Trafik analys

Socioeconomic marginal costs of icebreaking

Summery report 2017:4

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Trafikanalys
Adress: Torsgatan 30
113 21 Stockholm
Telefon: 010 414 42 00
Fax: 010 414 42 10
E-post: trafikanalys@trafa.se
Webbadress: www.trafa.se
Ansvarig utgivare: Brita Saxton
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Summery

Transport Analysis has been tasked with analysing the transport sector's socioeconomic costs in relation to levied taxes and fees. One important part of this process involves compiling and clarifying the marginal costs of various types of passenger and cargo transport. The purpose of this report is to elucidate in detail the marginal costs of icebreaking in Sweden, and to expand our knowledge in this area.

Icebreaking from the open ocean to sheltered waters is carried out by the Swedish Maritime Administration. The Maritime Administration does this using both its own vessels, known as "state icebreakers", and hired auxiliary icebreakers. The Maritime Administration has previously had access to "Viking icebreakers" as well. The Viking icebreakers are usually used in offshore operations, but can be called in by the Maritime Administration to aid in icebreaking.

In this PM report we will calculate the socioeconomic marginal costs of icebreaking using an estimated cost function, something that has not previously been done. Earlier studies of marginal costs have been based on case studies, flat-rate calculations, and average calculations. Despite differences in the calculation methods, the estimated marginal costs found in this study are consistent with earlier results.

The calculable costs considered relevant to the socioeconomic marginal costs comprise:

- maritime operating costs, consisting of
    - share of fuels and lubricants for state icebreakers
    - share of maintenance costs for state icebreakers
    - share of the cost of the Viking icebreakers
    - hired auxiliary icebreakers
- external effects, consisting of
    - air pollution emissions
    - greenhouse gas (GHG) emissions

The foregoing costs are considered to account for most of the costs. In addition, external effects in the form of noise, traffic safety problems, water pollution, sediment changes, habitat and biodiversity losses, crowding-out and delay effects of maritime operations in connection with icebreaking, and potential cost savings for maritime operations are also considered relevant to the socioeconomic marginal costs. However, it has been impossible to calculate these effects, most of which are also considered small. The marginal costs of external effects, including GHG emissions and air pollution, is of the same order of magnitude as the marginal cost of operation. However, how the external cost of air pollution emissions from maritime operations should be determined is somewhat unclear. Two marginal costs have consequently been reported, the values of which differ depending on how air pollution is valued.

The entire calculated marginal cost is external for maritime operations, as the vessels that receive icebreaking assistance from the Maritime Administration pay no associated special

fees. Nor is the cost of air pollution and GHG emissions internalised in the operating costs, as fuel for maritime operations is tax exempt.

The estimated models indicate that the costs generally considered variable do have a fixed component that does not vary depending on how much icebreaking is carried out. This is most obvious concerning fuel and lubricant costs, but applies to the cost of external effects associated with fuel consumption as well. Conceivable explanations for this are that fuel is also being consumed when the icebreakers are not providing assistance, for example, to keep the vessels in a stationary location while awaiting an icebreaking mission, or to power the auxiliary motors that produce electricity and heat. The model used to describe fuel and lubricant costs has significantly lower explanatory power than does the model describing the cost of external effects, which is directly proportional to fuel consumption. One conceivable explanation for this is that the model of fuel and lubricant costs is sensitive to price variations (despite price indexing), while the model of external costs is based on a fixed price tied to fuel consumption.

Because the costs have a fixed component, the average variable costs overestimate the marginal costs and should consequently not be used as an approximation of the marginal costs. The more icebreaking carried out, the lower the average variable cost.

Marginal costs have been estimated for several different units (i.e., assistance missions, assisted vessels, assisted hours, running hours, assisted nautical miles, and nautical miles). In all cases, the models yielded statistically significant results and high explanatory power, which are reported in Table 0-1. This indicates that it is relevant to talk about the marginal costs of icebreaking, which has been partly called into question in earlier studies.

Table 1. Estimated socioeconomic marginal costs of icebreaking; numbers marked with * and ** are significant at the 0.1 % and 1 % levels, respectively.**

	Air pollution valued as per ASEK (2016)		*Air pollution valued as per Nerhagen (2016)*	
Socioeconomic marginal cost per	*SEK*	*Model's explanatory power (adjusted R2 value)*	*SEK*	*Model's explanatory power (adjusted R2 value)*
Assistance (state icebreakers)	66 262**	0,51	41 466**	0,48
Assisted vessel (state icebreakers)	58 284**	0,60	35 823**	0,51
Assistance (all icebreakers)	88 255***	0,69	60 522***	0,66
Assisted vessel (all icebreakers)	69 617***	0,77	49 570***	0,74
Running hour (state and Viking icebreakers)	12 706**	0,61	7 510**	0,54
Assisted hour (state and Viking icebreakers)	27 916***	0,70	16 291**	0,60
Nautical mile (state and Viking icebreakers)	1 925***	0,75	1 156***	0,68
Assisted nautical mile (state and Viking icebreakers)	3 265***	0,68	1 959**	0,62

Several models for describing a cost function and calculating the marginal costs have been tested. The issue is partly whether the cost items should be estimated separately or using a

common function, and partly whether the cost function is linear and yields a constant marginal cost or whether the cost function should allow the marginal cost to increase or decrease depending on how much icebreaking is carried out. Because the explanatory variable is the same for the various cost items, a model has been chosen that is based on a common estimation of the summed costs rather than on several cost items separately. Each estimate entails an uncertainty, and by performing just one estimate we avoid compounding these uncertainties. The differences in the results obtained using a single common versus multiple separate cost functions are, however, minor.

A linear model has been chosen with respect to the cost function. This was done because the estimated parameters were not statistically significant in most of the models that include the explanatory variable both linearly and squared.

Separate estimates were performed for the marginal costs of the state icebreakers and hired icebreakers (i.e., auxiliary icebreakers and Viking icebreakers), respectively. The marginal cost of state icebreakers is generally lower than that of hired icebreakers, even though the state icebreakers are generally significantly larger than the hired icebreakers. The Maritime Administration should be able to influence the marginal costs of icebreaking by increasing or decreasing its icebreaker fleet. If the Maritime Administration has a large icebreaker fleet of its own and does not need as many hired icebreakers, then the marginal costs will decrease even as the fixed costs rise. If the Maritime Administration has a small private icebreaker fleet and uses a large number of hired icebreakers, then the marginal costs will increase even as the fixed costs decrease.

It has not generally been possible to demonstrate that the marginal costs are dependent on the severity of the winter. No winter severity-dependent effect on the marginal costs is evident in the vast majority of the analyses. Using dummy variables, a few isolated analyses have pointed to higher costs in very mild winters.

Trafik analys

Trafikanalys är en kunskapsmyndighet för transportpolitiken. Vi analyserar och utvärderar föreslagna och genomförda åtgärder inom transportpolitiken. Vi ansvarar även för officiell statistik inom områdena transporter och kommunikationer. Trafikanalys bildades den 1 april 2010 och har huvudkontor i Stockholm samt kontor i Östersund.

Trafikanalys
Torsgatan 30
113 21 Stockholm

Tel 010 414 42 00
Fax 010 414 42 10
trafikanalys@trafa.se
www.trafa.se