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The significance of transport costs in the Swedish forest industry Ψ

Henrik Hammar[1], Tommy Lundgren[2] and Magnus Sjöström[3]

Abstract

Environmental and transport policies based on marginal external costs, such as a kilometer tax for heavy goods vehicles, can be constrained by the risk of industries incurring higher production costs than competitors in other countries. However, the significance and size of this cost is largely an empirical question. We estimate factor demand elasticities in the wood and the pulp and paper industries using firm level data for the 1990-2001 period on input prices and quantities. The results show that the introduction of a kilometer tax for heavy goods vehicles affects transport demand as well as other factor demands and output, but that the effects are less pronounced in terms of changes in output. In the wood industry, production decreases by between 0.6 % and 3.0 %. The corresponding decrease in the pulp and paper industry is between 0.4 % and 1.3 %. The effects on average profits are small in both industries.

JEL Classification Numbers: D20, H23, R48
Key words: elasticity, factor demand, kilometer tax, forest industry, transport policy, environmental policy.

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1. Introduction

The purpose of this paper is to examine the potential effects of a kilometer tax, levied on heavy goods vehicles in Sweden, on the forest industry's factor demand and output. The Swedish forest industry is to a large extent dependent on heavy goods vehicles for the transportation of inputs and outputs. In 2004, the overall land transportation (rail and road) associated with the forest industry was roughly 13 million metric tonkm, which corresponds to roughly 25 percent of total land freight transportation in Sweden. Moreover, in the same year somewhat less than 5 million metric tonkm of wood products and slightly more than 5 million metric tonkm of pulp and paper products were shipped by water (SFA, 2006, Ch. 8). A kilometer tax implemented at "full" internalization may cause the price of heavy goods road transports to increase by up to roughly 30 percent.[4] It, hence, has the potential, depending on the cost share for transports and the substitution possibilities, to increase the costs of production for the forest industry. We choose to analyze this via an estimation of elasticities for output and factor demand in the forest industry. In particular, we estimate how sensitive the supply of output and the demand for labor, capital, electricity, fuels, and transport are to price changes. We focus on the manufacture of wood and wood products, excluding furniture (NACE 201), and manufacture of pulp, paper, and paper products (NACE 21). [5]

The paper is motivated by (1) the relevance for environmental policy-making to account for the small open economy context (e.g. Sweden) by estimating the size and significance of likely consequences on production (and profits) in the wood and pulp and paper industries. The focus on the forest industry is due to the fact that forest products to a large extent compete with price on the international market. (2) The relative importance of this sector in terms of contribution to GDP, industry exports, and employment makes the present study relevant from a policy implementation perspective, since large negative effects on the forest industry are major obstacles for a successful implementation of an otherwise attractive policy measure in terms of cost effectiveness.

In addition, due to worries that domestic production may be hampered, many countries face difficulties when planning to implement more stringent environmental policies, since an ambitious national policy may create incentives for moving production to countries with lower production costs. In an open economy, production factors as well as tax bases are relatively mobile, and, hence, it makes good sense to strive for policy co-ordination across countries in order to minimize free-riding and tax competition.

Furthermore, we extend the knowledge of how sensitive the Swedish forest industry production is to changes in factor prices due to an implementation of a kilometer tax. Depending on the likely consequences of an implementation, different adjustments might be called for, e.g. stringency of environmental policy, compensatory measures for different sectors, and structural adjustment measures.

The introduction of taxes in the transport sector is typically motivated by a mix of allocation and fiscal reasons in line with Pigouvian taxes (Pigou, 1924) and Ramsey taxation (Ramsey, 1927; Mirrlees, 1971; Diamond and Mirrlees, 1971), respectively. In the particular case of a kilometer tax, the Pigouvian rationale is fundamental and well motivated since it internalizes externalities that are not sufficiently accounted for in present prices including taxes. The relevant externalities to internalize are primarily emissions to the air (except CO_2) and road deformation, according to the suggested differentiation of the tax, which are both highly correlated with transport distance. Via

[4] Assuming tax levels based on a national weighted average of short-term marginal external costs for countryside (82%) and city (18%) for a heavy goods vehicle with an engine fulfilling EURO 2. This means a kilometer tax level of 3.67 SEK per vehicle kilometer for a 60 ton vehicle (typically used for transport of forest products). Assuming a cost per kilometer before tax of 13.50 SEK per vehicle kilometer, this corresponds to 27 percent. At present, most trucks are found in EURO 2. At the earliest possible time for an introduction of a kilometer tax, EURO 3 to 4 can be expected to be the most common classes, which will imply lower tax levels.

[5] NACE (Nomenclature statistique des Activités économiques dans la Communauté Européenne) corresponds to Swedish Standard Industrial Classification (SNI).

the kilometer tax there will be a much closer correspondence to the sources of these external effects compared to the present system of the vehicle tax (yearly tax without any relation to distance) and the diesel tax (perfect for internalizing CO_2 emissions). However, an introduction of such a tax does not imply that there will be no negative effects, largely depending on so-called tax interactions. A major concern from a Swedish perspective is the consequences for production in small open economies such as Sweden, i.e. that a higher relative cost of domestic production will decrease domestic production but increase production in other countries that may be less ambitious in regulating transport related externalities.

Forest products are a highly significant part of Swedish exports (13 percent in 2003), and appear even more significant if one considers regional aspects such as employment in less populated areas. It is also clear that Swedish exports of some forest products stand for a quite considerable share of world trade, which also implies that the market share for Swedish exports is relatively high in many countries.

Factor demand in the Swedish manufacturing industry has been investigated in several papers; for instance Dargay (1983), Walfridsson and Hjalmarsson (1991), Brännlund (1997, 2000), Lundgren and Sjöström (1999), and Brännlund and Lundgren (2004). Generally speaking, these studies focus on energy policies because of Sweden's tradition of an energy intensive industry and ambition to use energy more efficiently, reduce carbon dioxide emissions, and phase out nuclear power. Factor demand analysis is an established line of research in the literature, but papers that include transportation as an input are scarce. Existing studies of the demand for road freight by heavy goods vehicles have been surveyed by Oum et al. (1992) and Graham and Glaister (2002) who also point to the importance of accounting for firm output decisions, which is typically lacking in many studies using a cost-minimizing approach.

The paper is structured as follows. In the next section we present the empirical strategy, which includes our modeling approach and presentation of data. Thereafter we present the empirical findings, and simulate the model for different scenarios associated with an introduction of a kilometer tax. The paper ends with a concluding discussion, including policy implications of our findings.

2. Empirical strategy

2.1 Modeling approach

The modeling approach extends the analysis by Brännlund and Lundgren (2005) in two noteworthy ways. Firstly we include transports as an input in the demand and output equation system, and secondly we use a proxy variable for capital stock instead of estimating a demand equation for gross investments (more on this in the data section).

The present model is based on standard micro-economic foundations. We assume (a) that the objective of each individual firm is to maximize profits, (b) that each individual firm operates in a competitive environment, and (c) that each individual firm has access to a technology that transforms a number of inputs into a single output. Assumption (a) implies, *inter alia*, that given an output decision, each firm will choose a bundle of inputs that minimize costs. Furthermore, assumption (b) implies that all input and output prices are exogenous to the firm. Assumption (c) implies that we can describe the technology with a production function.

More specifically, we assume that the firms use an input vector $\mathbf{x} = [x_1,\ldots, x_n]$ to produce a single output q. Denote the corresponding input price vector as $\mathbf{w} = [w_1,\ldots, w_n]$, and the output price p. Then, given the assumptions above, we can write the profit function for a representative firm as:

$$\pi = pq^* - \mathbf{w}'\mathrm{x}^* = \pi(\mathbf{w}, p) \ , \qquad (1)$$

where q^* and $\mathbf{x}^*$ are the profit maximizing output and input choices.

The profit function in (1) has the usual properties, i.e. it is increasing in p, non-increasing in $\mathbf{w}$, homogenous of degree 1 in p and $\mathbf{w}$, and convex in p and $\mathbf{w}$. Applying Hotelling's lemma to equation (1), we obtain supply and demand as functions of all prices, i.e.:

$$\nabla_p \left[\pi(\mathbf{w}, p)\right] = q(p, \mathbf{w}) \ , \qquad (2)$$

$$\nabla_{\mathbf{w}} \left[\pi(\mathbf{w}, p)\right] = -\mathbf{x}(\mathbf{w}, p) \ . \qquad (3)$$

In order to obtain an operational form of the demand system we need to specify a functional form for the profit function. The chosen functional form should put as few restrictions as possible on the technology, but still be operational from an econometric point of view. Furthermore, for suitable parameter values it should satisfy the properties associated with a profit function (given by micro-economic theory). Three of the most common specifications used are the translog, the generalized Leontief, and the normalized quadratic profit function. All of these are second order approximations of any arbitrary profit function (see e.g. Chambers, 1988, for a discussion). In the present study we have chosen to normalize the quadratic profit function with output price[6] (see Lau, 1972, 1974, 1976a-b, 1978, for background and derivation of the quadratic profit function and elasticity formulas).

Due to the panel data structure, there are several possible approaches to estimate the demand and supply functions. One is to just pool the data or impose fixed effects at some level of aggregation. An alternative, and less restrictive, approach is to allow plants to be heterogeneous at certain levels of aggregation; that is, letting the parameters be sector specific. In practice this means that we estimate sector specific demand systems separately. An advantage with this approach is that it allows all parameters to vary between the different sectors, while a disadvantage is that the chosen level of aggregation does not correspond to differences and similarities in the actual technology of different firms in the sector. However, this is a general problem in this kind of analysis.

In this paper we have chosen the latter approach due to the differences in road transport intensity between the two studied sectors – it would be too restrictive to impose the same parameter values for the transport variable.

Given this approach we can write the normalized profit for a representative firm in sector m, using standard symmetry condition ($\alpha_{ijm} = \alpha_{jim}$), as:

$$\frac{\pi_m}{p_m} = \alpha_{0k} + \sum_{i=1}^{n} \alpha_{ik} \frac{w_{im}}{p_m} + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \alpha_{ijm} \frac{w_{im}}{p_m} \cdot \frac{w_{jm}}{p_m}, \quad i, j = 1, \ldots, n \quad m = 1, \ldots, M \ , \qquad (4)$$

where M is the number of sectors, i.e. the aggregation level (here two sectors, $M = 2$, wood and pulp and paper industries). The corresponding supply and demand system is then, by applying Hotelling's lemma:

[6] The selection procedure for the profit function was "trial and error" until finding the most adequate specification in terms of the profit function being well behaved (i.e. elasticities having the "right" signs).

$$q_m = \alpha_{0m} - \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n}\alpha_{ijm}\frac{w_{im}}{p_m}\cdot\frac{w_{jm}}{p_m}, \tag{5}$$

$$x_{im} = -\left(\alpha_{im} + \sum_{j=1}^{n}\alpha_{ijm}\frac{w_{jm}}{p_m}\right) \quad . \tag{6}$$

The econometric specification includes error terms in the profit, supply, and demand functions described above (assumed to have white noise properties). By adding a stochastic term to equations (4)-(6), we have a system that can be estimated with standard techniques such as seemingly unrelated equations (SURE) or full information maximum likelihood (FIML); see for example Greene (1993). In the estimations we include time trends and scale dummies (four different sizes of firm) that interact with prices. Given (4) – (6), it is straightforward to define the price elasticities for sector *m* as:

$$\varepsilon_{ijm} = -\alpha_{ijm}(w_{jm}/p_m)/x_{im}, \tag{7}$$

$$\varepsilon_{ipm} = -\sum_{j=1}^{n}\varepsilon_{ijm} \ , \tag{8}$$

$$\varepsilon_{pim} = \varepsilon_{ipm}(w_{im}/p_m)(x_{im}/q_m), \tag{9}$$

$$\varepsilon_{ppm} = -\sum_{i=1}^{n}\varepsilon_{pim} \ . \tag{10}$$

Equations (7)-(10) define the demand elasticities, the supply elasticity with respect to input prices, and the own price supply elasticity.

From theory it follows that the own price supply effect is positive, whereas the effect on supply from an increase in any input price is negative. The own price demand effect is negative, whereas the cross price effects cannot be determined *a priori*. The sign of the cross price effect will depend on the technology, and on whether inputs are gross substitutes or gross complements in production. The reason for using the term gross is that a price change will lead to two different effects: a substitution effect and a scale, or output, effect. The latter is due to a change in the profit maximizing level of output, which may then reinforce, or weaken, the pure substitution effect. That is, even if energy and labor are substitutes from a pure technological point of view, the scale effect from an increase in the energy price may lead to a decrease in labor input, i.e., energy and labor may be net substitutes and gross complements at the same time.[7] Which measure to use, net or gross, depends on the objective of the study. In this case, where the main objective is to analyze gross effects on input demands, the gross effects are more suitable. It should be noted that the gross effect can be decomposed into the two sub-effects (the substitution effect and the scale, or output, effect). An alternative would be to use the cost function instead of the profit function, meaning that the demand functions would be conditional on the production level, which in turn means that the substitution effects would be net effects.

It should be noted that equation (1)-(3) are derived under the assumption that all inputs are flexible. Among other things, this implies that the capital stock is allowed to adjust as a result of price changes. Thus, the model may be viewed as a long run model.

[7] It can be shown under which conditions inputs can be net substitutes and gross complements, or vice versa, at the same time; see for example Chambers (1988).

2.2 Data

The data set is a firm level unbalanced panel covering the 1990-2001 period. It contains plants with more than five employees and is classified according to the industry standard (NACE 201 and NACE 21, i.e. wood and pulp and paper industry, respectively) and includes plant level data on output (sales), input data on (quantities and values) labor, electricity and fuels used, gross investment, and transport costs.[8] We use the latter as a proxy for road transport costs, which admittedly creates scaling problem since total transport costs also include costs of air, water, and rail transportation. However, road transportation is a considerable part of all domestic transportation: roughly 70 percent for wood industry and roughly 25 percent in the pulp and paper industry. We have consequently scaled the transport data to reflect the direct road transport cost shares. The proxy for transport demand is constructed by dividing transport costs by a price index for heavy vehicle transports (more on this index below). Fuels are aggregated into a single variable (70-80 percent fossil fuels in aggregate the variable). Capital stock is calculated from data on investment, value added, and salary paid to employees. Assuming that value added is compensation to labor and capital (salaries plus capital costs), we can extract the capital stock residually.

Output price indices are sector specific, meaning that we have one output price index for the wood industry and one for the pulp and paper industry. Firm specific input prices can be calculated from the costs for labor, electricity, and fuels. Price of transports and capital are not firm specific. The calculations of these indices are based on national and industry based indices, respectively (taken from Statistics Sweden, producer price index section at www.scb.se), which seems plausible considering that firms have limited opportunities to affect the prices for capital (global market) and transports significantly. For the transport price we use a weighted index containing price indices for labor cost (for employees in the heavy vehicle transport sector), cost of capital, and diesel (used as fuel in heavy transportation vehicles), and a consumer price index reflecting the price development of other costs.[9] The weights used here are 42% for labor, 15% for capital, 26% for fuel, and 17% for other costs. For capital cost we use the standard definition of user cost of capital,[10] which is a function of an investment goods index, a sector output price index, an interest rate, and depreciation rates. The depreciation rates used are 8.7 percent for machinery and 2.9 percent for buildings (the two main components of gross investments).[11]

In sum, firms in the wood and pulp and paper industries produce a sector specific output, and use labor, capital, electricity, fuel, and road transports as inputs. Firms are faced with an output price at the sector level, but pay firm specific prices for labor, electricity, and fuels. Prices of capital and transports are on a sector and national level, respectively.

Figure 1 depicts the variation of road transport cost shares among firms and industries. It is clear that some firms have high transport cost shares, while this factor seems to be of less importance for other firms. The fact that firms in the wood industry have higher cost shares for road transports than firms in the pulp and paper industry does not, however, necessarily imply that the wood industry is more intensive in the use of transports as the costs of other transport modes are not included in the cost shares shown.

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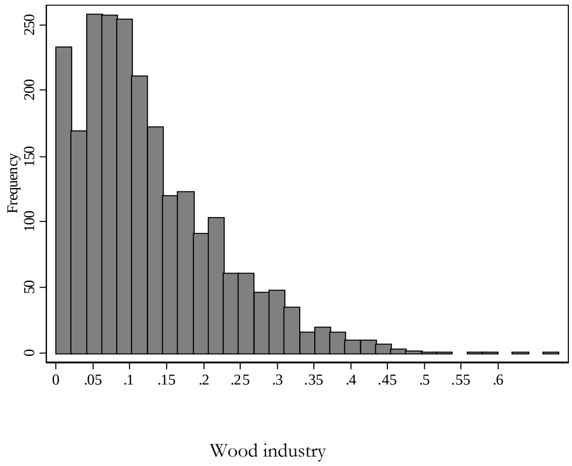
[8] It should be mentioned that we have excluded the observations of firms reporting no costs for transportation. The reason is that transport costs for these firms most probably are embedded in other production costs (fuel, labor, capital) or that the transports are so-called "in-house" as opposed to "for-hire". However, we cannot readily assume that the remaining observations are free of "in-house" transports.

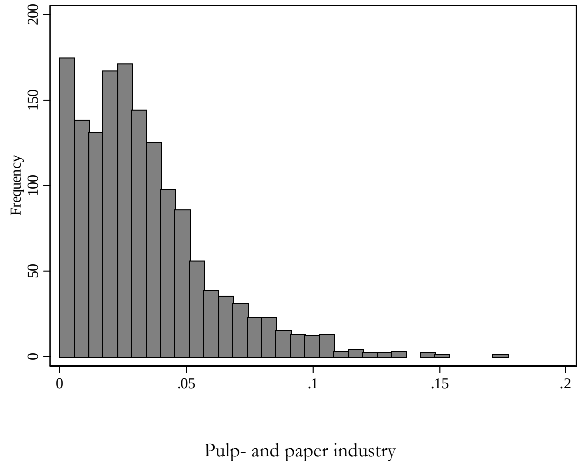
[9] The weights were supplied by TRANSEK, a consulting firm focusing on the transport sector, and are based on the cost of operating a heavy vehicle in road transportation. See Bjørner (1999) for a study estimating freight transport using aggregate quarterly time series, which use a similar price index as a measure of freight transport.

[10] See for example Jorgenson (1963) or Nickell (1978) for a discussion and derivation of user cost of capital.

[11] These rates are based on estimations from Swedish industry data in King and Fullerton (1984) and Bergman (1996).

Figure 1. Road transport cost shares for the wood industry and the pulp and paper industry, 1990-2001





The descriptive statistics of the data used in our analysis are presented in Table 1, which shows that the mean road transport cost share for the pulp and paper industry is 0.03, whereas it is 0.13 for the wood industry.[12] The cost shares for labor and capital add up to 0.88 and 0.80 for the pulp and paper industry and the wood industry, respectively, indicating their dominance in terms of production costs. The differences between sectors are significant for most variables. Typically, plants in the pulp and paper industry are larger, probably reflecting higher returns to scale. This also strengthens the validity of our sector specific estimation. We can note that the mean value for the input quantities is much higher in the pulp and paper industry compared to the wood industry, while the mean price for the inputs shows the reverse pattern, except for the price of labor. We also see that revenues in the pulp and paper industry are more than five times higher than those in the wood industry. The minor differences in the prices paid for transports reflect the fact that we have assumed the same transport price for the two sectors.

Table 1. Descriptive statistics, 1990-2001

	Wood industry		**Pulp and paper industry**	
	Mean	Std. Dev.	Mean	Std. Dev.
Sales (TSEK)	86 500	94 100	455 000	735 000
Labor (no. of employees)	47	42	232	307
Capital stock (TSEK)	47 800	766 000	586 000	1540 000
Electricity (MWh)	4 500	8 460	109 000	267 000
Fuel (MWh)	4 190	27 100	57 800	137 000
Transport (TSEK)	3 690	5 630	6 350	15 400
Output price (index)	0.77	0.10	0.94	0.01
Wage (TSEK/empl.)	214	41	248	54
User cost of capital (index)	0.21	0.03	0.17	0.04
Price of electricity (SEK/kWh)	0.33	0.08	0.28	0.11
Price of fuel (SEK/kWh)	0.29	0.11	0.26	0.16
Price of transport (index)	1.12	0.11	1.13	0.12
Cost share labor	0.48	0.17	0.55	0.20
Cost share capital	0.32	0.21	0.33	0.20
Cost share electricity	0.05	0.03	0.06	0.08
Cost share fuel	0.02	0.03	0.03	0.04
Cost share transport	0.13	0.10	0.03	0.03
Number of observations	2332		1513	

[12] In both industries it can be noted that firms with road transport cost shares larger than average are also slightly larger than average in terms of sales (roughly 40 percent of the firms with larger than average road transport cost shares stand for about 50 percent of total sales).

3. Results

In Table 2 below we present an elasticity matrix of factor demand price elasticities (based on parameter estimates made using Full Information Maximum Likelihood, FIML; see Table A1 in the Appendix) for each industry. As can be seen, the own price elasticities are all, as expected, negative, i.e. the higher the input price, the less the firm uses this particular input. We also present how input demand changes when output price increases, and how output changes when cost of production increases (input prices changes). We see, as expected, that when output price increases, then production increases, and hence the factor demand increases as well. Moreover, we also see that increasing factor prices imply a decrease in production. Output elasticities are based on more aggregate data as the output prices are not firm specific, which also implies that these are more uncertain (relative to the factor demand price elasticities).

Table 2. Elasticity matrix for the wood industry and the pulp and paper industry

	Own price and cross price elasticities – factor demand					Output price elasticities
	Price of labor	**Price of capital**	**Price of electricity**	**Price of fuels**	**Price of transport**	
			Wood industry (NACE 201)			
Labor	-0.18*	0.16*	-0.07*	0.04	-0.14	0.18*
Capital	0.22*	-0.30*	-0.01	-0.06	0.24*	-0.10
Electricity	-0.60*	0.06	-0.22	-0.37	0.34	0.80
Fuels	0.23	-0.23*	-0.21	-1.14*	-0.60*	1.91*
Transport	-0.23	0.28*	0.06	-0.18*	-0.94*	1.01*
Output	-0.02*	-0.01	-0.01	-0.04*	-0.06*	0.12*
			Pulp and paper industry (NACE 21)			
Labor	-0.42*	-0.45*	-0.25*	-0.06	-0.17*	1.35*
Capital	-0.19*	-0.13*	0.02	0.00	-0.01	0.32*
Electricity	-0.52*	0.09	-0.25*	-0.11	-0.05	0.84*
Fuels	-0.21	-0.02	-0.19	-0.37*	-0.30*	1.10*
Transport	-1.08*	-0.14	-0.15	-0.50*	-0.39	2.26*
Output	-0.15*	-0.08*	-0.04*	-0.03*	-0.04*	0.35*

* Statistically significant; p-value< 5 %.

It should be mentioned that the results, when it comes to whether inputs are complements or substitutes, are in line with previous research (e.g. Brännlund and Lundgren, 2005), but differ with respect to the size of the effects.

3.1 Own price elasticities

All own price elasticities of production factors are significant, except for electricity in the wood industry and transport in the pulp and paper industry.

The own price elasticity of road transportation in the wood industry and in the pulp- and paper industry is -0.94 and -0.39, respectively, indicating that road transportation is highly responsive to transport price changes in the wood industry.[13] Compared to other factor demands, road transportation is the second most price sensitive production factor in the wood industry.

The interpretation of the sensitivity to road transport price is, however, not straightforward and probably reflects a mix of factors such as a potential for better logistic planning (higher load factors) and/or less metric tonkm, changes in transport solutions, and more imported inputs (via sea). The fact that the pulp and paper industry has low road transport cost shares and is relatively more reliant on other transport solutions might serve as an explanation to the statistical insignificance of the own price elasticity for road transports.

3.2 Change in input when output price changes

Not surprisingly, the results show that when the price of a product increases, it is more attractive to increase production. As can be seen in Table 2, the pulp and paper industry is more sensitive to output product price changes (0.35) compared to the wood industry (0.12).

Higher output prices also imply higher demand for input factors. The relative sizes of the factor demand elasticities when output prices increase can be interpreted as a representation of the difference in underlying production possibilities between the two sectors. Loosely speaking, increasing the production is accomplished by turning up the speed on the existing machinery, i.e. increasing the productivity of capital. This implies an increase in the use of production factors, although the relative use of these factors differs between sectors.

3.3 Change in output when factor prices change

Generally speaking, marginal factor price changes imply only small effects on aggregate average production. However, it should be noted that even a small change in aggregate *average* production might have dramatic consequences at the local level.

Even if road transportation is responsive to road transport price for the wood industry, we see when looking at how output changes when transport prices increase in Table 2 that the effect on production is modest in absolute terms. Still, judging from the size of the output elasticities, changes in transport prices have relatively large effects on output compared to changes in other input prices. For the pulp and paper industry on the other hand, this effect is relatively small, which again might reflect that this industry relies less on road transports.

[13] To compare, in the survey by Oum et al. (1992) the elasticities for paper, plastic, and rubber products, and wood and wood products are -1.05 and between -0.56 and -1.55, respectively. In a more recent survey of estimates of price elasticity on the demand for road freight, Graham and Glaister (2002) report a mean of -1.07 based on 143 estimates. Hence, our estimates are in the same range. It should, however, be noted that data and exact NACE classification differ. Direct comparisons are therefore difficult to make.

4. Simulations

In this section we simulate the model for different scenarios associated with an introduction of a kilometer tax. Using the elasticity matrices presented in the previous section, we assess the partial effects of a policy change in parts of the forest industry. Before describing the different scenarios and the results from the simulations, we wish to draw attention to some crucial assumptions. The first important assumption is that all firms in both industries are price takers. Second, a policy change does not induce general equilibrium effects. That is, policy changes have effects only on the prices of those inputs directly affected by the specific policy. For example, an introduction of a kilometer tax translates directly and fully into an upward price change in heavy road transports. No other prices are assumed to change. This may be realistic in some cases, and less realistic in others. For example, significant increases in the road transport price will most likely affect the labor market. Increased transportation costs may affect labor demand, which in turn may affect the labor market and wage rates. In the end, this will affect the overall cost. The model we use here cannot track these types of general equilibrium effects, but the reader should be aware that they do exist to some degree. To account for all interactive effects between all sectors and markets, a computable general equilibrium model (CGE) would be more suitable (e.g. Östblom & Berg, 2006). However, this type of model is not without flaws; the modeling approach used in this analysis certainly has some benefits compared to a CGE. For example, the parameters used in the simulation have been estimated using very detailed micro-panel data, and the massive amount of information it contains is important to consider when choosing between different modeling approaches. It should, however, be stressed that even though we have the data, we cannot study each company separately. The effects from, for example, price changes are to be interpreted as effects for a group of firms, or as a mean effect for a specific group of firms.

Moreover, we have only considered *road* transport costs. The possibility to switch to other transport solutions is hence not explicitly accounted for. What seems clear is that road transport decreases, at least in the wood industry, but it is unknown to what degree other transport modes increase. Furthermore, a switch to other transport modes can be assumed to imply an increase in total production costs, even though the increase is smaller compared to "sticking with" road transports. Hence, the calculations do not reflect all production costs. This warrants complementary research on mode choices and transport solutions in the forest industry, e.g. using results from SIKA's Samgods model (SIKA, 2004). We simulate the following scenarios for each forest industry sub-division:

1. Three levels of kilometer tax: low, medium, and high. The assumption is that the price of road transportation increases by 10, 20, or 30%, the latter being the industry's own estimate of the cost increase (see Skogsindustrierna, 2006). However, two things should be mentioned regarding the "highest" scenario. First, a transport price increase of 30 % is definitely more than marginal, which calls for caution when interpreting the simulation results. Second, 30% may not be a realistic increase in the long run (e.g. future changes in transport solutions including cleaner vehicles with associated lower tax levels), making this scenario less interesting. We still choose to include it as an indication of a "worst case."
2. We will estimate and simulate the model for two different data sets: (*i*) all firms in the sample, and (*ii*) firms with a road transportation cost share larger than the full sample's mean value (elasticity matrices in the Appendix). Our conjecture is that firms with high shares are relatively more sensitive to a kilometer tax. This sub-sample is also likely to represent firms where the concern from producer interests and policy makers is most warranted, due to the risk of large costs in the form production losses.

The tables displaying simulation results below use the following notations:

D_L = percentage change in labor.
D_K = percentage change in capital.
D_E = percentage change in electricity.
D_F = percentage change in fuel.
D_T = percentage change in road transportation.
D_q = percentage change in output level.
D_TC = percentage change in total cost.
D_π = percentage change in profits.

Remember that all simulation results presented in the following section are to be considered long run effects. Changes in profits, production, and total costs are a result of changes in the input mix, which in turn are due to kilometre tax induced increases in road transportation prices. It should also be mentioned that supposedly small effects on the industry level might imply large effects on the local and/or firm level.

4.1 Wood industry

Full sample

The simulation results in Table 3 show that at the highest level of the tax, road transportation decreases by almost 30%, investment increases by roughly 7%, and labor decreases by about 4%. The effect on production and total cost is also negative, while profits are left almost unchanged. Production decreases by 2% and total costs by 5%, indicating some potential for downsizing in the wood industry. The decrease in total costs is due to substantial decreases in the use of fuel, road transportation, and labor. However, since the decrease in labor is not statistically significant, the estimate of the total cost decrease may be exaggerated.

Table 3. Simulation results, wood industry, whole sample. Low/medium/high refer to different percentual increases in the road transport price

	D_L	D_K	D_E	D_F	D_T	D_q	D_TC	D_π
Low	-0.014	0.024	0.034	-0.056	-0.094	-0.006	-0.014	-0.003
Medium	-0.028	0.047	0.067	-0.112	-0.188	-0.013	-0.031	-0.005
High	-0.041	0.071	0.101	-0.168	-0.282	-0.019	-0.052	-0.006

High road transport cost shares

Compared to the full sample, road transportation demand is twice as sensitive for firms with road transportation cost shares that are larger than the sample mean (about -2 instead of - 1). Other than that, only production and capital are significantly responsive to changes in the price of road transportation, with production being more sensitive than that in the full sample (see Table A2 in the Appendix). The mean cost share in this sub-sample is just above 20 %, which is substantially higher than the whole sample mean of about 12 %.

Table 4 below shows that road transportation demand goes down by almost 60 % in the most extreme case, which could mean that the most road transport intensive firms simply exit the market. Noteworthy is also the remarkable upswing in investment and capital stock (+23 % in high alternative). But even though capital increases significantly, total costs go down, mainly due to the severe drop in the use of road transportation. Production also falls by up to 3 %, which “evens out” the drop in total cost. Profits are affected only marginally.

Table 4. Simulation results, wood industry, high transport cost shares. Low/medium/high refer to different percentual increases in the road transport price

	D_L	*D_K*	*D_E*	*D_F*	*D_T*	*D_q*	*D_TC*	*D_π*
Low	-0.002	0.075	0.021	-0.009	-0.199	-0.010	-0.036	-0.001
Medium	-0.005	0.150	0.041	-0.018	-0.398	-0.020	-0.083	0.002
High	-0.007	0.225	0.062	-0.027	-0.597	-0.030	-0.140	0.010

4.2 Pulp and paper industry

Full sample

Table 5 shows that the use of every input decreases, with road transports, fuels, and labor changing the most (although only the changes in labor and fuel are statistically significant). In the worst case, labor decreases by 5.3 %. Production and total costs go down once the industry has adapted to the kilometer tax. Profits are left practically unchanged since both production and total costs go down. As in the wood industry, the decrease in production implies some degree of downsizing in the pulp and paper industry.

Table 5. Simulation results for the pulp and paper industry, whole sample. Low/medium/high refer to different percentual increases in the road transport price

	D_L	*D_K*	*D_E*	*D_F*	*D_T*	*D_q*	*D_TC*	*D_π*
Low	-0.018	-0.001	-0.005	-0.030	-0.039	-0.004	-0.011	0.001
Medium	-0.035	-0.002	-0.010	-0.060	-0.078	-0.008	-0.023	0.001
High	-0.053	-0.003	-0.015	-0.090	-0.116	-0.012	-0.035	0.003

High road transport cost shares

The sub-sample of pulp and paper firms with road transport cost shares larger than the whole sample mean of about 3% shows a cost share mean of 5.5%. Production is affected only marginally, although the change is statistically significant (see Table A2 in the Appendix), by an implementation of a kilometer tax. Again we see that road transport demand in the pulp and paper industry is sensitive to output price changes (demand for final product).

In Table 6 we see that road transports decrease by up to 17 %, although this decrease is not statistically significant. Production and total costs both decrease, the latter by almost 4 % in the high alternative. Profits are practically unaffected due to the low cost share for road transports and low marginal product for this input.

Table 6. Simulation results, pulp and paper industry, high transport cost shares. Low/medium/high refer to different percentual increases in the road transport price

	D_L	*D_K*	*D_E*	*D_F*	*D_T*	*D_q*	*D_TC*	*D_π*
Low	-0.013	-0.001	-0.014	-0.021	-0.056	-0.004	-0.012	0.000
Medium	-0.026	-0.001	-0.028	-0.042	-0.111	-0.009	-0.025	0.001
High	-0.038	-0.002	-0.042	-0.063	-0.167	-0.013	-0.038	0.003

4.3 Summary of the consequences for production and profits

We have seen that in the *wood industry,* the effect on production ranges from a 0.6 % decrease (whole sample, 10 % road transport price increase) to a 3.0 % decrease (sample with high road transport cost share, 30 % road transport price increase). The corresponding effects on profits are -0.3 % and +1.0, respectively.

We have seen that in the *pulp and paper industry,* the effect on production ranges from a 0.4 % decrease (whole sample, 10 % road transport price increase) to a 1.3 % decrease (sample with high road transport cost share, 30 % road transport price increase). The corresponding effects on profits are small improvements of 0.1 % and 0.3 %, respectively.

The interpretation of increased profits in some cases reflects that production with low profitability ceases as a result of increased road transport prices, which indicates that the mean profit in each industry can actually increase.

Finally, we also want to point out that the changes in the input mix to being less labor intensive have real effects on employment in these sectors. For the wood industry, which in 2005 employed 13,400 people (SFA, 2006), the simulations imply a job loss for the whole sample of between 200 and 600 jobs depending on the road transport price increase. For the pulp and paper industry, which employs 37,300 people, the corresponding figures are between 600 and 2,000.

5. Concluding remarks and policy implications

By using assumptions on market situations for the relevant products, the factor demand approach makes it possible to estimate effects of increased transport costs on production and input demands. Judging from our results, what can be said about the consequences of implementing a kilometer tax in Sweden? The results in this paper show that road transport prices affect the use of production factors, while the effect is less pronounced in terms of changes in output. However, this effect is only statistically significant for the wood industry. It also seems clear that road transport is responsive (but inelastic) to changes in road transport prices, and that this responsiveness is large relative to other production factors. We also conclude that the same increase in road transport prices will affect production in the two industries differently.

However, the forest industry does have reason to expect negative consequences among firms where road transport costs stand for a relatively large share of their total production costs. These firms are commonly found in the wood industry (see Figure 1). It should also be mentioned that some firms, especially in the pulp and paper industry, are likely to be able to bear additional transport costs. Moreover, these two aspects/effects also depend on the degree of reliance on road freight. Regardless of the industry, firms with small road transport cost shares should be able to accommodate for a kilometer tax. Consequently, their production losses should be small. On the other hand, there might be firms that are heavily reliant on road freight, and these are very likely to downsize, or even shut down.

It is also important to be aware of the limitations of our analysis. Our assumption that all road transport prices are equal to the national averages (due to lack of firm specific data) obviously translates into less variation in this variable than it possesses in reality. This data problem is of course unsettling, since the variable is of major concern to the analysis. Another potential problem in using the estimated elasticities for policy purposes is if policy implementation implies large, i.e. not marginal, changes. The case of a kilometer tax where the transport prices end up increasing by 30 percent must be considered more than a marginal change. As a comparison, the standard deviation of the transport price (cf. Table 1) is roughly 10 percent of the mean. Put together, these two limitations suggest that if policy makers are hesitant towards an implementation due to fear of production losses in the forest industry, a stepwise introduction to learn about the size of the risk of high transport prices might be appropriate. By using such a cautionary approach, large and uncertain effects may be avoided (with the potential cost of larger uncertainty regarding future tax levels.

In a wider perspective, there are other important factors that affect production volumes and employment opportunities, and it is important, in a final decision of potential implementation of a kilometer tax, to look not only at relative effects but also at absolute effects. Potential factors of large concern include exchange rates, GDP, world demand for forest products, climate policies, increased productivity, product differentiation and market power, technological development, free trade agreements etc.

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Appendix

Table A1. FIML Parameter estimates used to calculate elasticities in Table 3

	Wood industry[A]		**Pulp and paper industry[B]**	
Parameter	Estimate	t-statistic	Estimate	t-statistic
A1	-151	-55.89	-692	-13.29
A11	0.0353	5.36	0.422	4.33
A12	9.54	0.69	1065	2.91
A13	11.0	1.67	320	2.22
A14	-6.28	-1.28	56.4	0.69
A15	-0.867	-0.19	93.0	1.39
SD1WP	119	79.19	248	7.22
SD2WP	87.2	66.71	196	4.92
SD3WP	56.1	41.46	157	1.93
BWT	0.585	2.39	19.6	6.07
A2	-99700	-7.79	-1230000	-4.80
A22	216000	11.49	2670000	4.58
A23	10500	0.92	-66200	-0.19
A24	51800	2.88	-59200	-0.32
A25	-8300	-1.14	-63900	-0.39
SD1QP	20600	2.85	298000	1.71
SD2QP	9260	1.58	244000	1.23
SD3QP	-6610	-1.23	319000	0.33
BQT	-2030	-2.38	33300	2.58
A3	-13600	-3.89	-304000	-5.00
A33	6130	1.16	225000	2.42
A34	6940	1.15	47800	0.59
A35	-1570	-0.51	2630	0.04
SD1PELP	7350	3.80	95800	1.80
SD2PELP	5530	3.41	83800	1.23
SD3PELP	3300	2.28	90800	0.63
BPELT	-240	-1.12	11500	3.89
A4	-35000	-5.46	-175000	-7.06
A44	24700	4.86	127000	4.47
A45	421	2.29	48800	1.20
SD1PFP	16000	5.31	69100	2.81
SD2PFP	13000	4.69	65800	1.94
SD3PFP	116	4.07	67500	1.28
BPFT	-1510	-4.85	1700	0.89
A5	-2740	-1.75	-66500	-4.01
A55	5580	4.26	21000	0.95
SD1PTP	-2880	-4.76	26600	0.67
SD2PTP	-2780	-5.99	25700	0.78
SD3PTP	-1060	-2.45	26100	0.61
BPRT	-527	-4.51	-1140	-0.82
A0	73600	12.10	537000	7.46
SD1Y	-46300	-9.73	-236000	-2.52
SD2Y	-29800	-7.20	-199000	-1.62
SD3Y	-147	-3.68	-213000	-0.56
BYT	3050	5.70	-19700	-4.01

[A] Number of observations = 2332; Log likelihood =-167752; Schwarz B.I.C.= 167970

[B] Number of observations = 1513; Log likelihood =-131718; Schwarz B.I.C. =131927

Table A2. Elasticity matrix for the wood industry and the pulp and paper industry, high transport cost shares

	Own price and cross price elasticities – factor demand					Output price elasticities	Cost shares
	Price of labor	**Price of capital**	**Price of electricity**	**Price of fuels**	**Price of transport**		
			Wood industry (NACE 201)				
Labor	-0.248*	0.092	0.002	0.019	-0.023	0.157	0.455
Capital	0.150	-0.405*	-0.039	-0.118	0.751*	-0.340	0.243
Electricity	0.019	-0.210	-0.114*	-0.308*	0.206	0.406	0.060
Fuels	0.092	-0.354	-0.170*	-1.329*	-0.090	1.850*	0.027
Transport	-0.032	0.647*	0.033	-0.026	-1.992*	1.370*	0.215
Output	-0.016	0.021	-0.005	-0.039*	-0.100*	0.139*	
			Pulp and paper industry (NACE 21)				
Labor	-0.714*	-0.126	-0.236	-0.153	-0.128	1.358*	0.504
Capital	-0.058	-0.139*	0.016	-0.009	-0.007	0.198	0.318
Electricity	-0.459	0.068	-0.257*	-0.112	-0.141*	0.900	0.085
Fuels	-0.559	-0.076	-0.210	-0.475*	-0.212*	1.532*	0.039
Transport	-0.586	-0.074	-0.334*	-0.267*	-0.556	1.818*	0.055
Output	-0.147*	-0.047	-0.050	-0.045*	-0.043*	0.332*	

* Statistically significant; p-value< 5 %.

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