood and wood products
6. Mineral products	26	Manufacture of non-metallic mineral products
7. Pulp and paper mills	21	Manufacture of pulp, paper and paper products
	22	Printing and publishing
8. Drug industries	244	Manufacture of pharmaceutical products
	245	Manufacture of soap and detergents
9. Other chemical industries	24 excl 244,245	Manufacture of chemicals and chemical products
	25	Manufacture of rubber and plastic products
10. Iron & steel industries	271-273	Iron steel basic industries
11. Non-iron metal industries	274-275	Non-ferrous metal basic industries
12. Engineering	28	Manufacture of metal products
	29	Manufacture of mechanical machinery
	30,31	Manufacture of electrical machinery and computers
	32	Manufacture of communication equipment
	33	Manufacture of measuring equipment, etc.
	34,35	Manufacture of transport equipment
	36,	Other manufacturing industries
13. Petroleum refineries	23	Petroleum refining
14. Electricity supply	401	Electricity
15. Hot water supply	403	Steam and hot water supply
16. Gas distribution	402	Gas manufacture and distribution
17. Water and sewage	41	Water supply and sewage disposal
18. Construction	45	Construction
19. Railroad transports	601	Railway road transports
20. Road goods transports	6024	Road goods transports
21. Road passenger transports	6021-6023	Road passenger transports
22. Sea transports	61	Water transports
23. Air transports	62	Air transports
24. Other transports	63	Other transport activities
	64	Communications
25. Services	50-52	Wholesale and retail trade
	55	Restaurants and hotels
	65	Financial institutions
	66	Insurance
	71-74	Business services
	75,80-85,90-95	Other private services
26. Real estate	70	Letting of dwellings and other real estate

*Nomenclature Général des Activités Economiques dans les Communautés Européennes. The statistical classification of economic activities in the European Community amended in March 1993.

Definition of commodities

Commodity in EMEC	CPA code*	Commodity label in the Swedish National Accounts
1. Agricultural products	01	Products of agriculture and hunting
2. Fish	05	Fish and fishing products
3. Timber	02	Products of forestry and logging
4. Bio fuels	02 pt	Wastes from logging
5. Metal ores	13	Metal ores
	11,14	Other mining and quarrying products
	37	Recycled products
6. Coal	10	Coal
7. Products n.e.c.	15,16	Food products, beverages and tobacco products
	17-19	Textiles and textile products
	20	Wood and wood products
8. Mineral products	26	Non-metallic mineral products
9. Pulp and paper	21	Pulp, paper and paper products
	22	Printed matter
10. Pharmacy products	244	Pharmaceuticals and medical chemicals
	245	Soap,detergents and cosmetics
11 Other chemical products	24 excl 244,245	Chemicals and chemical products
	25	Rubber and plastic products
12. Iron and steel	271-273	Basic iron and steel , tubes and wires
13. Other metals	274,275	Basic non-ferrous metals
14. Engineering products	28	Metal products
	29	Mechanical machines
	30,31	Electric machines and computers
	32	Communication equipment
	33	Measuring equipment
	34,35	Transport equipment
	36,37	Other manufactured products
15. Fuels	23200 pt	Heating oils
16. Motor fuels	23200 pt	Motor gasoline,diesel and jet fuels
17. Other petroleum products	23200 pt	Other refined petroleum products
18. Crude petroleum	11	Crude petroleum
19. Electricity	401	Electricity
20. Steam and hot water	403	Steam and hot water
21. Gas	402	Manufactured and distributed gas
22. Fresh water	41	Collected, purified and distributed water
23. Buildings	45	Construction works
24. Rail transports	601	Rail transports
25. Passenger transports	6021 pt,6023	Passenger transports by bus
	6022	Passenger transports by taxi
26. Large truck transports	6024 pt	Goods transports by trucks > 32 tonnes
27. Medium truck transports	6024 pt	Goods transports by trucks 3.5 - 32 tonnes
28. Small truck transports	6024 pt	Goods transports by trucks < 3.5 tonnes
29. Sea transports	61	Sea transports
30. Air transports	620	Air transports
31. Other transports	63	Other transport products
	64	Communication products
32. Services	50-52	Wholesale and retail trade products
	55	Restaurant and hotel services
	65	Financial services
	66	Insurance services
	71-74	Business services
	75,80-85,90-95	Other private services
33. Dwellings	70	Real estate services

* EU Classification of products by Activity (CPA).

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