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External costs of transports imposed on neighbours and fellow road users

Winslott Hiselius, Lena

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External costs of transports imposed on neighbours and fellow road users

Lena Winslott Hiselius

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Paper II. Hiselius Winslott, L. (2003) The value of road and railway safety- an overview. Earlier version published as Working paper no. 13. Department of Economics, Lund University.

Paper III. Hiselius Winslott, L. (2005) Using choice experiments to assess peoples' preferences for railway transports of hazardous materials. *Risk Analysis*, vol: 25, no: 5. Reprinted with permission from Blackwell Publishing.

Paper IV. Hiselius Winslott, L. (2005) Preferences regarding road transports of hazardous materials using Choice Experiments – any sign of biases? Under submission for publication. Earlier version published as Working paper no. 30. Department of Economics, Lund University.

1. Introduction

The allocation of scarce resources is the basis of economics.[1] A good deal of the work of economists concerns theories and tools that can be used in the aim to reach an efficient situation where the resources of society are used in the best way. In doing so, economists tend to express our resources in terms of monetary values, even for amenities such as environmental goods.[2] However, this use of monetary values has been discussed and criticised, e.g. Ackerman and Heinzerling (2004), and Mattson (2004). The criticism mainly concerns the impossibility of measuring and valuing such things as a life or clean air and the ethics of this approach.

Even if there are obvious difficulties in valuing some of our resources monetarily, policy makers make extensive use of money metrics when evaluating and prioritising policies. Often these prioritisations do not incorporate all the factors influencing judgments on the social costs and benefits of a policy. If properly done, however, they may serve as an important tool in the decision making process, Arrow et al. (1996).

Authorities in Sweden make these kinds of prioritisations on a regular basis. There is a risk incurred in the application of monetary values in the prioritisation area, though, since resources or amenities not given monetary values tend to be disregarded or at least not given as much dignity as the rest. In order to improve the policy evaluations used, efforts ought to be made to ensure that all the effects of an action or policy are considered and valued. The overall purpose of this thesis is to study various external effects of the transport system; effects that are not considered (or not fully considered) today.

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[1] In chapter 1, we use some well-known concepts from the literature in Microeconomics. See Mas-Colell et al. (2005) or Nicholson (2005) for an extensive overview.
[2] The use of monetary values within the prioritisation area may be seen as a result of mental heuristics. Weighing different actions against each other is a complex task and requires that many dimensions of the decision are handled simultaneously. The decision may then be reduced into one dimension, e.g. monetary values, in order to be handled somewhat easier. Research has shown that people tend to use different mental heuristics in order to reduce cognitive challenging choices and decisions, Tversky and Kahneman (1974). Even if experts and decision makers are in a privileged situation in terms of information concerning a decision, they may be as likely to use mental heuristics as the general public. However, heuristics alone cannot explain the widespread use of monetary values of resources or amenities in the prioritisation area. The use of a single unit that is comprehensive and easy to apply, such as a monetary unit, is appealing and gives special significance to the economic aspects of a decision.

1.1 Externalities

In an ideal world, the pricing system will produce an economically efficient distribution of all goods, services, and factors of production. This is not the case in practice since market failures, such as externalities, are present. Externalities occur when an actor disregards the effect of his action on others, resulting in an inefficient outcome. In this case, there will be too much activity causing negative externalities and not enough activity creating positive externalities.

It may be desirable to internalise negative and positive externalities, i.e. external costs and benefits, since an internalisation may result in an altered behaviour leading to a more efficient situation. One method of reducing the effect of an externality is to impose a tax (Pigovian tax) equal to the marginal external cost in the case of a negative externality (or impose a subsidy in the case of a positive externality). Another way is to use regulations and legal actions. According to the Coase theorem, problems inherent in externalities can also be solved by a regulation of property rights provided that there are no major transactions costs.

An internalisation may thus be desirable. However, there are a number of problems associated with an internalisation strategy. External costs may be difficult to internalise due to transaction costs in designing and implementing the system of internalisation, making sure the rules and regulations of the system are followed or calculating the correct charge for each actor. Furthermore, there may be several externalities present and if the intention is to internalise the external costs, all external effects should be studied since positive and negative external effects may cancel each other out. Consequently, an internalisation strategy that is relevant for one externality may not be the best solution when all effects are considered. Instead, a situation may be reached where an externality is not fully internalised. An internalisation may also be obstructed by government failures caused by electoral pressures or pursuit of self-interest amongst politicians and policy makers, leading to inappropriate government spending and tax decisions. In this situation, the government intervenes to correct for externalities but ends up making things worse.

Risky behaviour often involves externalities. Laws and regulations are therefore frequently used to prohibit or regulate undesirable behaviour. For instance, in most countries, drunk or dangerous driving is a crime for which the Court may impose a fine or imprisonment. However, in order to be effective the penalties for breaking the law must be sufficiently harsh, and the inspections must be sufficiently frequent and rigorous.

1.2 Benefit–cost analysis

The costs considered in a benefit-cost analysis (BCA) are often external costs that the project of concern imposes on others and for which they are not being compensated. In a BCA, a project is evaluated by comparing the total costs, e.g. construction and maintenance costs, with the total benefits, e.g. reductions in travel time and in the number of accidents and improved environment.[3] A project is typically given the go-ahead if the benefits exceed the costs. This strategy is an application of the Kaldor-Hicks criterion where an activity is desirable if those that benefit from it could potentially compensate those that lose. Translated into BCA terms, the benefits of a project should be enough to compensate for the costs.

It is, however, important to distinguish between different types of external effects. There are pure externalities, having direct impact on others without being reflected in market prices. There are also pecuniary externalities, which operate through prices. These effects are often of secondary nature and not additional to those included in a BCA. For instance, low property values in areas near major roads and railways are likely to be an effect of noise, emissions, and vibrations caused by the activity nearby. Consequently, if the values of these nuisances are considered as well as reduced property values, there will be a double counting in the BCA.

1.3 Transport pricing

The transport sector is the area of interest of this thesis. Here, transport pricing is a generic term for charging for the use of roads and railways. For instance, road users may pay directly for driving on a particular road or in a particular area by road tolls or congestion pricing, or indirectly by gas-taxes, or other types of taxes. Users of the railway may pay user-fees to the maintainer per distance and number of wagons. Besides raising money to cover the construction costs or to build new facilities, an implementation of transport pricing may reduce traffic impacts such as congestion, pollution and accident risk. This type of pricing has also been discussed as a way to shift road transports to environmentally more friendly modes of transport, see e.g. European Commission. (1995).

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[3] See Just et al. (2004) for an overview of project and policy evaluation.

The basic principle behind transport pricing is that a user should pay the costs that he or she causes. The costs considered are largely external and imposed on the maintainer, fellow users, people living nearby, and on society in general. The amount of research on road pricing is extensive whereas the theory behind railway pricing is less developed, see Lindberg (2003) for an overview of the recent progress of transport pricing reforms.

1.4 Estimating individual preferences

When carrying out a BCA, the effects of a project or activity are quantified and normally assigned monetary values. In doing so, it is often argued that the valuation of societal investments should reflect as far as possible the values the affected population puts on the effects, see e.g. Beattie et al. (1998). Some effects can easily be measured through market prices, e.g. investment costs and operational costs. Non-monetary effects, e.g. pollution, noise nuisance, and various other inconveniences, on the other hand, may be hard to value. The general principle employed is to try to find out the value people place on obtaining the benefits or avoiding the costs.

There are broadly two empirical approaches to estimating non-market values. These are labelled the revealed preferences approach and the stated preferences approach. The revealed preference approach involves inferences from people's behaviour and implicit trade-offs that individuals make. For instance, by looking at house prices around airports compared to elsewhere, the value of a reduction in noise nuisance can be measured. A problem with this approach is finding directly comparable cases elsewhere. Since many other factors, besides noise, affect house prices, there is a need to disentangle the effects of noise nuisance from all these other influences. In the stated preference approach, the valuation is based upon the responses of individuals to questions about what their actions would be if a particular hypothetical situation were to occur. The advantage of the stated preference approach is that it is possible to ask questions directly about the trade-off between the activity in question and money. It is also possible to consider a wider and more systematic range of trade-offs than in the revealed preference approach.

The contingent valuation method, discussed in e.g. Mitchell and Carson (1989), is a direct stated preference approach where individual preferences are studied. By means of a questionnaire, a hypothetical market is described where the good or service in question is

traded. Respondents are then asked to express their maximum willingness to pay for a hypothetical improvement in the level of the provision of a good or service or their minimum sum of compensation in order to forego the improvement.

Another stated preference approach is the choice experiment method, Hanley et al. (2001) and Bateman et al. (2002). This method is a survey-based methodology for modelling preferences, where the activity is described in terms of the attributes and the levels that the activity takes. Respondents are presented with various alternative descriptions of the activity, differentiated by the attributes and levels, and are asked to rank the various alternatives, to rate them or to choose their most preferred. By including price or costs as one of the attributes of the activity, the individual willingness to pay can be indirectly obtained from people's rankings, ratings, or choices. The choice experiment method has been widely used in market research and transport literatures, e.g. Green and Rao (1971) and Hensher (1994) and is now being increasingly used in other areas such as environmental economics and health economics e.g. Hanley et al. (2003) and Ryan and Gerard (2003).

Both the contingent valuation method and the choice experiment method can be used to measure all forms of values including non-use values. The methods build upon Lancaster (1966) assuming that consumers' utilities for goods or services can be decomposed into utilities for composing characteristics. The choice experiment method has been argued to possess some advantages over the contingent valuation method, especially when studying non-market goods, Hanley (1998), Hanley et al. (2001), and Alpizar et al. (2001). One argument is that it may be desirable to obtain valuations of all non-market goods in conjunction rather than on a one-by-one basis. This is important because in e.g. transport policy making, trade-offs of several non-market goods are made. Given this study design, one may also argue that people are forced to realise that they cannot get everything but have to make trade-offs between conflicting policy objectives. Furthermore, in a choice experiment, a respondent is usually asked to rank or rate a number of alternatives or to perform a sequence of choices. In this way, more information is elicited from each respondent compared to the contingent valuation method.

The stated preference approach has been criticised, though, since there are several problems inherent in an estimation of individual preferences based on stated responses, e.g. Kahneman and Knetsch (1992) and McFadden (1999). Biases associated with the contingent valuation method have been explored in a number of studies, but analyses of biases when using the choice experiment method are so far limited in number. One general problem concerns the hypothetical nature of the stated preference approach, which may lead

respondents to misrepresent their true opinions for cognitive as well as strategic reasons. An additional source of a hypothetical bias may be the so-called warm glow effect. This effect occurs since people may be purchasing moral satisfaction rather than expressing a value of, for instance, environmental changes. Hypothetical biases may also occur since each study focuses on the issue in question and this focusing effect tends to magnify the stated willingness to pay for improvements. It has also been argued that the stated preference estimates are insensitive to the size of the change being offered. The estimates have also been shown to depend on the study design, e.g. the payment vehicle and the type of information given.

In spite of these shortcomings, stated preference studies are relevant and may serve policy-makers with important and credible information if carefully designed and carried out, Carson et al. (2001).

2. Benefits and costs in the transport area

In this thesis, we focus on economic analyses within the transport sector. Carrying out BCAs for transport investments is a complex task since transport activities have consequences for a wide range of actors, e.g. travellers, companies carrying out passenger and freight services, people living nearby, and maintainers of the infrastructure. The effects that should be considered can be listed as follows:
- Economic effects of traffic, e.g. construction costs, maintenance costs, and revenue and operational costs of the transportation actors.
- Effects imposed on those taking part in the activity, e.g. travel time, travel comfort, safety, and accessibility.
- Effects imposed on people not taking part in the activity such as people living next to a road, e.g. noise nuisance, emissions, vibrations, and safety.
- Environmental and land-use effects: barrier effects, e.g. water protection, environmental protection, recreation, and general aspects of landscape and cities.
- General effects, e.g. equality between the sexes and economic activity in the area.

In theory, all effects should be included in a BCA, regardless of whom the effects fall upon. Not all effects are considered in the transport area, though, when BCAs are carried out

in practice, e.g. the Swedish National Road Administration, SNRA, (1989). Of those effects considered, not all are given monetary values. There are effects that are assigned monetary values on a market and these effects can often be given monetary values directly, e.g. construction costs in infrastructure, costs and revenues of the transportation actors. There are also effects in case of an accident that can be valued more or less directly, e.g. property damages, lost production due to absence from work, activities of the police, and medical treatment of casualties.

However, there are also effects that are problematic to value economically, e.g. non-market commodities such as noise nuisance, travel time, and comfort. Additional non-market effects are the pain, grief, and suffering that arise from accidents. Instead, these non-market costs and benefits may then be assigned monetary values by studying individual preferences, i.e. using the methods described previously. For instance, the cost due to the pain, grief, and suffering that an accident results in may be estimated as the amount individuals are willing to pay to avoid a casualty, i.e. to reduce the risk of an accident. Early references within this area are Schelling (1968) and Mishan (1971). In the transport area, there are also effects considered that are not valued monetarily due to problems estimating the size of the effect, e.g. accessibility for disabled and equality between women and men. Instead, an indication is given of whether the effect is one of improvement or deterioration.

In spite of efforts made to consider all the benefits and costs of a transport activity there are shortcomings. The aim of this thesis is to improve the calculation of external costs within two areas of the transport sector. The first area to be studied is the marginal effect of the traffic flow. Currently, the external effect of the traffic flow is only partially considered due to lack of knowledge of the relationship between the traffic flow (homogeneous and inhomogeneous) and the accident frequency. The other area to be studied is the transport of hazardous materials by road and railway. There are possible shortcomings in the calculation of external costs carried out today in that some external costs are disregarded, and furthermore, the same value of safety is applied within the road and railway sectors.

2.1 External costs of the traffic flow

Transports give cause to a number of external effects. Focusing on the external cost of traffic accidents, Elvik (1994) identifies three types of external costs that are imposed on others and

not borne by the person whose activity generates the cost; a system externality, a traffic flow externality, and a physical externality. The system externality is the accident cost imposed on the rest of society and not borne by road users as such, e.g. costs of medical treatment and administrative costs. The physical externality is the cost that one group of road users imposes on another in crashes involving both groups, e.g. the cost a car driver imposes on pedestrians and cyclists. This type of externality is also denoted as traffic category externality, e.g. in Lindberg (2001). The traffic flow externality is the marginal cost (or revenue) of an additional road user if an additional user changes the accident risk for other road users.

It may be desirable to internalise the external accident cost, e.g. by pricing the divergence between the social and the private marginal cost, since an internalisation is supposed to change driving behaviour and to reduce the number of accidents. In an ideal situation, a separate cost function should be estimated for each individual and vehicle, as the external cost is dependent on various factors. However, in order to calculate the external accident cost empirically, various assumptions and simplifications have to be made. For instance, the external accident cost is often calculated as an average external cost per vehicle and kilometre driven, under the assumption that there is no traffic flow externality, e.g. Jones-Lee (1990), Elvik (1994), and Persson and Ödegaard (1995). In this case the accident rate, i.e. the number of accidents per vehicle, is assumed to be constant and unaffected by the traffic flow. There are studies estimating the marginal external accident cost that not only consider the system and physical externality but also the traffic flow externality, e.g. Newbery (1988) and Jansson (1996). These models are further developed in Lindberg (2001) where the heterogeneity of cars is regarded. His model considers that the physical externality may also consist of external costs imposed by one road user on other road users of the same category. According to his model for multi-vehicle accidents, the external marginal accident cost consists of six components.[4] Cost-component a equals the road users' valuation of a reduction in the accident risk. Since this is a purely selfish value there may be an additional value that relatives and friends outside the household may be willing to pay for a reduction in the accident risk for a road user. Consequently, cost-component b equals the valuation of a risk reduction that relatives and friends of the road users may have. Cost-component c equals the cost imposed on society at large due to the system externality. The other components in the model of the marginal external accident cost are the examined road user's risk of being involved in a multi-vehicle accident, r, the share of the total accident cost per collision that is

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[4] A similar expression can be derived for single-vehicle accidents by setting $\theta = 1$ and interpreting E as the single-vehicle accident risk elasticity, Lindberg (2001).

already borne by the examined user, θ, and the risk elasticity, E, if the accident risk is affected by the traffic volume. Based on these components the marginal external accident cost can be calculated as:

$$MC = r \, (a + b + c) \, [(1 - \theta) + E] + rc\theta \tag{1}$$

It is often assumed that the road user understands his own risk and consequently already bears the value related to his own risk of being a victim. Consequently, in Lindberg's model the examined road user is assumed to internalise the expected cost related to his own risk, a, and the risk value expressed by his relatives and friends, b. Accident costs defined as external, and thus included in the cost-component c, are the accident costs disregarded or not fully regarded by the examined road user. These costs are, according to e.g. Elvik (1994) and Persson and Ödegaard (1995), costs of lost production, medical treatment, administrative work, and material damages.

If the number of accidents increases in proportion to the traffic volume, the accident risk will be constant and the risk elasticity will be nil. If the number of accidents increases less than proportionally with the traffic flow, the accident risk will decrease and the risk elasticity will be negative. In this case the accident risk reduces for other road users when an additional road user joins. Finally, if the number of accidents increases more than proportionally with the traffic flow, the accident risk will increase and the elasticity will be positive. In this case, an additional vehicle will impose an increased risk on other road users. Consequently, in order to estimate the marginal external accident cost, we have to determine the relationship between the accident risk, i.e. the risk elasticity, and the traffic flow.

Accidents are generally studied separately for urban and inter-urban roads e.g. Lord et al. (2003), and Golob and Recker (2004) and for intersections and links, e.g. Kulmala (1995) and Hiselius (2004). With regard to accidents involving only motor vehicles on urban road links, the general result of the literature suggests that the accident risk is independent of the traffic flow. For accidents at urban intersections empirical evidence indicates an increasing relationship between the accident risk and traffic flow. In the literature for rural road types, the estimated relationship between the traffic flow and the number of accidents show a great variation. An early report from Vickrey (1968) suggests that the marginal accident rate is 1.5 times the average accident rate. On the other hand, Vitaliano and Held (1991) cannot detect any significant increase in the accident rate as the traffic flow increases and, according to

Hauer and Bamfo (1997) and a majority of the results reviewed in Ardekani et al. (1997), the accident rate even decreases with an increasing number of vehicles. There are also findings suggesting that the accident rate of single vehicle accidents decreases and the accident rate of multi vehicle accidents increases as the traffic flow increases. Only a few empirical studies analyse the effects of the traffic flow separated for different road user groups, though, e.g. Jovanis and Chang (1986), Hiselius (2004), and Lord et al. (2004). The results of these studies are quite diverse, indicating both increasing and decreasing accident frequencies as the number of cars and lorries increases.

Thus, research suggests that the relationship between the traffic flow and the accident frequency varies, depending on whether we are studying urban/interurban areas and intersections or links and whether we are considering different road user categories and accident types. It is thus important to recognise that the estimated marginal external accident cost is specific for the situation studied and for the circumstances considered.

When the effect of the traffic flow has been analysed empirically, together with the distribution of the accident cost in collisions, the marginal external accident cost can be calculated using, for instance, the model in Lindberg (2001). Monetary values are then assigned to the accident cost, i.e. the cost-components a, b, and c in Equation 1. The road users' willingness to pay for a marginal reduction in the accident risk, cost component a, is estimated in e.g. Persson et al. (2001) and de Blaeij et al. (2003). This value is sometimes referred to as the value of a statistical life. There are few studies estimating the valuation of relatives and friends, cost component b, though. The findings of e.g. Schwab Christie et al. (1995) and Lindberg (1999) do suggest a value of 40% of the value of a statistical life, i.e. 40% of cost-component a. Finally, the external accident costs due to the system externality, cost component c, are for instance calculated by Elvik (1994), and Persson and Ödegaard (1995).

2.2 External costs of transports of hazardous materials

In 1994, an economic model was developed in Sweden for projects concerning transports of hazardous materials by road and railway, Persson and Svarvare (1994). This model considered the following cost components when estimating the incremental costs of accidents involving hazardous materials; costs due to medical treatment, loss of production, the value of

the risk reduction itself, loss of time, rescue operations, decontamination, loss of crops, damage to property, and environmental pollution. Due to lack of relevant estimates, the value of a risk reduction calculated for an average road accident, as used by the Swedish National Road Administration, was applied when transports of hazardous materials by both road and railway were studied. This application can be questioned since research suggests that we ought to distinguish between different kinds of accidents as well as between different transport modes, possibly assigning different values to them, see Hiselius (2003) for an overview. Psychologists have provided extensive evidence indicating that the public's perceptions of, and attitudes to, risk may vary substantially over different hazards, see Fischhoff et al. (1978), and Slovic et al. (1980) for early references. The main argument for assessing risks differently is that the characteristics of a situation, in which the hazard is encountered, affect us differently.

Based on the research presented in Hiselius (2003) we can find arguments for the use of a higher value of preventing a fatality within the railway sector than in the road traffic sector. For instance, there are quite a few characteristics of railway hazards, e.g. involuntary, incontrollable, and large sized accidents, which indicate a preference for reducing risks in this sector compared to risks in the road traffic sector. Furthermore, accidents within the railway sector occur infrequently. One may then argue that railway accidents are characterised both by uncertainty regarding the consequences and by unknown probabilistic properties (i.e. genuine uncertainty) of an accident. Road accidents on the other hand occur on a daily basis and we have knowledge of both their probability and outcome. Based on the theory of risk aversion and uncertainty aversion, presented in Hiselius (2003), one may then argue that individuals prefer risk-reducing investments in the railway sector to such investments in the road traffic sector.

Consequently, there may be reasons to study each transport area separately in order to extract a relevant value of safety. When preference-based values of marginal risk reductions have been estimated empirically within the railway and road contexts, some disparities have indeed been shown, e.g. Jones-Lee (2001), Chilton et al. (2002), and Bäckman (2002). The size of the calculated disparity is, however, not of the same magnitude as the disparity that can be observed when studying safety levels.

Research has also proven that individuals tend to value reductions in different hazards differently, i.e. we are likely to value a reduction in an average road accident differently from an accident involving hazardous materials, Kraus and Slovic (1988). Thus, these findings

suggest that we ought to study values of safety not only for different transport modes but also for different accident types.

Diversifying the analysis of different accident types involves difficulties, however, since we are likely to deal with very small probabilities. Research has shown that people have difficulties estimating and understanding probabilities, especially small ones. The standard result in the literature, e.g. in Lichtenstein et al. (1978) and Slovic et al. (1980), has been that people over-assess low probability events and under-assess larger risks, leading to the well-established size-related bias in risk perceptions. These differences have been explained by the use of mental heuristics, Tversky and Kahneman (1974). They suggest that people use heuristics in order to simplify the task of estimating probabilities, which may lead to systematic bias in risk estimation. These circumstances suggest that estimating individual preferences regarding small changes in risk is a difficult task, especially when studying very small risks such as the risk of an accident involving hazardous materials. The accident outcome of an accident involving hazardous materials is furthermore very diverse, depending on type of substance involved, speed of leakage, weather conditions etc.

In order to study individual preferences regarding transports of hazardous materials, a more suitable approach may be to analyse people's preferences regarding a change in the exposure to hazardous materials, e.g. the number of wagons or lorries per day carrying hazardous materials, rather than a change in the accident risk. In this case, we may avoid the problems connected with the use of small probabilities and diverse accident outcomes. We may also capture costs that are not directly connected with an accident as such. This is an important aspect since there may be negative effects, i.e. costs, other than those directly connected with an accident involving hazardous materials, which ought to be considered when studying the costs and benefits of a transport investment project. These effects may be the ones that people living nearby experience on a daily basis, and not just associated with a leakage of hazardous substances. For instance, people living nearby may also be anxious in cases when there has only been an incident, i.e. an accident with no leakage. In this situation, people are often very distressed and may panic until information about the outcome is given and, furthermore, they may have to leave their homes during the clearing up. This mental stress and the inconvenience of an evacuation may be seen as negative external effects that ought to be valued.

Adler (2004) defines distressing mental states as a welfare loss and coins the term fear assessment. In the abstract of his paper, he says:[5]

> Risk assessment is now a common feature of regulatory practice, but fear assessment is not. In particular, environmental, health and safety agencies such as EPA, FDA, OSHA, NHTSA, and CPSC, commonly count death, illness, and injury as costs for purposes of cost-benefit analysis, but almost never incorporate fear, anxiety, or other welfare-reducing mental states into the analysis. This is puzzling, since fear and anxiety are welfare setbacks, and since the very hazards regulated by these agencies - air or water pollutants, toxic waste dumps, food additives and contaminants, workplace toxins and safety threats, automobiles, dangerous consumer products, radiation, and so on – are often the focus of popular fears. Even more puzzling is the virtual absence of economics scholarship on the pricing of fear and anxiety, by contrast with the vast literature in environmental economics on pricing other intangible benefits such as the existence of species, wilderness preservation, the enjoyment of hunters and fishermen, and good visibility, and the large literature in health economics on pricing health states.

Thus, when studying transports of hazardous materials it is of interest to estimate costs directly associated with an accident involving hazardous materials as well as costs caused by the transports of hazardous materials as such. To the knowledge of the writer, Hiselius (2005a) and Hiselius (2005b) are the only studies carrying out this type of analysis using exposure as an alternative way to communicate risk. The results suggest that this is a practicable way. The approach is similar to the method used when studying individual's preferences towards e.g. ferry traffic, airports, and nuclear plants, Kriström (1997), Carlsson et al. (2004), and Zweifel et al. (2005).

When applying the results of the studies previously mentioned, including those of Hiselius, it is important to keep in mind that changes in existing activities are studied. The applicability of the results on new activities is therefore limited. In addition, since the activities studied have been present for some time, it is possible that the respondents living nearby are selected based on their preferences regarding the hazardous activity. In this case, individuals living close to the hazard may consider e.g. transports of hazardous materials less dangerous than individuals living further away do. Consequently, the preferences of people living nearby may differ from the preferences of a non-selected population.

Furthermore, in order to use this method and its estimates in the decision-making process, we have to analyse more deeply what costs the respondents consider when stating

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[5] The abstract of this paper is presented on the internet at the following address:
http://lsr.nellco.org/upenn/wps/papers/16

their choices. If, for instance, respondents consider damages to property when stating their preferences regarding a change in exposure to transports of hazardous materials, this cost should not be included as an additional item in the BCA. There are also reasons to explore whether the effect of hazardous transports can be separated from the effects of other transports or traffic, i.e. whether it is feasible to ask respondents to consider other effects, e.g. noise nuisance and emissions, as unchanged.[6] This kind of separability is assumed in Hiselius (2005a) and Hiselius (2005b). Potentially, however, exposure may be more applicable when studying all the effects of an activity together.

There is also a question concerning how the estimated values should be applied when calculating the welfare measure for possible scenarios.[7] Regression models applied in the analysis of a choice experiment often involve an intercept term, a so-called alternative specific constant (ASC). This term may be estimated separately for each alternative but one in the choice set, or jointly for all but one of the presented alternatives. The use of ASCs depends on the type of choice experiment carried out. If each alternative is labelled and represents a special case, e.g. type of transport mode or medical treatment, the ASCs may capture effects not given by the attributes that are used. On the other hand, if the alternatives represent a variation of a single activity and a status quo option is included, a common ASC estimated for the proposed alternatives may capture the utility (or disutility) of moving away from the current situation, all else equal. In this case, the general finding is that the ASC is significant and negative, which indicates a preference for the current situation.

There is no consensus in the literature concerning the interpretation of the ASC and whether it should be included when calculating welfare estimates. Some studies exclude the ASC even if it is included in the model, e.g. Algers et al. (1995) and Adomowicz et al. (1998). In these studies the intercept term is interpreted as an endowment effect or an artefact of the stated preference survey methodology. The omission of the ASC is then justified on the grounds that even though it may improve the model fit, it is not related to specific attributes and hence does not explain choice in terms of observable attributes. A criticism of this approach is that it is not usual statistical practice to drop a part of the best fitted model ex post for predictive interpretations, Li and Hultkrantz (1999). Morrison et al. (2002) argue that

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[6] The result of Hiselius (2005a), suggests in part that it is possible for individuals to distinguish the effects of transports of hazardous transports from other effects. In this study, it is shown that the level of information given in the questionnaire on accidents involving hazardous materials affects the preferences being stated. If a number of other effects, i.e. other than the ones directly connected with hazardous materials, are being considered when the preferences are stated, the level of information included may be shown to be less important.

[7] The welfare measure, i.e. the compensating variation, measures the change in household income needed to bring the household back to the original utility level after a change has occurred.

given that the ASC explains real parts of the respondents' choices, the intercept term ought to be included in the welfare estimation process. In addition, if moving away from the current situation involves a decision cost for the respondent, this is a cost that ought to be reflected in the welfare measures. Another way to deal with the problem is to estimate welfare measures both with and without the ASC, e.g. Abou-Ali and Carlsson (2004). The case without an intercept is then argued to be a measure of the WTP, given that the respondents are willing to make a trade-off. Li and Hultkrantz (1999) suggest that an inclusion of the intercept term is not plausible since it may predict a negative marginal value for, for instance, travel time savings below a certain threshold value. Instead, alternative analysis models that consider individual threshold values can be used.

Thus, there is no simple answer to how to deal with the ASC since different interpretations give different applications. Until we have a better understanding of the individual behaviour and decision making process in stated preference studies, it is, in my opinion, more risky to exclude the intercept term in the process of welfare measures than to include it.

2.3 Whose preferences are to be considered?

For long, the value of safety used in the road traffic area has been based on individual preferences. This use seems to be well established. However, the use of individual preferences as a base for investments has been questioned in other areas, e.g. in decisions concerning transports of hazardous goods and the location of nuclear plants. Instead of individual preferences, one may rely on "expert opinions" from policy makers, expert panels, and stake-holder groups. The use of expert opinions has been motivated by an uncertainty regarding the dignity of individuals' preferences for complex activities of which they have very little or inaccurate information. These activities tend to be characterised by low accident frequencies and unfamiliar or unknown accident outcomes. Transports of hazardous materials may be seen as such an activity. Can individuals living near these transports possibly be the ones to decide where and how transports of hazardous materials should be carried out, and even "worse" express preferences about prevailing transports, which are then applied to new investments involving people elsewhere?

Beattie et al. (1998) discuss various arguments for and against resource allocations based on individual preferences. The authors conclude that individual perceptions may play an important role for public expenditure even though there are cases where the preferences stated are likely to be biased. At the same time, it is stressed that individual preferences should not be the only input into decisions. Instead, they may be given an advisory or information-providing role rather than a decisive role.

In addition, when discussing transports of hazardous materials, the negative effect is not entirely connected with probabilities of accidents of different types. Even though people in general have a biased knowledge of some probabilities, they do have an unbiased judgement of their anxiety and distress and who can estimate this nuisance but the people being affected?

3. Summary of the thesis

Analysing all the effects of a transport system is a demanding and information-intensive activity. The purpose of this thesis is to contribute to the knowledge of some effects that arise from road and railway transports and the monetary values that may be assigned to these effects. It also contributes to the development of the choice experiments method in the area of risk analysis. The aim and results of the four papers are briefly summarised here and more thoroughly presented in the following sections.

The thesis consists of three empirical papers and one literature overview. The first paper, Hiselius (2004), examines the relationship between the frequency of road accidents and the traffic flow. This relationship is studied since external costs may occur due to the effect of the traffic flow on the number of accidents. An external cost may then arise since the road user, who causes the cost, does not take into account the fact that the accident rate may be affected by his or her presence on the road.

The second paper, Hiselius (2003), is a literature overview that discusses factors possibly influencing individuals' perception of risk and their willingness to trade risk for money. The study seeks to combine results, from e.g. the field of psychological studies, with work performed by economists in order to analyse whether the value of preventing a statistical life can be expected to differ between the road and railway sectors.

The last two papers concern the costs and effects induced by transports of hazardous materials on people living nearby. Railway transports are studied in Hiselius (2005a) and road

transports in Hiselius (2005b). In both studies, exposure is used as a proxy for risk. This approach is used since we are dealing with very small probabilities that may be hard for the respondents to understand and relate to other risks. Furthermore, outcomes in the case of an accident involving hazardous materials may be quite diverse depending on the specific circumstances of the accident. Since the risk faced by people is closely related to the degree of exposure to hazardous materials, a more suitable approach may be to investigate preferences with respect to changes in this kind of exposure. The studies are carried out using the same study design in order to explore similarities and differences in individuals' preferences regarding transports of hazardous materials by road and by railway.

3.1 Paper I: Estimating the relationship between accident frequency and homogeneous and inhomogeneous traffic flows

One type of externality that may occur due to traffic accidents is the traffic flow externality, see section 1.2. Depending on the shape of the relationship between the traffic flow and number of accidents, there may be a positive traffic flow externality (decreasing accident rate) or negative traffic flow externality (increasing accident rate) or no traffic flow externality at all (constant accident rate). In this paper we test the hypothesis that the number of accidents increase in proportion with the traffic flow, i.e. the accident rate is constant and independent of the traffic flow. If this hypothesis is rejected a traffic flow externality may be defined.

The data set of this paper is limited to motor vehicle accidents and the flow of motor vehicles on links in rural areas in Sweden. In this way we disregard the external effect on unprotected road users and the external costs occurring in urban areas. These limitations are bound to affect the result since research has shown that the relationship between the number of accidents and the traffic flow is dependent on road type and area studied as well as on the road user categories and the accident types considered, see section 1.2. The application of the results of this paper is therefore limited to an estimation of the marginal external accident cost arising from the traffic flow externality for motor vehicles on links in rural areas. Since we are disregarding the effect of the traffic flow on unprotected road users, only reciprocal externalities are considered. On the other hand, the result is useful for road pricing on selected links, e.g. with road toll systems, where there are no unprotected road users present.

The aim of this paper is to estimate the relationship between the accident frequency and the traffic flow treated as both homogeneous, i.e. consisting of homogeneous vehicles, and inhomogeneous, i.e. consisting of cars and lorries. The data set, received from the Swedish National Road Administration, consists of motor vehicle accidents and traffic flows occurring on link-sections in rural areas of Sweden over a period of 6.5 years. Information on the traffic flow is treated in two different ways. In line with other studies, the traffic flow is assumed to consist of a single traffic mode, i.e. all vehicles are treated as if they are alike. However, since the driving speed and weight vary between different types of vehicles, it is unlikely that they affect the accident frequency and the accident outcome in the same way. Therefore, the traffic flow is also separated into two traffic modes, cars and lorries.[8] The result is analysed for both alternative ways of treating the traffic flow, in order to establish whether it is important to consider different types of vehicles. Poisson and Negative Binominal regressions are used.

This paper suggests that the estimated relationship between the expected number of accidents per hour and kilometre, and the traffic flow differs considerably depending on whether different types of traffic modes are considered or not, i.e. whether a homogeneous or a inhomogeneous traffic flow analysis is carried out. In the homogeneous traffic flow analysis regarding accidents that have occurred throughout the day, we reject the hypothesis that the expected number of accidents increases proportionally with the traffic flow for the majority of road types studied. Instead, there is a decrease, i.e. a positive externality.

As cars constitute the main part of the traffic flow, one may expect the outcome, with respect to the number of cars per hour, to be similar to that of the homogeneous traffic flow analysis. The indication is, however, that the expected number of accidents increases in proportion, or more, to the number of cars per hour. In the same way, studying the effect of an increasing number of lorries, one might expect that the presence of more lorries on the road would increase the frequency of accidents since the incidence of possibly dangerous overtaking manoeuvres increases. This paper indicates, however, that at a given number of cars per hour, the expected number of accidents will decrease with an increasing number of

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[8] In this study the traffic mode "car" is defined as cars with and without trailer, light lorries with and without trailer and motorcycles. Heavy lorries with and without trailer are defined as the traffic mode "lorry". The reasons for these definitions are that, for each group, the same type of driving license is required and similar speed limits are used. The type of the vehicle passing the sensors is distinguished by its length between the axles. Complicated traffic situations, for instance when vehicles are passing the sensors simultaneously, can cause problems when distinguishing the number and type of vehicles. A technique called imputation is then used to complete the data that is lost. In these cases, information about the traffic flow that passed just before is used. If the level of imputation is too high, the data will be treated as totally lost. There are also cases when data for the traffic flow is lost for a longer period due to technical failure of the sensors, etc. Information of variation patterns and trends in the traffic flow from adjacent complete periods is then used.

lorries per hour. This safety effect of lorries may be regarded as counterintuitive at first glance. It is, however, possible that the number of accidents decreases as an effect of a speed reduction, as the speed limit for lorries is lower than for cars. An increasing number of lorries per hour will accordingly slow down the average speed. With respect to the flow of lorries this may also be due to people's unease when sharing the road-space with a lorry, causing their attention to increase. Hence, important information is lost if no consideration is given to vehicle type.

3.2 Paper II: The value of road and railway safety - an overview

It can be argued that the level of safety investments varies between sectors. The safety investments legally required and carried out in the railway sector indicate that there is a higher implicit value placed on preventing a fatality within the railway sector than within the road sector. In order to analyse whether the value of preventing a statistical life in the road traffic sector is different compared to the railway sector, the literature overview discusses factors possibly influencing individuals' perception of risk and their willingness to trade risk for money. This paper combines results from e.g. psychology, sociology, and decision theory with work performed by economists.

As mentioned previously, legislated safety standards in the railway sector imply that the value of prevention of a rail fatality greatly exceeds its road counterpart. The disparity is also supported e.g. by the literature on people's risk perception. Psychologists have provided extensive evidence indicating that the public's perceptions of, and attitudes to, risk may vary substantially over different hazards. Based on the research presented in the literature overview, we can find arguments for the use of a higher value of preventing a fatality in the railway sector than in the road traffic sector. For example, unlike road hazards, railway hazards may be seen as involuntary and incontrollable. Furthermore, when rail accidents occur they tend to involve more people and larger areas than road accidents. Road accidents, on the other hand, occur on a daily basis, which gives us knowledge of both their probability and outcome. These circumstances indicate a preference for reducing risks in the railway sector compared to the road sector.

When preference-based values of marginal risk reductions have been estimated in the railway and road contexts, some disparities have indeed been shown. The size of the

calculated disparity is, however, not in the same range as the disparity that can be observed when studying actual safety levels.

This can be interpreted in two ways. If we believe that the elicitation method used is correct and the estimated values of preventing a rail fatality are unbiased and consistent, this in its turn suggests that the value of preventing a rail fatality, implied by e.g. legislated safety levels, is grossly overestimated. An important task is then to call attention to this problem and to support an alteration of the safety policy, see Jones-Lee (2002). If we, on the other hand, believe that the values implied by safety standards etc, do reflect individual preferences, we then have a methodological problem of trying to find better methods to estimate preference-based values of safety. Different approaches are discussed in, for instance, Beattie et al. (1998).

Research indicates, furthermore, that the variation of perceived risk within the context of one traffic mode may be as large as, or even larger than, the variation between different traffic contexts. This implies that studies estimating the value of a statistical life should focus not only on disparities between transport modes *per se*, but also on disparities between accident types.

3.3 Paper III: Using choice experiments to assess people's preferences for railway transports of hazardous materials

The main purpose of this paper is to investigate the potential of choice experiments for modelling preferences regarding changes in the exposure to hazardous materials transported by rail in order to assess the costs and benefits of different transport configurations. To the best knowledge of the writer, this is the first time a choice experiment study is being carried out using exposure as a proxy for probabilities and accident outcomes. The exposure to hazardous materials is described by three attributes; the number of wagons per day; the hazardousness of the hazardous material being transported and the time of transportation.[9] Due to the novelty of this method and the complexity of the activity studied, special attention is given to the viability of the approach. The response rate and a test of consistency are

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[9] The levels used for the attribute *number of wagons per day* equals twice as many as today, the same number as today; half as many as today, and no wagons at all. Since people may have problems distinguishing between twice as many and half as many, the attribute levels are described in numbers rather than words in the choice sets.

discussed to assess whether the choice experiment method can be usefully applied. Moreover, the preferences of people exposed to the transportation of hazardous materials and the determinants of these preferences are estimated and compared with a priori theoretical expectations, giving an indication of internal validity. The values people place on changes in their exposure are also tentatively calculated. Referring to the exposure to hazardous materials highlights the importance of providing the respondents with adequate information in order to help them understand the consequences of an accident and the size of the accident risk. A further objective of this paper is then to study the effect of background information on the preferences being stated. The data set, used to analyse transports of hazardous material by rail, consists of a mail survey involving 600 individuals in the city of Lund and 400 in the city of Borlänge.[10]

This paper suggests that the choice experiment approach can be used to estimate people's preferences regarding different configurations of the transport of hazardous materials by rail, despite the complexity in the activity studied and in the choice experiment method used. The response rate was 45-60% and internal consistency was indicated by a test within one of the six blocks of questionnaires. In the Lund sub-sample, all 25 respondents answered consistently, whereas 3 of 12 respondents answered inconsistently in the Borlänge sub-sample. The application of this method is also supported by the internal validity, i.e. the estimated parameters are of expected sign. A reduction in the number of wagons with hazardous materials and a reduction in the degree of hazardousness increase utility, and people are thus willing to pay for these improvements or they demand compensation for changes for the worse. The overall finding suggests that level of information and distance to the railway may affect valuations and so does the status of one's residential owning. The effect of time of transportation is inconclusive. This is not necessarily surprising, as a change in the time of transportation of hazardous materials can be interpreted as affecting people's exposure and safety both negatively and positively, leaving the summed effect insignificant.

The major result of this paper is that the choice experiment method seems applicable even in a setting with numerous difficulties. Furthermore, the analysis reveals that the choice experiment approach may provide a rich description of people's preferences and the determinants of their preferences.

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[10] A questionnaire providing substantial information on transports of hazardous materials and used in the Lund sub-sample is presented in Appendix A. For the Borlänge sub-sample necessary adjustment are made in the text.

3.4 Paper IV: Preferences regarding road transports of hazardous materials using Choice Experiments – any sign of biases?

In this paper, people's preferences regarding transports of hazardous materials by road are assessed using the choice experiment approach. Road transports are thus studied using the same method and study-design as in the previous paper on railway transports.[11] In a mail survey involving 2000 individuals in Stockholm, exposure to hazardous materials was used to describe different transport configurations for lorry transports.[12] The results were analysed in the light of the previous paper on railway transports, with special attention given to biases associated with the choice experiment method. The presence of hypothetical bias was explored by the use of self-reported degree of confidence that the respondent would express the same preferences in a real referendum as in this study, and the presence of a focusing effect was explored by an inclusion of information on other fatal risks in half of the questionnaires.

The response rate was 47% in this mail survey. A test carried out within one of the six blocks of questionnaires indicated a high degree of internal consistency, with only 3 of 136 respondents answering inconsistently. Moreover, the estimated parameters were of expected sign, and individual background data regarding transports of hazardous materials affected individuals in expected ways, suggesting internal validity.

Comparing with Hiselius (2005a), there are no major differences in individual preferences regarding hazardous materials transported by rail or road. The estimated parameters are generally of the same sign and of the same magnitude in spite of the differences between the situations analysed. Furthermore, the inclusion of additional information on other risks has no effect, which can be interpreted in two ways. Firstly, there is no focusing effect present and thus no exaggeration of the estimates, and secondly, the information section included is too short to attract any attention and to detect the presence of such a bias.

This paper also analyses whether the estimated result is dependent on how certain the respondents are that they would express the same preferences in a real situation A follow-up

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[11] The levels used for the attribute *number of lorries per day* differ from the levels used for the attribute *number of wagons per day* in the study of transports of hazardous material by rail, though. In the railway study, the level reflecting an increase in the number of wagons differs from the level reflecting a decrease. In the road study, the increase and decrease in the number of lorries is the same.

[12] A questionnaire providing information on other fatal risks and used in the Stockholm survey is presented in Appendix B.

question therefore concerns the certainty that the respondent would vote the same way if faced by a real referendum regarding transports of hazardous materials nearby. Under the assumption that only the respondents who answer "yes, definitely" or "yes, probably" are actually revealing their true preferences, the presence of a hypothetical bias is sought. Calibrations based on self-reported degree of confidence used in contingent valuation studies suggest that overstated responses are sorted out, since the calibrated estimates correspond to actual preferences or are underestimated, e.g. Blumenschein et al. (1998) and Johannesson et al. (1998). This paper suggests, however, that individuals stating that they would vote the same way in a real referendum express higher values of willingness to pay and willingness to accept than the other individuals do, i.e. the calibration leads to an increase in willingness to pay/accept, not a decrease. Interpreting this difference as a hypothetical bias suggests that this type of bias tends to push estimated values downwards.

4. Concluding remarks

The results of this thesis show that some effects of a transport system are dependent on the level on which the analysis is carried out. For instance, in the first paper it is shown that the relationship between the accident frequency and the number of vehicles on the road is dependent on whether the traffic flow is treated as homogeneous or as consisting of cars and lorries. This indicates that an internalisation strategy using, for instance, marginal cost pricing is dependent on the level of analysis. In the same way, the second paper of this thesis indicates that individual preferences for safety may vary between different hazards. There are thus reasons to estimate different individual values of safety for different transport modes and accident types.

What level of analysis should then be used? Are external costs to be calculated for i) the transport area as a whole, ii) for each transport system, e.g. rail and road, iii) for each transport mode in the transport system, e.g. cars and lorries, iv) for each accident type for each transport system or v) for each accident type for each transport mode for each transport system? Each level is characterised by different factors, which may influence the statistical analysis and the individual preferences. These differences may result in various estimates of the external cost of an activity. Optimally, we would like to explore the relevant external cost for each unique situation. This is not feasible, of course.

In order to decide the level of analysis, we need to know if information is lost if we disregard differences between transport systems, transport modes, and accident types. In addition, we need to have relevant methods to estimate various effects and the individual preferences. The aim of the thesis is to contribute to these areas in discussions pertaining to the external costs of the traffic flow imposed on fellow road users, and the external costs of transports of hazardous materials imposed on people living nearby. The work that has been carried out here is exploratory and there are a number of future challenges.

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Appendix A

Lund 2002-11-18

Department of Technology and Society

Investigation of Issues Surrounding Transports of Hazardous Materials by Rail

The Department of Technology and Society at the Lund Institute of Technology is currently conducting a research project aimed at ascertaining how residents in the vicinity of a railway line perceive goods trains and their loads. We are particularly interested in your attitude to the transport of so-called hazardous materials by rail. Answering this questionnaire will give you the opportunity to make your voice heard and express your opinion on the transport of hazardous materials. Your answers to the questions in the questionnaire may then be used to determine what investments in the railroads and roads are to be made in the future.

The questionnaire contains some sections that describe what hazardous materials are and what you should keep in mind when answering the questions. If you read through these sections carefully, the questionnaire should be quite easy to answer.

Your answers will be treated in the strictest confidence and no single individual's views will be identifiable in the results. Naturally, your participation in this investigation is entirely voluntary, but at the same it is important to get as many opinions from as many people as possible. Your answer cannot be substituted by anyone else's.

When you have answered all the questions, put the questionnaire in the addressed return envelope and post it. A postage stamp is not required. Post the letter as soon as possible!

If you have any questions, do not hesitate to phone me at 046-222 97 48 or send an e-mail message to lena.hiselius@tft.lth.se and I will phone you back or answer by e-mail.

We thank you in advance for your help!

Lena Hiselius   Christer Hydén
Doctoral candidate, project leader   Professor

1) Gender   ☐ Man
              ☐ Woman

2) Age _____

3) Total number of adults (18 or older) who live in your household
(including yourself)   _____

Total number of children (17 or younger) who live in your household _____

4) What is the highest educational level you have attained or are presently in the
process of attaining?
    ☐   compulsory 9-year comprehensive school or equivalent
    ☐   upper secondary school or equivalent
    ☐   university or other institute of higher education or equivalent
    ☐   other

5) Type of housing
    ☐   rented (tenancy right)
    ☐   cooperative ownership of house/flat
    ☐   detached house
    ☐   other

6) What is the total cost of housing for your household per month (including
interest payments)?
    ☐   1 – 3 000 kr/month
    ☐   3 001 – 5 000 kr/month
    ☐   5 001 – 7 000 kr/month
    ☐   7 001 – 9 500 kr/month
    ☐   9 501 kr/month or more

7) What is the combined income of your household per month (i.e. income from employment, pension and/or business enterprise) before tax?
- ☐ 1 – 8 000 kr/month
- ☐ 8 001 – 15 000 kr/month
- ☐ 15 001 – 30 000 kr/month
- ☐ 30 001 – 60 000 kr/month
- ☐ 60 001 kr/month or more

8) How far from the railway line do you live?
- ☐ the railway line is adjacent to my home
- ☐ the railway line is not adjacent to my home but I can still hear the trains from there
- ☐ the railway line is not adjacent to my home and I cannot hear the trains from there

9) Are you normally in Lund in the daytime?
- ☐ yes
- ☐ no

If your answer to question 9 is no, go directly to question 11.

10) How far from the railway line, compared to your home, is the place in Lund where you normally spend your daytime?
- ☐ it is closer to the railway line than my home
- ☐ it is further from the railway line than my home
- ☐ it is about the same distance from the railway line as my home
- ☐ don't know

11) Have you ever reflected on the fact that hazardous materials are being transported on the railway line near you?
- ☐ daily
- ☐ sometimes
- ☐ once in a while
- ☐ never

It is important for you to read through the following sections before you answer any further questions.

What is meant by hazardous materials?

About 3% of the goods that are transported by rail today are classified as hazardous. Hazardous materials are substances that can injure people and damage the environment and property.

How often does an accident with hazardous materials occur in or near Lund?

At present about 70 goods trains, using Södra stambanan, go through the centre of Lund everyday. The probability of a goods train being derailed on the Eslöv-Malmö stretch is estimated to be 3 to 4 derailments over a period of 10 years, i.e. somewhat less than one every other year.

Goods trains transporting hazardous materials are rarely involved in accidents. Since the standards required of wagons that are used to transport the goods are rather demanding, spillage of hazardous substances is equally rare in the unlikely event of an accident. For instance, the probability of such an accident taking place on the Eslöv-Malmö stretch, and as a result of which gas leaks out, has been calculated to be one in 2000 years.

What may happen if a hazardous material leaks out?

If a hazardous material leaks out, injury to people and damage to property and the environment may be the results, as well as inconvenience for the people living close by, who may have to be evacuated during clearance work. Even if there is no spillage of hazardous materials, people living in the area may have to be evacuated as a safety measure. In some cases residents may have to leave their homes for up to a week.

Just how serious the consequences of an accident are depends mainly on what the spilled substance is, and the amount and speed of the leakage. Conditions in the immediate surroundings, such as the weather and distance to built-up areas, may also affect the consequences.

Should a hazardous material be spilled as a result of an accident, it is most likely that the outcome will be such that no people are injured and no property is damaged. Out of 10 accidents, 5 or more have no consequences at all, other than a decontamination of the scene of the accident.

What can happen in the worst-case scenario?

Worst-case accidents could mean dire consequences for people, property and the environment. For example, if a large leakage of ammonia occurs, a toxic gas cloud could build up, leading to fatalities in the immediate vicinity and injuries to people within a radius of several kilometres from the accident site.

A large leakage of inflammable gas, when ignited, can lead to an explosion that may be directly fatal for people in the area. This type of accident also causes great damage to buildings and property.

However, the probability of the occurrence of an accident of the "worst type" is extremely small and may be expressed as:

Assume that 10 000 accidents take place in which some dangerous substance leaks out (which very rarely happens). In only one of these cases will the accident be followed by very serious consequences.

No one has died in an accident involving hazardous materials in Sweden in the last 50 years. The probability that someone will die in an accident involving hazardous materials along the Eslöv-Malmö stretch is estimated to be one in 5 000 years.

Rail transport of hazardous materials through Lund

The last page of the questionnaire contains a map of the two railway lines that pass through Lund, Södra stambanan and Västkustbanan. About 70 wagons with hazardous materials pass through Lund on Södra Stambanan both day and night. No goods trains run on Västkustbanan.

Sources: Riskstudie av farligt godstransporter. *SSPA, 2002*
Idéstudie, riskanalys Eslöv-Lockarp. *Banverket, 2000*.
Riskanalysmetod för transporter av farligt gods på väg och järnväg. *VTI-rapport 387:1-6, 1994.*

What is your standpoint regarding changes in the transport of hazardous materials?

This study assumes that the transport configuration of hazardous materials through Lund can be influenced. In turn, the transport configuration is assumed to influence the value of the properties in the area close to the railway line. The change in property value then gives rise to changes in the rateable value and real estate tax, expressed as an increased or decreased housing cost per month. These changes are assumed to affect the occupants of all types of housing, i.e. detached/semi detached houses, collective ownership and tenancies.

A further assumption is that the transported amount of hazardous materials can be classified according to its degree of hazardousness. The combinations of substances that constitute today's transports are assumed to have a degree of hazardousness of 2 on a scale from 1 (less hazardous) to 3 (very hazardous).

We now ask you to choose from different choice sets of configurations of transports of hazardous materials along Södra Stambanan through Lund.

Each choice set contains:
- the number of wagons with hazardous materials that use the line daily
- when the goods trains carrying hazardous materials use the line. Daytime is between 06 and 22 and nighttime is between 23 and 05
- the classification of hazardousness of the transported material
- the altered housing cost for your household compared to today

Everything else is unchanged compared to the way you live today. The frequency of trains is assumed to be unaltered and thereby the level of noise that the railway causes.

Each box below describes a choice set. The one you make will be either one of the two alternatives for the transport of hazardous materials through Lund, or the situation today.

We would like you to mark with a cross the alternative you choose.

Choice set no 1.

	Alternative 1	Alternative 2	Situation today
Number of wagons with hazardous materials	No wagons with hazardous materials	70 wagons/day	70 wagons/day
Time of transport of hazardous materials		Nighttime	Daytime and nighttime
Degree of dangerousness		Class 1	Class 2
Housing costs for your household	30 kr higher housing costs/month	200 kr lower housing costs/month	Unchanged housing costs

Mark with a cross the alternative you choose!

☐ **Alternative 1**   ☐ **Alternative 2**   ☐ **Situation today**

Choice set no 2.

	Alternative 1	Alternative 2	Situation today
Number of wagons with hazardous materials	35 wagons/day	35 wagons/day	70 wagons/day
Time of transport of hazardous materials	Daytime	Nighttime	Daytime and nighttime
Degree of dangerousness	Class 1	Class 1	Class 2
Housing costs for your household	150 kr higher housing costs/month	30 kr higher housing costs/month	Unchanged housing costs

Mark with a cross the alternative you choose!

☐ **Alternative 1**   ☐ **Alternative 2**   ☐ **Situation today**

Choice set no 3.

	Alternative 1	Alternative 2	Situation today
Number of wagons with hazardous materials	70 wagons/day	140 wagons/day	70 wagons/day
Time of transport of hazardous materials	Daytime	Daytime	Daytime and nighttime
Degree of dangerousness	Class 3	Class 2	Class 2
Housing costs for your household	Unchanged housing costs/month	40 kr lower housing costs/month	Unchanged housing costs

Mark with a cross the alternative you choose!

☐ **Alternative 1**   ☐ **Alternative 2**   ☐ **Situation today**

Choice set no 4.

	Alternative 1	Alternative 2	Situation today
Number of wagons with hazardous materials	140 wagons/day	No wagons with hazardous materials	70 wagons/day
Time of transport of hazardous materials	Daytime		Daytime and nighttime
Degree of dangerousness	Class 2		Class 2
Housing costs for your household	200 kr lower housing costs/month	150 kr higher housing costs/month	Unchanged housing costs

Mark with a cross the alternative you choose!

☐ **Alternative 1**   ☐ **Alternative 2**   ☐ **Situation today**

Choice set no 5.

	Alternative 1	Alternative 2	Situation today
Number of wagons with hazardous materials	35 wagons/day	35 wagons/day	70 wagons/day
Time of transport of hazardous materials	Nighttime	Daytime	Daytime and nighttime
Degree of dangerousness	Class 2	Class 3	Class 2
Housing costs for your household	Unchanged housing costs/month	30 kr higher housing costs/month	Unchanged housing costs

Mark with a cross the alternative you choose!

☐ **Alternative 1**   ☐ **Alternative 2**   ☐ **Situation today**

Choice set no 6.

	Alternative 1	Alternative 2	Situation today
Number of wagons with hazardous materials	35 wagons/day	140 wagons/day	70 wagons/day
Time of transport of hazardous materials	Daytime	Daytime and nighttime	Daytime and nighttime
Degree of dangerousness	Class 3	Class 1	Class 2
Housing costs for your household	40 kr lower housing costs/month	200 kr lower housing costs/month	Unchanged housing costs

Mark with a cross the alternative you choose!

☐ **Alternative 1**   ☐ **Alternative 2**   ☐ **Situation today**

Concluding Questions

12) In making your choices, did you take into consideration any of these factors?

	Yes	No	Don't know
A. The risk of injury to myself or other member of my household	☐	☐	☐
B. The risk of damage to my property	☐	☐	☐
C. The risk of being evacuated	☐	☐	☐
D. Worry and inconvenience	☐	☐	☐
E. The risk of damage to the environment	☐	☐	☐
F. The effects on business enterprises in the area	☐	☐	☐

13) As mentioned previously, no one has been killed in an accident involving hazardous materials in Sweden in the last 50 years. What do you think is the probability that a railway accident resulting in fatalities will occur in the next 50 years?

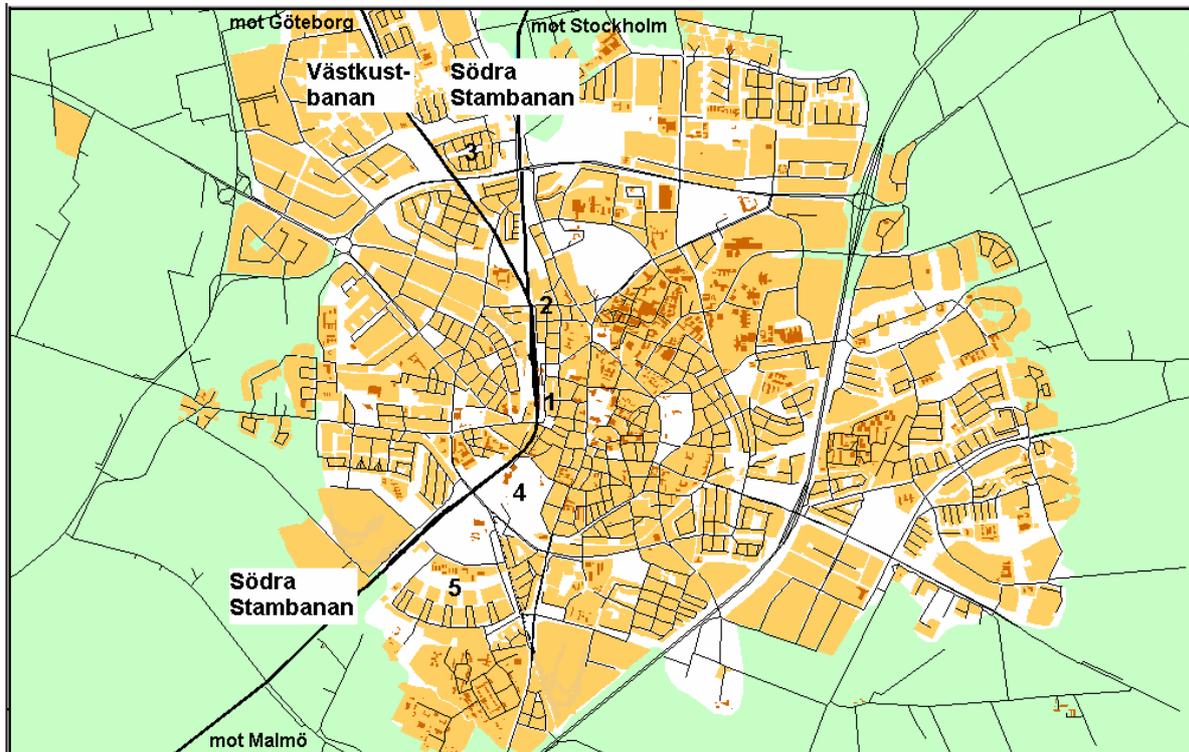|			
☐	☐	☐	☐
very small	small	large	very large

14) Has this survey influenced your opinion on transports of hazardous materials?
- ☐ yes
- ☐ no
- ☐ don't know

15) If your answer to question 14 is yes; in what way?

_____

_____

Thank you for your valuable participation!

Railways through the built-up area of Lund

Västkustbanan and Södra Stambanan are marked.
We have also marked five other places on the map to make your orientation easier.

1. Järnvägsstationen
2. Kung Oscars väg
3. Oscarshem
4. Stadsparken
5. Klostergården

Appendix B

Department of Technology and Society

Lund 2003-11-17

Investigation of Issues Surrounding Transports of Hazardous Materials

The Department of Technology and Society at the Lund Institute of Technology is currently conducting a research project aimed at ascertaining how residents in the vicinity of Norrtull/Roslagstull/Valhallavägen/Lidingövägen/Tegeluddsvägen perceive the truck traffic on this passage. We are particularly interested in your attitude to the transport of so-called hazardous materials.
Answering this questionnaire will give you the opportunity to make your voice heard and express your opinion on the transport of hazardous materials. Your answers to the questions in the questionnaire may then be used to determine what investments in the railroads and roads are to be made in the future.

The questionnaire contains some sections that describe what hazardous materials are and what you should keep in mind when answering the questions. If you read through these sections carefully, the questionnaire should be quite easy to answer.

Your answers will be treated in the strictest confidence and no single individual's views will be identifiable in the results. Naturally, your participation in this investigation is entirely voluntary, but at the same it is important to get as many opinions from as many people as possible. Your answer cannot be substituted by anyone else's.

When you have answered all the questions, put the questionnaire in the addressed return envelope and post it. A postage stamp is not required. Post the letter as soon as possible!

If you have any questions, do not hesitate to phone me at 046-222 97 48 or send an e-mail message to lena.hiselius@tft.lth.se and I will phone you back or answer by e-mail.

We thank you in advance for your help!

Lena Hiselius   Christer Hydén
Doctoral candidate, project leader   Professor

1) Gender ☐ Man
☐ Woman

2) Age _____

3) Total number of adults (18 or older) who live in your household
(including yourself) _____

Total number of children (17 or younger) who live in your household _____

4) What is the highest educational level you have attained or are presently in the
process of attaining?
☐ compulsory 9-year comprehensive school or equivalent
☐ upper secondary school or equivalent
☐ university or other institute of higher education or equivalent
☐ other

5) Type of housing
☐ rented (tenancy right)
☐ cooperative ownership of house/flat
☐ detached house
☐ other

6) What is the total cost of housing for your household per month (including
interest payments)?
☐ 1 – 3 000 kr/month
☐ 3 001 – 5 000 kr/month
☐ 5 001 – 7 000 kr/month
☐ 7 001 – 9 500 kr/month
☐ 9 501 kr/month or more

7) What is the combined income of your household per month (i.e. income from employment, pension and/or business enterprise) before tax?

- ☐   1 – 8 000 kr/month
- ☐   8 001 – 15 000 kr/month
- ☐ 15 001 – 30 000 kr/month
- ☐ 30 001 – 60 000 kr/month
- ☐   60 001 kr/month or more

8) Are you living next to the passage: Norrtull/Roslagstull/Valhallavägen/ Lidingövägen/Tegeluddsvägen?

- ☐ yes
- ☐   no

9) Are you normally in the centre of Stockholm in the daytime?

- ☐ yes
- ☐ no

If your answer to question 9 is no, go directly to question 11.

10) How far from the passage: Norrtull/Roslagstull/Valhallavägen/ Lidingövägen/Tegeluddsvägen, compared to your home, is the place where you normally spend your daytime?

- ☐ it is closer to the passage than my home
- ☐ it is further from the passage than my home
- ☐ it is about the same distance from the passage as my home
- ☐ don't know

11) Have you ever reflected on the fact that hazardous materials are being transported on the passage: Norrtull/Roslagstull/Valhallavägen/ Lidingövägen/Tegeluddsvägen?

- ☐ daily
- ☐ sometimes
- ☐ once in a while
- ☐ never

It is important for you to read through the following sections before you answer any further questions.

What is meant by hazardous materials?

Between 8 and 10% of the goods that are transported by trucks today are classified as hazardous. Hazardous materials are substances that can injure people and damage the environment and property.

What may happen if a hazardous material leaks out?

If a hazardous material leaks out, injury to people and damage to property and the environment may be the results, as well as inconvenience for the people living close by, who may have to be evacuated during clearance work. Even if there is no spillage of hazardous materials, people living in the area may have to be evacuated as a safety measure. In some cases residents may have to leave their homes for up to a week.

Just how serious the consequences of an accident are depends mainly on what the spilled substance is, and the amount and speed of the leakage. Conditions in the immediate surroundings, such as the weather and distance to built-up areas, may also affect the consequences.

Should a hazardous material be spilled as a result of an accident, it is most likely that the outcome will be such that no people are injured and no property is damaged. Out of 10 accidents, 3-4 have no consequences at all, other than a decontamination of the scene of the accident.

What may happen in the worst-case scenario?

Worst-case accidents could mean dire consequences for people, property and the environment.
For example, if a leakage of aircraft fuel occurs, puddles of fuel may be formed. If there is an ignition of these puddles people may be injured and buildings may be damaged by the flames and the heat.
If there is a leakage of petrol, gas may be gathered in wells and ditches. An ignitiation of the gas, can lead to an explosion that may be directly fatal for people in the area. This type of accident also causes great damage to buildings and property.

However, the probability of the occurrence of an accident of the "worst type" is extremely small and may be expressed as: Assume that 1 000 accidents take place in which some dangerous substance leaks out (which very rarely happens). In only one of these cases will the accident be followed by very serious consequences.

What is the probability that someone will die in an accident involving hazardous materials compared to other fatal risks?

In the table below the number of fatalities per year are shown for different causes of death. Fatalities due to accidents involving hazardous materials are excluded in the table since no one has died in an accident involving hazardous materials in Sweden during the last 50 years.

Number of fatalities/year	Cause of death
3000	Lung cancer
600	Motor vehicle accidents
100	Drowning
4	Electric power
0.5	Stroke of lightning

How often does an accident with hazardous materials occur in Stockholm?

The probability of an accident involving hazardous materials to occur on the E4 trough Stockholm, is estimated to be one accident in 8 years. The probability of an accident to occur involving truck transports of aircraft fuel from Loudden to Arlanda airport, has been calculated to be one accident in 17 years.

Truck transports of hazardous materials through the centre of Stockholm

Transports of hazardous materials through the centre of Stockholm by trucks constitute mainly of oil-products from the harbour of Loudden. The following passage is used for these transports: Norrtull/Roslagstull/Valhallavägen/Lidingövägen/Tegeluddsvägen. The last page of the questionnaire contains a map where this passage is marked out.

According to information from 1998, 140 lorries per day are leaving Loudden carrying different kinds of oil-products. The transports are carried out between 5 am and 10 pm.

Sources: Idéstudie, riskanalys Eslöv-Lockarp. *Banverket, 2000.*
Olycksrisker i Stockholms län. Länsstyrelsen i Stockholms län. Rapport 2001:17
Riskanalys, Solna-Sundbybergs Brandförsvarsförbund, 1997.
Riskanalysmetod för transporter av farligt gods på väg och järnväg. VTI-rapport 387:1-6, 1994.

What is your standpoint regarding changes in the transport of hazardous materials?

This study assumes that the transport configuration of hazardous materials on the passage: Norrtull/Roslagstull/Valhallavägen/Lidingövägen/Tegeluddsvägen can be influenced. In turn, the transport configuration is assumed to influence the value of the properties in the area close to the passage. The change in property value then gives rise to changes in the rateable value and real estate tax, expressed as an increased or decreased housing cost per month. These changes are assumed to affect the occupants of all types of housing, i.e. detached/semi detached houses, collective ownership and tenancies.

It is also assumed that the total number of lorries using the passage is unaffected by the amount of hazardous material being transported. Since the number lorries is unaffected the level of noise and the emissions that the lorries causes are also unaltered.

A further assumption is that the transported amount of hazardous materials can be classified according to its degree of hazardousness. The combinations of substances that constitute today's transports are assumed to have a degree of hazardousness of 2 on a scale from 1 (less hazardous) to 3 (very hazardous).

We are now asking you to choose...

We now ask you to choose from different choice sets of configurations of transports of hazardous materials on the passage: Norrtull/Roslagstull/Valhallavägen/ Lidingövägen/Tegeluddsvägen.

Each choice set contains:
- the number of lorries with hazardous materials that use the passage daily
- when the transports of hazardous materials are carried out. Daytime is between 06 and 22 and nighttime is between 23 and 05
- the classification of hazardousness of the transported material
- the altered housing cost for your household compared to today

Everything else is unchanged compared to the way you live today.

Each box below describes a choice set. The one you make will be either one of the two alternatives for the transport of hazardous materials on the passage: Norrtull/Roslagstull/Valhallavägen/Lidingövägen/Tegeluddsvägen or the situation today.

We would like you to mark with a cross the alternative you choose.

Choice set no 1.

	Alternative 1	Alternative 2	Situation today
Number of lorries with hazardous materials	140 lorries/day	No lorries with hazardous materials	140 lorries/day
Time of transport of hazardous materials	Nighttime		Daytime
Degree of dangerousness	Class 1		Class 2
Housing costs for your household	130 kr higher housing costs/month	70 kr higher housing costs/month	Unchanged housing costs

Mark with a cross the alternative you choose!

☐ **Alternative 1** ☐ **Alternative 2** ☐ **Situation today**

Choice set no 2.

	Alternative 1	Alternative 2	Situation today
Number of lorries with hazardous materials	60 lorries/day	35 lorries/day	140 lorries/day
Time of transport of hazardous materials	Nighttime	Daytime and nighttime	Daytime
Degree of dangerousness	Class 1	Class 1	Class 2
Housing costs for your household	70 kr higher housing costs/month	250 kr lower housing costs/month	Unchanged housing costs

Mark with a cross the alternative you choose!

☐ **Alternative 1** ☐ **Alternative 2** ☐ **Situation today**

Choice set no 3.

	Alternative 1	Alternative 2	Situation today
Number of lorries with hazardous materials	140 lorries/day	220 lorries/day	140 lorries/day
Time of transport of hazardous materials	Daytime	Daytime and nighttime	Daytime
Degree of dangerousness	Class 1	Class 1	Class 2
Housing costs for your household	190 kr higher housing costs/month	250 kr lower housing costs/month	Unchanged housing costs

Mark with a cross the alternative you choose!

☐ **Alternative 1**   ☐ **Alternative 2**   ☐ **Situation today**

Choice set no 4.

	Alternative 1	Alternative 2	Situation today
Number of lorries with hazardous materials	No lorries with hazardous materials	60 lorries/day	140 lorries/day
Time of transport of hazardous materials		Daytime and nighttime	Daytime
Degree of dangerousness		Class 1	Class 2
Housing costs for your household	190 kr higher housing costs/month	40 kr higher housing costs/month	Unchanged housing costs

Mark with a cross the alternative you choose!

☐ **Alternative 1**   ☐ **Alternative 2**   ☐ **Situation today**

Choice set no 5.

	Alternative 1	Alternative 2	Situation today
Number of lorries with hazardous materials	140 lorries/day	220 lorries/day	140 lorries/day
Time of transport of hazardous materials	Daytime and nighttime	Daytime	Daytime
Degree of dangerousness	Class 1	Class 3	Class 2
Housing costs for your household	70 kr higher housing costs/month	250 kr lower housing costs/month	Unchanged housing costs

Mark with a cross the alternative you choose!

☐ **Alternative 1**   ☐ **Alternative 2**   ☐ **Situation today**

Choice set no 6.

	Alternative 1	Alternative 2	Situation today
Number of lorries with hazardous materials	220 lorries/day	60 lorries/day	140 lorries/day
Time of transport of hazardous materials	Daytime	Daytime	Daytime
Degree of dangerousness	Class 1	Class 3	Class 2
Housing costs for your household	Unchanged housing costs	190 kr higher housing costs/month	Unchanged housing costs

Mark with a cross the alternative you choose!

☐ **Alternative 1**   ☐ **Alternative 2**   ☐ **Situation today**

Concluding Questions

12) In making your choices, did you take into consideration any of these factors?

	Yes	No	Don't know
A. The risk of injury to myself or other member of my household	☐	☐	☐
B. The risk of damage to my property	☐	☐	☐
C. The risk of being evacuated	☐	☐	☐
D. Worry and inconvenience	☐	☐	☐
E. The risk of damage to the environment	☐	☐	☐
F. The effects on business enterprises in the area	☐	☐	☐

13) Suppose that the configuration of transports of hazardous material close to you is to be estimated in a local referendum with real consequences for your budget. Would you then vote the same way as you have done in the questionnaire?

☐	☐	☐	☐	☐
yes, definitely	yes, probably	don´t know	no, probably not	no, definitely not

14) As mentioned previously, no one has been killed in an accident involving hazardous materials in Sweden in the last 50 years. What do you think is the probability that an accident resulting in fatalities will occur in the next 50 years?

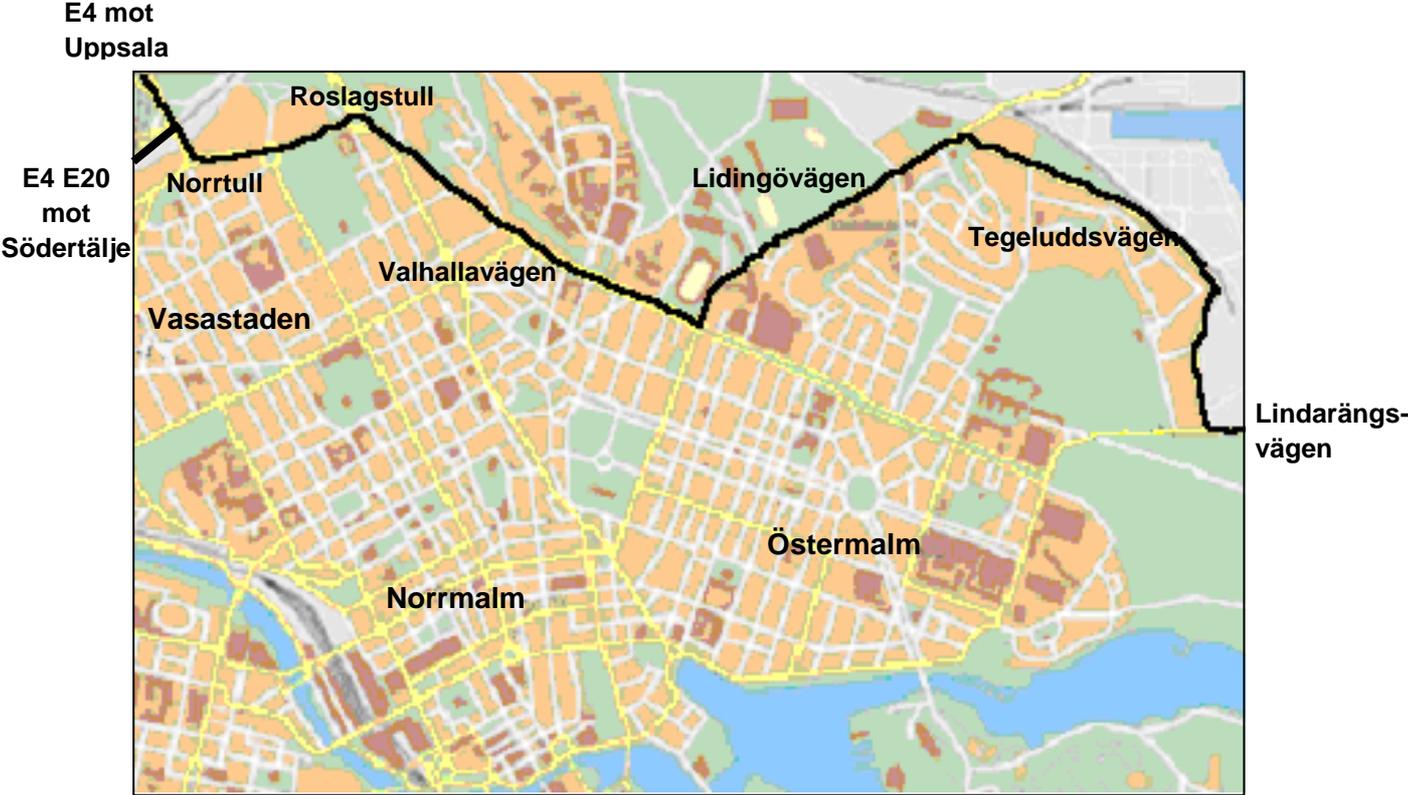| ☐	☐	☐	☐
very small	small	large	very large

15) Has this survey influenced your opinion on transports of hazardous materials?
- ☐ yes
- ☐ no
- ☐ don't know

16) If your answer to question 15 is yes; in what way?

_____

_____

Thank you for your valuable participation!

Passage with transports of hazardous materials through the centre of Stockholm

E4 mot
Uppsala

E4 E20
mot
Södertälje

Norrtull

Roslagstull

Lidingövägen

Tegeluddsvägen

Valhallavägen

Vasastaden

Lindarängs-
vägen

Östermalm

Norrmalm

Lund Economic Studies

1.	Guy Arvidsson	Bidrag till teorin för verkningarna av räntevariationer, 1962
2.	Björn Thalberg	A Trade Cycle Analysis. Extensions of the Goodwin Model, 1966
3.	Bengt Höglund	Modell och observationer. En studie av empirisk anknytning och aggregation för en linjär produktionsmodell, 1968
4.	Alf Carling	Industrins struktur och konkurrensförhållanden, 1968
5.	Tony Hagström	Kreditmarknadens struktur och funktionssätt, 1968
6.	Göran Skogh	Straffrätt och samhällsekonomi, 1973
7.	Ulf Jakobsson och Göran Norman	Inkomstbeskattningen i den ekonomiska politiken. En kvantitativ analys av systemet för personlig inkomstbeskattning 1952-71, 1974
8.	Eskil Wadensjö	Immigration och samhällsekonomi. Immigrationens ekonomiska orsaker och effekter, 1973
9.	Rögnvaldur Hannesson	Economics of Fisheries. Some Problems of Efficiency, 1974
10.	Charles Stuart	Search and the Organization of Marketplaces, 1975
11.	S Enone Metuge	An Input-Output Study of the Structure and Resource Use in the Cameroon Economy, 1976
12.	Bengt Jönsson	Cost-Benefit Analysis in Public Health and Medical Care, 1976
13.	Agneta Kruse och Ann-Charlotte Ståhlberg	Effekter av ATP - en samhällsekonomisk studie, 1977
14.	Krister Hjalte	Sjörestaureringens ekonomi, 1977
15.	Lars-Gunnar Svensson	Social Justice and Fair Distributions, 1977
16.	Curt Wells	Optimal Fiscal and Monetary Policy - Experiments with an Econometric Model of Sweden, 1978
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