Slutrapport för projektet
”Metodutveckling för värdering av farligt gods olyckor”

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1) Enkätexempel för enkät utskickad i Lund, version med mycket information.
2) Enkätexempel för enkät utskickad i Stockholm, version med information om andra dödsrisker.
3) Hiselius Winslott, L. (2003) The value of road and railway safety- an overview. Working paper nr. 13. Nationalekonomiska institutionen, Lunds Universitet.
4) Hiselius Winslott, L. (2005a) Using choice experiments to assess peoples' preferences for railway transports of hazardous materials. *Risk Analysis*, 25:1199-1214.
5) Hiselius Winslott, L. (2005b) Preferences regarding road transports of hazardous materials using Choice Experiments – any sign of biases? Working paper nr. 30. Nationalekonomiska institutionen, Lunds Universitet.
6) Hjalte, K. och Hiselius Winslott, L. (2005) Assessment of fear and anxiety- bundled or unbundled risk valuation? Artikelutkast. Nationalekonomiska institutionen, Lunds Universitet.

I L. Hiselius avhandling "The external costs of transports imposed on neighbours and fellow road users" ingår följande arbeten:

Hiselius Winslott, L. (2004) Estimating the relationship between accident frequency and homogeneous and inhomogeneous traffic flows. *Accident Analysis and Prevention*, 36, 985-992.

Hiselius Winslott, L. (2003) The value of road and railway safety- an overview. Working paper nr. 13. Nationalekonomiska institutionen, Lunds Universitet.

Hiselius Winslott, L. (2005a) Using choice experiments to assess peoples' preferences for railway transports of hazardous materials. *Risk Analysis*, 25, 1199-1214.

Hiselius Winslott, L. (2005b) Preferences regarding road transports of hazardous materials using Choice Experiments – any sign of biases? Working paper nr. 30. Nationalekonomiska institutionen, Lunds Universitet. Inskickad för bedömning i vetenskaplig tidskrift.

1. Inledning

En modell för ekonomisk analys av farligtgodsolyckor (FAGO olyckor) utvecklades under 1993 och redovisas i VTI rapport 387:1-6. Det övergripande syftet var att konstruera modeller som möjliggör att sannolikheten för en olycka med FAGO och olyckans konsekvenser beräknas samt att de samhällsekonomiska kostnaderna för en olycka skattas.
De olyckskostnader som togs fram, Persson och Svarvare (1994), byggde på den kunskap om enskilda individers värdering av en riskminskning, s.k. riskvärdet, som då var tillgänglig. Detta medför att skattningarna av vissa kostnadskomponenter är behäftade med osäkerhet. I modellen användes ett riskvärde beräknat för vägtrafikolyckor. Frågan är om detta riskvärde kan användas vid katastrofsituationer (mindre sannolikhet med större konsekvenser) såsom FAGO olyckor. Det finns skäl att misstänka att riskvärderingen underskattades. Empiriska studier har genomförts av t.ex. Jones-Lee och Loomes (1995) i England och Bäckman (2002) i Sverige som ökat förståelsen för värdering av minskad risk vid katastrofer. Det finns tecken som tyder på att faktorerna scale, dvs. olyckans omfattning, samt context, dvs. i vilken miljö olyckan inträffar, påverkar riskvärdets storlek.

I den ekonomiska analysmodellen för FAGO olyckor på väg och järnväg tas endast hänsyn till kostnader som uppstår då en olycka inträffar. Olyckskostnaden för de som omkommer och skadas beräknas således. Såvitt projektets medarbetare vet har ingen studie gjorts på den dagliga ”belastning” det innebär för en vid väg eller järnväg närboende, att utsättas för risken för en FAGO olycka. En sådan olycka kan innebära risk för personskada, skada på egendom, belastning att lämna hemmet under den tid en sanering sker, etc. Detta obehag kan sägas vara en merkostnad som väg- och järnvägstrafiken utsätter en närboende för och som den boende inte får någon ersättning för, en extern kostnad enligt den ekonomiska välfärdsteorin.
Denna kostnad, till följd av risken för en FAGO olycka, kan jämföras med den belastning som väg- och järnvägstrafikens buller utgör för närboende. Buller värderas dock i den samhällsekonomiska kalkylen vilket exponering för FAGO inte gör. En empirisk skattning av väg- och järnvägstrafikens externa kostnader till följd av FAGO olyckor bör därför göras.

Genom att den empiriska studiens upplägg är den samma för väg- och järnvägstrafik kan intressanta jämförelser mellan de två trafikslagen göras. Dessa jämförelser är speciellt intressanta då väg- och järnvägstrafik ofta ställs emot varandra.

I den diskussion som idag finns huruvida godstrafik skall ledas genom tätorter är det svårt att motivera nya sträckningar med en minskad olyckskostnad som argument. Den genomsnittliga olyckskostnaden blir mycket låg (trots stora konsekvenser vid en olycka) eftersom sannolikheten för att en olycka skall inträffa är liten. De boende utmed sträckningarna är dock engagerade och deras engagemang tyder på att det finns ett obehag, eg. en kostnad, som inte tas med i den samhällsekonomiska kalkylen. Den finns således en diskrepans mellan den upplevda situationen och hur kostnaderna beskrivs i den ekonomiska modellen.

Med hjälp av den kunskap projektet genererar kan kostnadskomponenterna i den ekonomiska analysmodellen för FAGO olyckor revideras och kompletteras.

2. Syfte och metod

Projektets syfte är att kartlägga och utveckla metoden för att skatta FAGO olyckors samhällsekonomiska kostnader speciellt vad gäller enskilda individers värdering av FAGO olyckor. Projektet innefattar även en genomgång av studier som bl.a. behandlar skillnader mellan väg- och järnvägstrafikens riskvärde. Denna del av projektet redovisas i Hiselius (2003) vilken även bifogas som bilaga till denna slutrapport.

Två empiriska studier har genomförts med syftet att skatta väg- och järnvägstrafikens externa kostnader till följd av de närboendes exponering för FAGO. I den ekonomiska analysmodellen tas endast hänsyn till kostnader som uppstår då en olycka inträffar. Såvitt projektets medarbetare vet har ingen studie genomförts tidigare där exponering använts istället för risker när FAGO diskuteras. Projektet utgör även ett bidrag till den forskning som bedrivs för att t.ex. skatta värdet på intrång genom att öka kunskapen om Choice Experiments metoden.

Ett antal syften och frågeställningar har ställts upp för den empiriska delen av projektet.

- Se om metoden fungerar. Får vi konsistenta och logiska svar?
- Hur påverkar enkäten individerna? Etiska aspekter, ökad oro.
- Studera skillnad i värdering mellan urval med mycket/lite information om FAGO
- Studera skillnad i värdering beroende på avstånd till järnväg
- Studera vilka attribut som har betydelse när förändrad exponering av FAGO värderas
- Skatta värdet på en förändring i exponering av FAGO

- Studera skillnad i betalningsvilja för minskad exponering (WTP) och ersättning som behövs för att acceptera en ökad exponering (WTA).
- Finns det någon certainty effect, dvs är man beredd att betala extra för att reducera exponeringen till noll?
- Studera om villa- och bostadsrättsägare svarar strategiskt på enkätens frågor genom att ta hänsyn till att värdet på deras fastighet påverkas av FAGO transporterna och att en eventuell kostnadsförändring kapitaliseras vid en framtida försäljning.
- Studera skillnad i värdering mellan Lund och Borlänge till följd av skillnader i initialrisk, exponering, effekter för näringslivet etc.
- Studera skillnader mellan individers värdering av FAGO transporter på väg respektive järnväg.
- Studera förekomst av hypotetisk bias och fokuseringseffekt.

Dessa punkter gås dels igenom i de artiklar som projektet resulterat i, Hiselius (2005a) och (2005b) vilka bifogas som bilaga, och i denna slutrapport.

Inom projektet har även en rapport skrivits som behandlar huruvida om och hur oro som inte är direkt förknippad med en olycka kan skattas, Hjalte och Hiselius (2005). Detta artikelutkast bifogas som bilaga. Syftet med den rapporten är att fördjupa analysen av oro och obehag till följd av t.ex. exponering av farligtgods. Rapporten inkluderas som bilaga till denna slutrapport.

3. Choice Experiment metoden

3.1 Allmänt

En mängd Stated preference studier har genomförts med syfte att skatta individers preferenser (betalningsvilja) för riskförändringar. Majoriteten av dessa studier har varit använt Contingent valuation (CV) metoden. Eftersom det inte finns någon marknad för säkerhet skapas med denna metod en hypotetisk marknad och respondenten ombedes att ange sin maximala betalningsvilja för den aktuella åtgärden. Förståelsen för problem med CV-ansatsen har dock ökat betydligt de senaste åren. Bland annat har det sagts att betalningsviljan i vissa fall är okänslig för storleken på varan man köper eller för variationer i varans karaktär, vilket medför att betalningsviljan inte varierar som kan förväntas. I och med att en hypotetisk marknad skapas i intervjusituationen finns det även risk för att svaren inkl. uppgiven betalningsvilja blir hypotetiska.

För att undvika en del av de problem som är förknippade med CV-studier har vi i detta projekt använt Choice experiments (CE) ansatsen. Choice Experiments metoden har sina rötter inom marknadsundersökningar men har kommit att användas inom allt fler områden, t.ex. miljöekonomi och hälsoekonomi. Stated preference anstasen baseras på att människor inte enbart gör sina val utifrån enstaka faktorer t.ex. pris, komfort, färg etc. Valet anses istället bero på en kombination av faktorer och att individen väljer det alternativ som ger störst nytta för henne. Så kallade spel konstrueras där respondenten ställs inför valsituationer där olika alternativ beskrivs med hjälp av ett antal attribut. Genom att variera nivåerna på attributen kan den relativa betydelsen av de ingående faktorerna särskiljas.

Under senare år har Stated Preference ansatsen använts framgångsrikt för att ta reda på vilka faktorer i transportsystemet som är viktigast i förhållande till andra faktorer. Enligt en sammanställning av Lindkvist Dillen (1998) kan t.ex. syftet med att analysera värderingar och beteende vara:

- Att studera effekter av olika åtgärder
- Ta fram underlag för prioritering mellan åtgärder
- Att identifiera målgrupper
- Att experimentera utan att faktiskt genomföra.

Grunden för Stated preference anstasen är att den bygger på ett hypotetiskt beteende, dvs. att respondenterna uppger hur de skulle bete sig i olika valsituationer. Denna grund ger upphov

till en mängd problem men också ett antal fördelar. Fördelarna är att vi kan designa en studie som analyserar just de faktorer som vi är intresserade av och där vi också kan särskilja betydelsen av olika faktorer ifrån varandra. Vi har också möjligheten att jämföra olika alternativa lösningar utan att faktiskt genomföra åtgärderna. Ett överskuggande problem är dock att de svar som avges är hypotetiska och det finns alltid en osäkerhet att de avgivna svaren skiljer sig ifrån hur respondenterna faktiskt skulle bete sig i en valsituation i det verkliga livet, ett s.k. hypotetisk bias. Detta problem är dock väl känt och mycket forskning bedrivs kring hur vi bäst designar en studie och analyserar dess resultat för att ta hänsyn till eventuella hypotetiska bias.

Den Stated preference metod som använts i detta projekt är CE metoden, (tidigare ofta benämnd som Conjoint Analysis metoden). Att designa en CE studie innebär att man först väljer ut vilka variabler eller faktorer som skall ingå för att beskriva olika scenarios. När man vet vilka faktorer som skall användas tar man ställning till vilka värden eller nivåer som dessa faktorer skall anta. Nivåerna måste vara rimliga och bör bygga på existerande nivåer och individernas egna erfarenheter. Därefter bestäms vilka scenarios respondenterna skall få ta ställning till. I designen eftersträvas att faktorernas nivåer är ortogonala, dvs. att faktorerna varierar helt oberoende av varandra. Antalet tillgängliga alternativ i en full design är ofta oöverstigligt många dock. Istället brukar antalet alternativ reduceras med hjälp av en fraktionell faktoriell design. Detta kan t.ex. göras med hjälp av olika experimentella designer som finna att hämta i böcker eller speciella datorprogram. Scenariona kombineras sedan ihop till olika valsituationer. För att inte trötta ut respondenterna rekommenderas att antalet val som man ber en respondent att göra begränsas till max 6-8 stycken.
För att analysera de val som respondenterna avger används en modell som kallas logit modellen, diskuterad mer utförligt i Hiselius (2005a) och (2005b). Modellen förutsätter att individen väljer det alternativ som maximerar dess nytta och att individens nytta av alternativen i sin tur beror på de olika alternativens egenskaper (de ingående faktorerna). De finns dock ett antal variabler (egenskaper hos alternativen och hos individen) som ej kan observeras eller mätas. I logit modellen brukar man anta att slumpparameter, ε, följer en Gumbelfördelning.

I analysmodellen antas att sannolikheten för att välja ett visst alternativ beror på alternativets nytta i förhållande till nyttan för de andra alternativen. Individernas värderingar beräknas med

en Random Utility Model. Vi kan då formulera individ t's nyttofunktion för alternativ j som $U_{jt} = \beta x_{jt} + \varepsilon_{jt}$, där varje alternativ karaktäriseras av ett antal attribut $x_{jt.}$

Vi kan inte observera vilken nytta en individ får men väl vilket alternativ han/hon väljer. Sannolikheten att alternativ j kommer att väljas bland t.ex. 3 alternativ kan då skrivas på följande sätt:

$$\Pr ob\,(j) = \frac{\exp^{\beta x_j}}{\sum_{m=1}^{3} \exp^{\beta x_m}}$$

I logit modellen skattas nyttofunktionens vikter/parametrar (β) för de ingående attributen. Dessa parametrar anger hur de olika attributen värderas i förhållande till varandra. Kvoten mellan 2 ingående attribut i modellen utgör den marginella substitutionskvoten mellan dessa attribut och beskriver således individernas trade off dem emellan. Genom att ett attribut utgör en kostnad/ersättning kan värdet på en förändring i de övriga ingående attributen studeras genom att dividera den skattade koefficienten för ett visst attribut med koefficienten för kostnad/ersättning. Kvoten utgör den marginella betalningsviljan för en förändring i detta attribut. β_2/β_1 ger t.ex. värderingen av att dubblera antalet vagnar. Ett positivt tecken på en kostnadskvot betyder att individen behöver en ersättning för att bli kompenserad för nyttoförsämringen och ett negativt tecken betyder att individen är villiga att betala för nyttoförbättringen.

3.2 Choice experiments metoden vid studie av FAGO olyckor

Projektets titel är "Metodutveckling för värdering av farligtgodsolyckor" men vad är det som skall värderas? När värdet på säkerhet diskuteras framställs problemet vanligen som värdet på en förändring i risken att dödas/skadas. FAGO transporter karakteriseras dock av mycket små sannolikheter för att en olycka skall inträffa samt vitt skilda olycksutfall. Dessa omständigheter medför problem att beskriva riskförändringen av intresse men också svårigheter för respondenten att förstå och ta in vad riskförändringen innebär.

I detta projekt har vi istället valt att uttrycka riskförändring som en förändring i exponeringen av FAGO. Vår hypotes är att denna mer generella frågeställning gör att frågan blir lättare att förstå. En generell frågeställning medför dock andra problem som t.ex. minskad kontroll för vilka faktorer och kostnader som respondenten tar hänsyn till i sitt svar.

I studien ombedes respondenterna att välja mellan olika utformningar av transporter av farligtgods på järnväg eller väg i deras närhet. Respondenterna väljer mellan två föreslagna alternativ och dagens situation.

Följande exempel är hämtat från en enkätversion som skickades ut i Lund för FAGO transporter på järnväg:

Varje ruta beskriver en valsituation. Valet står mellan två olika utformningar av transporter av farligtgods på järnväg genom Lund och dagens situation.

Vi vill att du för varje val kryssar för det alternativ som du väljer.

	Alternativ 1	**Alternativ 2**	**Dagens situation**
Antal vagnar med farligtgods	Inga vagnar med farligtgods	70 vagnar/dygn	70 vagnar/dygn
Tidpunkt för transport av farligtgods		Nattetid	Dagtid och nattetid
Farlighetsgrad på det transporterade godset		Klass 1	Klass 2
Boendekostnad för ditt hushåll	30 kr högre boendekostnad/mån	200 kr lägre boendekostnad/mån	Oförändrad boendekostnad

Kryssa för det alternativ som du väljer!

Alternativ 1 **Alternativ 2** **Dagens situation**

Följande attribut och nivåer användes i järnvägsstudien:

Attribut	**Nivåer***
Antal vagnar/dygn med farligtgods:	Lund: 0, 35, **70**, 140
	Borlänge: 0, 70, **140**, 280
Tidpunkt för transport:	ingen, **både dagtid och nattetid**, enbart dagtid, enbart nattetid
Farlighetsgrad (fg):	ingen, fg 1 (mindre farligt), **fg 2**, fg 3 (mycket farligt)
Förändrad boendekostnad/mån:	-200, -100, -40, **±0**, +35, +50, +150, +250

*Nivåer i fet stil utgör tillsammans dagens situation i Lund respektive i Borlänge

Följande attribut och nivåer användes i vägstudien:

Attribut	**Nivåer***
Antal lastbilar/dygn med farligtgods:	0, 60, **140**, 220
Tidpunkt för transport:	ingen, både dagtid och nattetid, **enbart dagti**d, enbart nattetid
Farlighetsgrad (fg):	ingen, fg 1 (mindre farligt), **fg 2**, fg 3 (mycket farligt)
Förändrad boendekostnad/mån:	-250, -130, -50, **±0**, +40, +70, +190, +310

*Nivåer i fet stil utgör tillsammans dagens situation

De tre första attributen utgör tillsammans en beskrivning av den exponering av farligtgodstransporter som närboende individer har att ta ställning till. Exponeringen antas således bero på antalet vagnar/lastbilar med farligtgods, vilken farlighetsgrad det är på godset samt vid vilken tidpunkt transporterna sker.

Det fjärde attributet, förändrad boendekostnad per månad, motiveras på följande sätt i enkäten (här hämtat för järnvägsstudien i Lund):

I denna studie antas att transporterna av farligtgods genom Lund kan påverkas genom att krav ställs på hur transporterna utformas. Transporternas utformning antas i sin tur påverka värdet på de fastigheter som ligger i områden utmed järnvägen. Förändringen i fastighetsvärde ger då upphov till en förändring i taxeringsvärde och fastighetsskatt, uttryckt som ökad eller minskad boendekostnad per månad. Denna förändring antas ske för såväl boende i villa och bostadsrätt som i hyresrätt.

Två mindre pilotstudier genomfördes inom projektet och resultaten visade på att respondenterna uppfattade kostnadens motivering som trovärdig. Kostnadsparameterns utformning medför dock att de individer som äger sitt boende (villa- och bostadsrättsägare) kan svara strategiskt på enkätens val. Dessa individer kan antas lättare acceptera en kostnadsökning per månad eftersom de får tillbaka kostnadsökningen vid en framtida försäljning av fastigheten. Omfattningen av detta problem undersöks i studien.

Alla möjliga kombinationer av nivåer och attribut kunde inte presenteras i studien. En mindre antal alternativ valdes därför ut som i olika kombinationer utgjorde de valsituationer som respondenterna fick ta ställning till. Baserat på fraktionell faktoriell design, två pilotstudier och simuleringar togs 34 olika valsituationer fram. För att kunna presentera så många valsituationer som möjlig skapades sex olika enkätversioner om 6 val vardera. Varje respondent erhöll endast en enkätversion.

En linjär nyttofunktion användes i analysen av FAGO transporter på väg och järnväg. Generellt har regressionsmodellen samma utseende för transportområdena där de ingående faktorerna kodats med hjälp av dummyvariabler och där basen för dummyvariablerna utgörs av dagens situation, dvs. dagens antal vagnar/lastbilar, farlighetsgrad 2 på godset och transporter både dagtid och nattetid för järnväg samt transorter dagtid för väg.
För järnvägstransporterna ser basmodellen ut som följer:

$$U = \alpha + \beta_1 \text{Kostn} + \beta_2 \text{Dubbl} + \beta_3 \text{Halv} + \beta_4 \text{Inga} + \beta_5 \text{Fg1} + \beta_6 \text{Fg3} + \beta_7 \text{Dag} + \beta_8 \text{Natt} + \varepsilon$$

Använda variabler:

Kostn =	förändrad boendekostnad/månad

Dummy variabler

Dubbl =	140 vagnar i Lund, 280 vagnar i Borlänge.
Halv =	35 vagnar i Lund, 70 vagnar i Borlänge.
Inga =	inga vagnar
Fg1 =	farlighetsgrad 1
Fg3 =	farlighetsgrad 3
Dag =	transporter endast dagtid
Natt =	transporter endast nattetid

Som tidigare nämndes utgjordes valsituationen av 2 föreslagna alternativ samt dagens situation. I den regressions modell som använts skattas endast en konstant vilken är gemensam för de föreslagna alternativen. Konstanten kan då tolkas som den förändring i nytta sin en förflyttning från dagens situation innebär även som de föreslagna alternativen är identiska med dagens situation. Det vill säga, själva förändringen från dagen situation kan upplevas som en förbättring eller en försämring. Ofta observeras ett negativt tecken på konstanten vilket kan tolkas som att individer upplever att en förändring från dagens situation är något negativt.

3.3 Datainsamling för järnvägsstudien

Det totala urvalet bestod av 1000 slumpmässigt utvalda individer, ålder 18-65 år, boendes i Lund och i Borlänge. Av dessa 1000 individer var 800 personer boendes nära järnvägen (på parallellgator) i Lund respektive Borlänge. (400 i Lund och 400 i Borlänge.) Av dessa personer fick 200 i Lund och 200 i Borlänge en enkät med mycket bakgrundsinformation om FAGO transporter och lika många fick en enkät med lite information. För att studera avståndets inverkan på individers preferenser för förändring i exponering av farligtgodstransporter drogs även totalt 200 personer i Lund på två olika avstånd till järnvägen. Dessa individer fick samtliga en enkät med mycket bakgrundsinformation om FAGO transporter.

Studien genomfördes som en enkätstudie och enkäterna skickades ut i november 2002. (Se bilaga för ett exempel på en enkät som skickades ut i Lund, version med mycket information.) Utskicket föregicks av två pilotstudier vars resultat utelämnats i denna redovisning. Efter två veckor skickades en påminnelse ut och efter 1 månad skickades en påminnelse tillsammans med en ny enkät. En bortfallsenkät skickades ut i februari.

3.4 Datainsamling för vägstudien

Det totala urvalet bestod av 2000 slumpmässigt utvalda individer, ålder 18-65 år, boendes utmed stråket: Norrtull/Roslagstull/Valhallavägen/Lidingövägen/Tegeluddsvägen. Av dessa personer fick 1000 individer en enkät som innehöll information om andra dödsrisker än FAGO transporter och 1000 individer fick en enkät där denna information inte fanns med.

Enkäterna hade i stort sett samma design som i järnvägsstudien bortsett från en justerade nivåer på kostnadsparametern till följd av högre boende kostnader i Stockholm samt en anpassning av valen för att överensstämma med dagens situation i Stockholm med avseende på antal lastbilar med FAGO samt tidpunkt för transport. Enkäterna skickades ut i november

2003. (Se bilaga för ett exempel på en enkätversion med information om andra dödsrisker.) Efter två veckor skickades en påminnelse ut och efter 1 månad skickades en påminnelse tillsammans med en ny enkät. En bortfallsenkät skickades ut i februari.

4. Resultat

I denna rapport presenteras statistikuppgifter från det insamlade materialet samt resultat från regressionsanalys av jämförelser mellan FAGO transporter på järnväg genom Lund och Borlänge samt mellan FAGO transporter på väg och järnväg. Resultaten från regressionsanalysen för järnväg respektive väg behandlas i Hiselius (2005a) och (2005b).

Ett antal frågor som projektet syftade att svara på ställdes upp i avsnitt 2. Majoriteten av frågorna besvaras i de 2 vetenskapliga artiklar som publicerats/submittats och som bifogas.

Projektets resultat, presenterade i artiklarna, visar på att:
1) Metoden fungerar och ger konsistenta och logiska svar, Hiselius (2005a) och (2005b). De studerade attributen, dvs. förändringar i antal vagnar/lastbilar samt farlighetsgrad påverkar preferenserna på förväntat sätt. Konsistenstestet visar på att individerna klarar av att rangordna olika alternativ på så att om de väljer ett alternativ i ett val väljer de också ett ännu bättre alternativ i ett annat val. Endast ett fåtal individer svarade inkonsistent.
2) Värdet på en förändring i exponering av FAGO kan skattas, Hiselius (2005a) och Hiselius (2005b). Vidare forskning måste dock genomföras för att studera vilken analysmodell som bör användas, Multinomial Logit eller Random Parameter Logit samt hur regressionsmodellen bör ställas upp, t.ex. om dummy variabler eller effect kodning skall användas och om korrelationer mellan attributen skall studeras och inkluderas.
3) Antal vagnar/lastbilar samt farlighetsgrad har betydelse när förändrad exponering av FAGO värderas. En ökning av antalet vagnar/lastbilar samt farlighetsgrad upplevs som något negativt samtidigt som en minskning upplevs som något positivt. Resultatet är mer svårtolkat vad gäller tidpunkt för FAGO transporter, Hiselius (2005a) och (2005b).
4) Resultatet indikerar att det finns en skillnad i värdering mellan urval med mycket/lite bakgrundsinformation om FAGO, Hiselius (2005a). De individer som fick mycket information i sin enkät uttryckte en lägre värdering av en ökad exponering/minskad jämfört med de individer som endast fick lite bakgrundsinformation.

5) Avstånd till järnvägen påverkar värderingen av en förändrad exponering, Hiselius (2005a). Ju längre ifrån järnvägen man bor desto mindre betalningsvilja har man för att minska exponeringen av FAGO. Resultatet stödjer att metoden ger logiska svar.
6) Resultaten visar på att det finns en skillnad mellan betalningsviljan för minskad exponering (WTP) och den ersättning som behövs för att acceptera en ökad exponering (WTA) även om förändringarna är av samma storlek, Hiselius (2005b). Resultatet visar på att det krävs en större kompensation för att en intervjuperson skall acceptera en försämring jämfört med betalningsviljan för att få en lika stor förbättring.
7) Resultatet tyder på att det finns en certainty effect, dvs. är man beredd att betala extra för att reducera exponeringen till noll, Hiselius (2005b).
8) Resultatet indikerar en förekomst av hypotetisk bias, Hiselius (2005b). Detta bias påverkar dock resultatet i motsatt riktning än vad som var förväntat. I studien gjordes separata analyser beroende på hur säkra intervjupersonerna angav att de var på sina svar. Detta gjordes genom att intervjupersonen fick ange huruvida han/hon skulle välja på samma sätt som i enkäten i en lokal folkomröstning med verkliga ekonomiska effekter. Individer som angav att de inte skulle välja på samma sätt i en verklig situation uttrycker en lägre betalningsvilja än de som skulle välja på samma sätt. Om detta tolkas som ett hypotetisk bias leder således detta bias till en underskattning av individernas värderingar inte till en överskattning som man brukar hävda.
9) En fokuserings effekt kan ej påvisas, Hiselius (2005b). Tidigare studier har visat på att individer tenderar att överskatta den aktivitet som studeras i en enkät relativt andra aktiviteter, ett s.k. fokuseringsbias. För att studera huruvida resultatet påverkades av att andra dödsrisker nämndes i enkäten innehöll halva enkätutskicket i studien av FAGO transporter på väg i Stockholm information om både FAGO transporter och andra dödsrisker. I den andra halvan fanns endast information om FAGO transporter. Inga skillnader kunde dock påvisas mellan de olika delmaterialen. Resultatet beror antingen på att det inte finns någon fokuseringseffekt eller att den inkluderade informationen om andra dödsrisker inte framträtt tillräckligt tydligt.

Projektets resultat, ej redovisade i artiklarna, visar även på att:

10) Enkäten verkar inte ha ökat oron hos respondenterna.

11) Majoriteten av de villa- och bostadsrättsägare som kontaktades per telefon tog ej hänsyn till att värdet på deras fastighet påverkas av FAGO transporterna på järnväg när de gav sina svar.

12) Skillnader kan påvisas i värdering av ”inga transporter” när FAGO transporter på järnväg genom Lund och Borlänge studeras. Skillnader finns även i vilka faktorer som respondenten har tagit hänsyn till när de gjorde sina val.

13) Individers värdering av FAGO transporter på väg skiljer sig ifrån värderingen av FAGO transporter på järnväg. En reducering av exponeringen för FAGO transporter på järnväg värderas lägre än en reducering av exponeringen för FAGO transporter på väg. Skillnader finns dock i vad som transporteras och transporternas mängd.

Resultaten sammanfattade i punkt 10-13 samt statistik från den insamlade datamängden kommer nu att presenteras utförligare.

Svarsfrekvensen presenteras i tabell 1. Svarsfrekvensen varierar beroende på närhet till den studerade transportvägen. Resultatet tyder även på att respondenterna är mer benägna att välja dagens situation (status quo) i samliga val ju längre ifrån den studerade transportvägen de bor. Personer som bor långt ifrån FAGO transporterna upplever troligen inte dem som något större problem.

Hur enkäter med enbart status quo svar kan diskuteras. Det finns studier t.ex. som väljer att ta bort dessa svar ifrån analysen eftersom de anses utgöra protestsvar. Samtidigt kan fallet vara att individer faktiskt väljer dagens situation för att de tycker att detta alternativ är det bästa. Eftersom vi inte har någon kunskap om varför en del individer enbart väljer dagens situation har analysen genomgående gjorts med dessa enkäter inkluderade.

Tabell 1. Svarsfrekvens samt svar med enbart status quo.

	Urvalsstorlek	**Svarsfrekvens**	**Enbart status quo**
Lund *Centralt, mycket information*	200	57%	9%
Lund *Centralt, lite information*	200	62%	9%
Lund *Mindre centralt, mycket information*	100	55%	25%
Lund *Ocentralt, mycket information*	100	46%	32%
Borlänge *Centralt, mycket information*	200	45%	25%
Borlänge *Centralt, lite information*	200	45%	31%
Stockholm *Information om andra dödsrisker*	1000	48%	4%
Stockholm *Ingen information om andra dödsrisker*	1000	46%	5%

Demografisk statistik presenteras i tabell 2. Skillnader i den demografiska statistiken kan observeras mellan de studerade orterna. Intervjupersonerna i Lund är generellt yngre, har högre utbildningsnivå och inkomst samt lägre grad av bostadsägande än intervjupersonerna i Borlänge. Statistiken skiljer sig dock inte nämnvärt mellan delgrupperna med mycket/lite information för Lund och Borlänge (gäller även för tabell 3) vilket understödjer att de skillnader som kan observeras i regressionsanalysen av de olika delgrupperna är ett resultat av skillnader i den bakomliggande informationen som ges i enkäten.

Tabell 2. Demografisk data

	Ålder *mv/md*	**Ant. personer** *mv. vuxna mv. barn*	**Kön (%)** *man kvinna*	**Äger ej boende (%)**	**Utb. (%)** *Grundsk. Gymnasie Högskola*	**Hushålls-inkomst** *mv*
Lund *Centralt, mycket information*	39 33	1,7 0,3	49 51	75	3 12 83	32.875
Lund *Centralt, lite information*	38 31	1,9 0,2	54 46	70	2 8 87	35.316
Lund *Mindre centralt, mycket information*	40 33	1,5 0,2	55 45	57	2 12 82	30.480
Lund *Ocentralt, mycket information*	40 41	1,8 0,9	52 48	41	9 18 70	35.953
Borlänge *Centralt, mycket information*	45 40	1,6 0,2	39 59	42	23 37 30	24.322
Borlänge *Centralt, lite information*	48 51	1,6 0,1	42 58	41	17 41 34	25.267
Stockholm *Information om andra dödsrisker*	38 32	1,6 0,2	58 42	57	3 15 80 2	33.590
Stockholm *Ingen information om andra dödsrisker*	38 32	1,6 0,3	55 45	61	3 14 80 3	35.573

mv = medelvärde, md = median

I tabell 3 presenteras statistik över FAGO relaterad data. Även om det statistika urvalet var begränsat till områden som angränsar till järnvägen både i Borlänge och i Lund är det ändå större andel av intervjupersonerna boendes nära järnvägen i Borlänge som anger att de inte hör järnvägen ifrån sin bostad jämfört med urvalet nära järnvägen i Lund. Skillnaden kan bero på att järnvägen är relativt väl nedsänkt genom Borlänges tätort medan järnvägen går i markplan genom Lund.

Enligt resultatet finns det skillnader mellan Lund, Borlänge och Stockholm med avseende på hur ofta intervjupersonerna funderar på FAGO transporter men också hur stor de tror att sannolikheten är för att en FAGO olycka skall inträffa i framtiden. Intervjupersonerna i Stockholm tänker i högre grad på FAGO transporter i sin närhet än intervjupersonerna i Lund och Borlänge. Vid jämförelse av Lund och Borlänge visar resultatet på att intervjupersonerna i Borlänge oftare tänker på FAGO transporter än intervjupersonerna i Lund. Skillnader mellan Lund och Borlänge kan bero på att Borlänge har upplevt tillbud med FAGO transporter med efterföljande avspärrningar och evakueringar.

Resultatet för FAGO transporter genom Borlänge med avseende på den uppgivna sannolikheten för en FAGO olycka liknar till viss del resultatet för FAGO transporter på väg i Stockholm.

Tabell 3. FAGO relaterad data för Lund och Borlänge (järnväg) samt Stockholm (väg). Alla värden är angivna i %.

	Avstånd till järnväg/väg *Gränsar* *Hör jrnv/väg* *Hör ej jrnv/väg*	**Vistas i orten dagtid**	**Dagtid, samma eller kortare avstånd till järnvägen**	**Funderar på FAGO transporter** *Dagligen* *Ibland* *Ngn gång* *Aldrig*	**Slh för FAGO olycka** *Mycket liten* *Liten* *Stor* *Mycket stor*	**Enkäten påverkat synen på FAGO-transporter**
Lund *Centralt* *Mycket information*	55 44 1	83	22	5 34 34 27	39 44 13 4	29
Lund *Centralt* *Lite information*	53 47 -	74	25	4 32 38 26	28 47 18 7	35
Lund *Mindre centralt* *Mycket information*	10 57 33	72	49	4 20 40 36	43 35 18 4	39
Lund *Ocentralt* *Mycket information*	- 23 75	89	68	3 25 45 27	46 35 12 7	32
Borlänge *Centralt* *Mycket information*	30 53 17	86	53	11 43 38 8	32 27 30 11	20
Borlänge *Centralt* *Lite information*	26 55 19	92	57	6 47 41 6	26 41 24 9	26
Stockholm *Information om andra dödsrisker*	96 4 -	85	29	24 41 21 14	14 39 33 13	32
Stockholm *Ingen information om andra dödsrisker*	94 6 -	84	29	22 44 20 14	12 47 29 11	29

I tabell 4 och 5 presenteras den insamlade statistiken över hur ofta intervjupersonerna tänker på FAGO transporter samt hur stor sannolikheten är att en allvarig FAGO olycka skall inträffa är, uppdelat på olika åldergrupper. Vissa delgrupper utgörs av mycket få intervjupersoner. Dessa är gråmarkerade i tabellerna. Resultatet för dessa grupper skall tolkas med stor försiktighet. Då jämförelser mellan järnväg och väg görs, dvs. mellan Lund/Borlänge och Stockholm används datamaterial baserad på enkäter med mycket information för Lund och Borlänge samt enkäter med ingen information om andra dödsrisker för Stockholm. Vid jämförelse mellan Lund och Borlänge används även datamaterial baserat på enkäter med lite information.

Resultatet tyder på att ju äldre intervjupersonen är desto oftare funderar de på FAGO transporterna i sin närhet. Avstånd till FAGO transporterna verkar ha mindre betydelse då de olika delgrupperna för Lund jämförs.

Tabell 4. Hur ofta intervjupersonerna tänker på FAGO transporter, uppdelat på olika åldersgrupper, %.

Funderar på FAGO transporter	**Ålders-grupp**	**Lund** centralt, mycket info	**Lund** centralt lite info	**Lund** mindre centralt mycket info	**Lund** ocentralt, mycket info	**Borlänge** centralt, mycket info	**Borläng e** centralt, lite info	**Stockholm** ingen info om andra risker
Dagligen		0	0	8	0	0	0	11
Ibland	Ålder	31	11	0	0	39	23	33
Ngn gång	0-26	38	46	15	38	50	54	32
Aldrig		31	42	77	63	11	23	25
Dagligen		5	3	0	4	9	3	20
Ibland	Ålder	29	34	25	26	43	48	47
Ngn gång	27-50	33	29	45	48	37	42	20
Aldrig		33	33	30	22	11	6	13
Dagligen		8	9	6	0	19	9	38
Ibland	Ålder	46	42	29	44	46	52	48
Ngn gång	50-73	35	45	53	44	32	37	8
Aldrig		12	3	17	11	3	2	5

Gråmarkerade fält markerar delgrupper med få intervjupersoner.

Tabell 5. Hur stor sannolikheten är för att en olycka med dödlig utgång skall inträffa under den kommande 50-års perioden, uppdelat på olika åldersgrupper, %.

Slh för FAGO olycka	**Ålders-grupp**	**Lund** centralt, mycket info	**Lund** centralt, lite info	**Lund** mindre centralt, mycket info	**Lund** ocentralt, mycket info	**Borlänge** centralt, mycket info	**Borlänge** centralt, lite info	**Stockholm** ingen info om andra dödsrisker
Mycket liten		32	54	62	50	28	38	13
Liten	Ålder	64	38	15	50	33	46	59
Stor	0-26	4	8	15	0	39	15	21
Mycket stor		0	0	8	0	0	0	8
Mycket liten		41	21	35	38	33	29	12
Liten	Ålder	38	52	45	31	25	32	44
Stor	27-50	18	9	15	19	22	29	32
Mycket stor		4		5	12	19	10	11
Mycket liten		41	18	39	67	33	20	13
Liten	Ålder	33	47	39	33	25	46	40
Stor	50-73	11	25	22	0	33	24	33
Mycket stor		7	9	0	0	8	11	15

Gråmarkerade fält markerar delgrupper med få intervjupersoner.

I tabell 6 presenteras statistik för hur stor sannolikhet intervjupersonen tror att det är att en olycka med dödlig utgång skall inträffa under den kommande 50-års perioden, uppdelat på om intervjupersonen aldrig tänker på FAGO transporterna i sin närhet jämfört med övriga intervjupersoner.

Föga förvånande tyder resultatet på att de som sällan tänker på FAGO transporterna i sin närhet också tror att sannolikheten för en FAGO olycka är mycket liten.

Tabell 6**.** Hur stor sannolikheten är för att en olycka med dödlig utgång skall inträffa under den kommande 50-års perioden, uppdelat på om intervjupersonen aldrig tänker på FAGO transporterna i sin närhet jämfört med övriga intervjupersoner, %.

		Slh för FAGO olycka	
Lund *Centralt, mycket information*	Funderar aldrig på FAGO	*Mycket liten*	48
		Liten	42
		Stor	10
		Mycket stor	0
	Övriga	*Mycket liten*	36
		Liten	44
		Stor	15
		Mycket stor	5
Lund *Centralt, lite information*	Funderar aldrig på FAGO	*Mycket liten*	39
		Liten	54
		Stor	3
		Mycket stor	3
	Övriga	*Mycket liten*	23
		Liten	45
		Stor	24
		Mycket stor	8
Borlänge *Centralt, mycket information*	Funderar aldrig på FAGO	*Mycket liten*	75
		Liten	0
		Stor	12
		Mycket stor	12
	Övriga	*Mycket liten*	28
		Liten	29
		Stor	32
		Mycket stor	11
Borlänge *Centralt, lite information*	Funderar aldrig på FAGO	*Mycket liten*	83
		Liten	17
		Stor	0
		Mycket stor	0
	Övriga	*Mycket liten*	21
		Liten	43
		Stor	26
		Mycket stor	9
Stockholm *Ingen information om andra dödsrisker*	Funderar aldrig på FAGO	*Mycket liten*	20
		Liten	61
		Stor	14
		Mycket stor	6
	Övriga	*Mycket liten*	11
		Liten	45
		Stor	32
		Mycket stor	12

Gråmarkerade fält markerar delgrupper med få intervjupersoner.

I tabell 7 presenteras statistik över de kommentarer som individerna givet när vi bett dem beskriva hur enkäten har påverkat deras syn på FAGO transporter. Kommentarerna har grupperats för att ge bätre överskådlighet. Enligt resultatet i tabell 7 har enkäten gett upphov till ökad oro för intervjupersonerna i Borlänge. Majoriteten av de synpunkter på enkäten som angetts är att den givit en ökad medvetenhet om FAGO transporterna. Vi vet dock ej om ökad medvetenhet även inkluderar en ökad oro.

Tabell 7. Hur enkäten har påverkat synen på FAGO transporter, % av totalt antal synpunkter.

	Minskad oro eller låg risk	*Ökad oro*	*Ökad medvetenhet*	*FAGO bör gå på jrnv*	*FAGO ej i tätort*	*FAGO på lastbil*	*Övriga synpkt.*
Lund *Centralt, mycket information*	6		74	3			16
Lund *Centralt, lite information*	3		85	3	5		10
Lund *Mindre centralt, mycket information*	6	6	88				
Lund *Ocentralt, mycket information*	8		92				
Borlänge *Centralt, mycket information*	5	23	35	5		5	29
Borlänge *Centralt, lite information*	12		53	6	6		
Stockholm *Ingen information om andra dödsrisker*	8	4	71		4		12

I tabell 8 presenteras faktorer som intervjupersonerna uppgett sig ta hänsyn till när de avgett sina svar. Faktorer som intervjupersonerna tog hänsyn till är i stort sett desamma i de olika orterna. Intervjupersonerna i Borlänge var dock mer benägna att ta hänsyn till effekter på näringslivet när de gjorde sina val. Tabellen visar dock inte på någon större skillnad i oro och obehag vilket annars de egna kommentarerna, sammanställda i tabell 7, antyder.

Tabell 8. Faktorer som intervjupersonen tog hänsyn till när valen gjordes.

Lund, urval centralt, mycket information

	Person-skador	**Egendoms-skador**	**Risk att bli evakuerad**	**Oro och obehag**	**Miljö-skador**	**Effekter på näringsliv**
Ja	89%	34%	48%	68%	69%	22%
Nej	10%	62%	46%	26%	25%	70%
Vej ej	1%	4%	6%	5%	6%	8%

Borlänge, urval centralt, mycket information

	Person-skador	**Egendoms-skador**	**Risk att bli evakuerad**	**Oro och obehag**	**Miljö-skador**	**Effekter på näringsliv**
Ja	76%	40%	56%	63%	71%	56%
Nej	18%	55%	37%	32%	21%	33%
Vej ej	5%	5%	7%	5%	8%	11%

Stockholm**,** urval utan information om andra dödsrisker

	Person-skador	**Egendoms-skador**	**Risk att bli evakuerad**	**Oro och obehag**	**Miljö-skador**	**Effekter på näringsliv**
Ja	83%	43%	45%	72%	76%	27%
Nej	13%	50%	46%	24%	19%	64%
Vej ej	4%	7%	8%	4%	5%	9%

Lund, urval centralt, lite information

	Person-skador	**Egendoms-skador**	**Risk att bli evakuerad**	**Oro och obehag**	**Miljö-skador**	**Effekter på näringsliv**
Ja	92	36	50	70	71	20
Nej	8	62	43	27	23	72
Vej ej	0	2	6	3	6	8

Borlänge, urval centralt, lite information

	Person-skador	**Egendoms-skador**	**Risk att bli evakuerad**	**Oro och obehag**	**Miljö-skador**	**Effekter på näringsliv**
Ja	75	39	56	64	69	59
Nej	19	52	36	32	21	26
Vej ej	6	7	8	4	8	13

I tabell 9 presenteras resultat av en regressionsanalys gjord för Lund- och Borlängematerialet tillsammans. I regressionsmodellen kan urskiljas vilka attribut som är viktiga för individernas preferenser vad gäller en förändring i deras exponering av FAGO. En signifikant parameter signalerar att individerna har tagit hänsyn till detta attribut när valen gjordes.

För att urskilja skillnader mellan Lund och Borlänge används dummyvariabler där parametrarna för Lund utgör nollnivån. Parametrarna som tillkommer för Borängematerialet skattas på så sätt separat. För att få den totala koefficientskattningen för Borlänge summeras således t.ex. Dubbl+DubblB. Resultatet tyder på att för de undergrupper som fick utförlig information om FAGO transporter skiljer sig endast värderingen av inga transporter mellan Lund och Borlänge. Intervjupersonerna i Lund visar sig då värdera en total reducering dessa transporter högre. Om man istället tittar på de undergrupper som fick begränsad information skiljer sig även värderingen för tidpunkt av transporter. Skillnaden i resultat mellan undergrupperna med lite/mycket information kan eventuellt förklaras med att om intervjupersonerna får tillgång till utförlig information om FAGO transporterna har tidpunkten för transporterna mindre betydelse för individernas värderingar av en förändring i exponeringen av FAGO transporter.

Det är dock viktigt att poängtera att FAGO transporterna i dagens situation skiljer sig emellan Lund och Borlänge både med avseende på typ av gods som transporteras och vilken mängd. Initialrisken är således olika i de båda orterna. Detta gör att jämförelse mellan t.ex. en värdering av en dubblerad mängd av FAGO inte bygger på samma förändrad mängd FAGO för Lund och Borlänge. Detta försvårar givetvis tolkningen av resultatet. Regressionsmodellen kan ändå sägas ge en fingervisning om eventuella skillnader mellan Lund och Borlänge.

I tabellen presenteras även den marginella substitutionskvoten, dvs. förhållandet mellan ett attribut och kostnadsparametern. Den marginella substitutionskvoten kan tolkas som en genomsnittlig individs betalningsvilja, positivt tecken på MRS kvoten, eller belopp som krävs för att kompensera för en försämring, negativt tecken på MRS kvoten.

Tabell 9. Regressionsmodell för Lund och Borlänge. Urval: centralt. Totalt MRS för Borlängematerialet anges inom parantes, SEK.

Parametrar	***mycket information*** Koefficient t-värde	***MRS***	***lite information*** Koefficient t-värde	***MRS***
Konstant	-0.510* -2.056		-0.972 -4.689	
Kostn/månad*1000	-3.369* -4.513		-4.806* -6.630	
Dubbl	-1.309* -6.006	388	-1.048* -4.879	218
Halv	0.435* 2.672	-129	0.408* 2.449	-85
Inga	1.350* 4.927	-401	1.646* 5.810	-342
Fg1	0.380* 2.200	-113	0.301 1.692	-63
Fg3	-1.840* -7.365	546	-1.380* -5.954	287
Dag	0.185 0.968	-55	0.811* 4.032	-169
Natt	-0.085 0.466	25	0.508* 2.572	-106
För Borlängematerialet tillkommande koefficienter				
DubblB	0.306 1.138	-91 (297)	0.116 0.432	-24 (194)
HalvB	-0.335 -1.488	99 (-30)	-0.074 -0.329	15 (-70)
IngaB	-1.073* -4.866	318 (-83)	-0.655* -2.867	136 (-206)
Fg1B	-0.387 -1.762	115 (2)	0.294 1.309	-61 (-124)
Fg3B	0.476 1.490	-141 (405)	0.423 1.385	-89 (198)
DagB	-0.292 -1.168	87 (32)	-0.518* -2.042	108 (-61)
NattB	-0.197 -0.757	58 (83)	-0.597* -2.233	124 (18)

I tabell 10 presenteras resultatet från en regressionsmodell för Lund-, Borlänge- och Stockholmsmaterialet tillsammans. Modellen har ställts upp så att skillnader mellan FAGO transporter på väg och järnväg kan studeras. Här finns dock samma typ av problem som i den regressionsmodell som presenterades i tabell 9. Skillnader finns mellan orterna vad gäller typ av FAGO som transporteras vilket medför att sannolikheten för att en viss typ av olycka skall inträffa skiljer sig åt. Även mängden FAGO som transporteras skiljer sig också. Den sammanlagda modellen kan alltså inte tolkas entydigt. Det kan ändå vara intressant och se om intervjupersonernas värderingar skiljer sig mellan väg och järnvägstransporter. Resultatet tyder på att förändringar i exponeringen för FAGO transporter värderas lägre för FAGO transporter på järnväg än på väg.

Tabell 10. Regressionsmodell för Lund-, Borlänge- och Stockholmsmaterialet. Urval: centralt, mycket information för Lund och Borlänge, ingen information om andra dödsrisker för Stockholm. Totalt MRS för Stockholmsmaterialet anges inom parantes, SEK.

Parametrar	Koefficent t-värde	**MRS**
Konstant	-3.342* -4.405	
Kostn/månad*1000	-2.518* -10.814	
Högre	-1.339* -15.338	304
Lägre	0.930* 14.121	-211
Inga	1.942* 19.155	-441
Fg1	0.455* 6.370	-103
Fg3	-1.352* -15.076	307
För Lund och Borlänge tillkommande koefficienter		
HögreJ	0.478* 3.325	-108 (196)
LägreJ	-0.731* -6.756	166 (-45)
IngaJ	-1.510* -12.323	343 (-98)
Fg1J	-0.341* -3.263	77 (-26)
Fg3J	0.329* 2.137	-75 (232)

*signifikant på 5% nivån

I tabell 11 presenteras skattningar som är hämtande ifrån artikel Hiselius (2005b). Här ses att betalningsviljan för minskad exponering är lägre i Lund än i Stockholm och på samma sätt är beloppet för att acceptera en ökad exponering lägre i Lund.

Tabell 11. WTP/WTA, SEK per månad och hushåll, inkomst L, nära stråk, äger ej bostad, mycket information för Lund, utan information om andra dödsrisker för Stockholm.

Lund, järnväg		**Stockholm, väg**	
Antal vagnar (SQ = 70)		*Antal lastbilar (SQ=140)*	
140 (fördubbling)	215	220 (mindre än fördubbling)	329
35 (halvering)	-41	60 (mer än halvering)	-260
0	-224	0	-386
Farlighetsgrad		*Farlighetsgrad*	
Klass 1	-65	Klass 1	-89
Klass 3	292	Klass 3	340

I tabell 12 presenteras statistik från bortfallsenkäten. Enligt resultatet är de som inte svarat på enkäten generellt yngre och äger ej sitt boende i större utsträckning än de som svarat.

Tabell 12. Statistik från bortfallsenkäten

	Svarsprocent	**Ålder** *mv/md*	**Kön (%)** *man kvinna*	**Äger ej boende (%)**	**Utb. (%)** *Grundsk. Gymnasie Högskola*
Lund *Centralt, mycket information*	20	36 30	50 50	67	0 22 78
Lund *Centralt, lite information*	25	35 29	40 60	70	10 10 80
Lund *Mindre centralt, mycket information*	18	34 28	44 56	67	0 11 89
Lund *Ocentralt, mycket information*	16	35 29	44 56	38	0 25 75
Borlänge *Centralt, mycket information*	21	42 40	48 52	61	17 44 39
Borlänge *Centralt, lite information*	16	41 36	39 61	56	11 45 44
Stockholm *Information om andra dödsrisker*	16	37 30	67 33	59	7 16 77
Stockholm *Ingen information om andra dödsrisker*	16	37 30	46 54	51	9 13 77

I enkäterna angavs att förändringen i boendekostnad som intervjupersonen hade att ta ställning till baserades på en förändring i marknadsvärdet på fastigheten och därigenom en förändrad fastighetsskatt. Denna formulering kan medföra problem då individer som äger sitt boende kan ha incitament till att acceptera en kostnadsökning för hushållet per månad mot att i stället få en minskad exponering av FAGO. Acceptansen för kostnadsökningar kan antas öka för dessa individer då denna kostnadsökning kapitaliseras den dag man säljer fastigheten. För att studera om individer som äger sitt boende har tagit hänsyn till förändringar i marknadsvärdet på sin fastighet när de har svarat på enkäten kontaktades totalt 64 individer per telefon som uppfyllde följande kriterier:

- Äger sitt boende, dvs. bor i bostadsrätt eller villa
- Har telefon och som jag har fått tag på
- Svarat inom 2 veckor
- Ej enbart givit status quo val

Frågan som ställdes var: När du gjorde dina val i enkäten tog du då hänsyn till förändringar i marknadsvärdet på din fastighet? Resultaten från telefonintervjun presenteras i tabell 13.

Tabell 13. Grad av hänsyn till förändringar i marknadsvärdet på fastigheten när enkäten besvarades, antal personer.

	Lund	**Borlänge**
Ingen hänsyn	24 (80%)	26 (76%)
Hänsyn till viss del	2 (7%)	4 (12%)
Hänsyn	4 (13%)	4 (12%)
Totalt antal	*30*	*34*

I Borlänge var det totalt 23% som tog hänsyn till förändring i marknadsvärde på fastigheten i någon mån och i Lund var det totalt 20%. Denna undersökning löser dock inte problemet med att vissa intervjupersoner kan svara strategiskt. Vi har dock fått en fingervisning om storleken på problemet. Denna typ av studie genomfördes inte i Stockholm.

5. Sammanfattning

Projektet har utgjorts av 2 delar. Dels en litteraturstudie över värdet av säkerhet inom väg- och järnvägssektorn samt dels ett empiriskt arbete där närboendes inställning till FAGO transporter på väg och järnväg studeras. Litteraturöversikten finns presenterad i Hiselius (2003) och behandlar värdet av säkerhet inom väg- och järnvägssektorn genom att kombinera psykologiska studier med ekonomisk litteratur. Genomgången visar på att olika värden av säkerhet kan motiveras teoretiskt inom olika trafikområden men då empiriska studier genomförs kan inte några större skillnader påvisas. Genomgången visar även på att hänsyn bör tas till skillnader i säkerhet mellan olika typer av olyckor och inte bara på olika typer av transportområden.

Syftet med det empiriska arbetet har varit att ta fram en metod för att värdera FAGO olyckor. Tidigare metod för värdering av olyckor där man har skattat individers värderingar av riskförändringar är mindre tillämpbar när FAGO olyckor studeras. Utöver svårigheter med att uttrycka och förstå små riskförändringar samt att beskriva en mångfald av olyckstyper och olyckutfall innebär den tidigare metoden att kostnader som FAGO transporter kan anses ge upphov till inte fångas in. De kostnader som tidigare uteslutits är den belastning som FAGO transporter kan anses utgöra för de som bor in närheten vad gäller oro, obehag, svårigheter i samband med icke-olyckor, dvs. incidenter utan läckage vilka tekniskt sett inte definieras som en olycka. För att fånga in denna belastning valde vi att istället för att låta intervjupersonen värdera riskförändringar få värdera olika mängder av exponering för FAGO. Arbetet inom projektet har således använts för att ta fram detta nya tillvägagångssätt i strävan att få fram en ny metod där fler effekter tas hänsyn till.

De empiriska studierna som behandlar närboendes inställning till farligtgodstransporter på järnväg har genomförts med hjälp av Choice experiment metoden. Individernas exponering för farligtgods har använts för att beskriva olika transportutformningar. Studien visar på att metoden fungerar och att individernas preferenser gentemot dessa transporter kan studeras. I den empiriska studien där FAGO transporter på väg studeras analyserades förekomsten av hypotetisk bias genom att individerna fick ange om de skulle välja på samma sätt i en verklig folkomröstning om farlig gods transporter som de gjort i enkäten. Även förekomsten av fokuserings effekt studerades. Studiens resultat tyder på att individer som är säkra på sina svar (skulle valt på samma sätt i en verklig folkomröstning) uttrycker högre betalningsvilja för en minskad exponering av farligtgods än de som är osäkra. Vidare kunde ingen fokuseringseffekt

urskiljas. Studierna har även medfört att förståelsen för faktorer som påverkar värderingen av minskad risk för FAGO olyckor har ökat.

6. Diskussion

I en rapport från Räddningsverket (2001, s: 61) angående olycksrisker och miljökonsekvensbeskrivningar (MKB) står följande: ”Effekter på människor kan vara olika former av ohälsa som kan orsakas av olyckor, t.ex. obehag, symptom, fysiska och psykiska skador, sjukdomar och dödsfall. Även obehag och rädsla för olyckor bör räknas som effekter på människor.” De sistnämnda effekterna är således effekter som vi bör ta hänsyn till när samhällsekonomiska kalkyler beräknas.

Oron och obehaget som riskfyllda aktiviteter medför kan dessutom antas variera. FAGO transporter är t.ex. en aktivitet som ger konsekvenser även om ingen olycka inträffar i teknisk mening. Även vid tillbud (dvs. en händelse utan läckage) kan närboende uppleva stor oro och obehag och de kan även bli utsatta för en evakuering. Om vi enbart studerar effekter av en olycka bortser vi således från dessa negativa effekter.

Oro och obehag som är förknippade med en riskfylld aktivitet kan dels studeras explicit och dels som en delmängd av andra effekter. I det projekt som genomförts har vi valt att studera oro och obehag som en del av de effekter som uppkommer vid en förändrad exponering av FAGO transporter. Enligt den litteraturgenomgång som gjorts inom ramen för projektet är det bara Zeidner och Shechter (1994) som försökt skatta oro och obehag explicit. Att separera risk från oro och obehag medför dock stora svårigheter när en studie designas varför vi valt att inte skatta oro och obehag explicit. Vi undgår på så sätt även att beskriva de olika transportalternativen med hjälp av traditionella riskmått. I Hjalte och Hiselius (2005) diskuteras dock möjligheten att skatta värderingen av oro och obehag separat.

För att tillämpa de värden som beräknats inom ramen för detta projekt måste vi dock ha bättre kunskap om vilka effekter tar individerna hänsyn till när en förändrad exponering diskuteras. Viss information har vi dock, se tabell 8, vilken tyder på att individerna tagit hänsyn till såväl personskador (mellan 75 och 92 %) som oro och obehag (mellan 64 och 72 %) när de gjort sina val i den genomförda studien, men en fördjupad analys ser vi som en nödvändighet.

Inom den framtida forskningen är således väsentligt att kvalitativa studier görs i samband med själva värderingsstudien. Fångar vi till exempel den värdering av en förändrad olycksrisk som

brukar inkluderas i Banverkets och Vägverkets samhällsekonomiska kalkyler när vi nu mer översiktligt ber individerna värdera en förändrad exponering av FAGO? Denna fråga är central eftersom vi i så fall riskerar att utföra en dubbelräkning om både olyckskostnad (eg. riskvärdet) och värderingen av en förändrad exponering inkluderas i en samhällsekonomisk kalkyl. Samtidigt krävs en fördjupad analys för att studera huruvida de effekter som mäts är effekter av FAGO transporter speciellt och inte av järnväg och väg generellt. Dessa frågor bör studeras vidare genom t.ex. djupintervjuer vilket dock inte har inrymts inom det genomförda projektet.

När vi har denna fördjupade kunskap kan de beräknade värdena användas på ett flertal sätt. Det genomförda projektet visar på att denna typ av analyser kan genomföras för att få en bättre bild av hur individer boendes utmed transportleder med FAGO värderar en förändrad exponering av FAGO. Genom att använda Choice experiment ansatsen där olika attribut av FAGO transporter värderas separat, kan vi studera vilka faktorer som är viktiga för de närboende och vi kan också studera hur bakomliggande faktorer så som bostadsägande och avstånd till transportled påverkar individers värderingar. Det sistnämnda är speciellt viktigt för att identifiera målgrupper och berörda populationer. Skillnader och likheter i individers inställning och värdering av exponering av FAGO transporter via lastbil och järnväg kan även studeras.
Analyserna kan användas för att jämföra och ta fram underlag för prioritering mellan olika åtgärder, dvs. mellan olika typer av transport designer. Genom att använda skattade värden kan vi således experimentera utan att faktiskt genomföra.

Sammantaget kan vi säga att projektet har resulterat i en metod som ännu ej är färdigutvecklad. Mer forskning krävs för att den skall bli generellt tillämpbar för olika typer av investeringar. Trots dess brister pekar den dock på att en allmän oro finns och att den ger upphov till belastningar för närboende som inte är direkt kopplad till en olycka, som bör värderas. Att använda exponering när olika transportscenarios diskuteras kan vara ett sätt att fånga denna kostnad. Analysen visar på att denna typ av studie kan ge vägledning till hur infrastrukturen skall anpassas och användas och även insamla intressant information kring farligtgodstransporter. Genom större urval i framtida studier kan mer kunskap utvinnas samtidigt som förståelsen för analys metodens styrkor och svagheter ökar.

Den genomförda studien har även syftat till att utveckla Choice experiment metoden och att öka kunskapen kring dess skattningsproblem. I t.ex. SIKA PM 2005:8 diskuteras problem som är förknippade med Stated preference ansatsen, t.ex. hypotetisk bias, strategisk bias och scale bias. Hypotetisk bias refererar till att frågorna är hypotetiska och det är då oklart om den tillfrågade personen verkligen svarar sanningsenligt och i enlighet med sina verkliga värderingar. Det kan också finnas strategiska överväganden bakom svaret för att få personliga fördelar. Med scale bias menas problemet med att storleken på en, t.ex. riskminskning, har visat sig påverka betalningsviljan mycket lite. Detta bias tyder på att individer har svårigheter med att förstå och förhålla sig till dels enskilda risknivåer med också förändringar i risk.

Dessa problem har främst diskuterats med utgångspunkt från studier gjorda med Contingent valuation ansatsen. I denna ansats, diskuterad på sidan 10, får intervjupersonerna uppge sin hypotetiska betalningsvilja för t.ex. en riskreduktion. I den genomförda studien har vi istället valt att använda Choice experiment metoden där individerna ombeds göra ett antal hypotetiska val mellan olika scenarios. Vi har även studerat förekomsten av hypotetisk bias genom att tillfråga individerna om de skulle valt på samma sätt i en faktisk folkomröstning med faktiska ekonomiska konsekvenser. Enligt studiens resultat uppger individer som är osäkra på sitt svar uppger en högre betalningsvilja än individer som är säkra på sina svar. Om denna skillnad tolkas som ett hypotetisk bias kan vi alltså med denna teknik sålla bort de individer som inte svarar enligt sina sanna preferenser.

Enligt litteraturen är dessutom förekomsten av strategisk bias ett mindre problem när Choice experiment metoden används. Eftersom en mängd attribut varieras samtidigt är det svårt att svara på ett strategiskt sätt. Slutligen visar studiens resultat på att individerna är känsliga för en förändring i exponering av FAGO transporter vilket antyder att vi har mindre problem med scale bias i denna Choice experiment studie jämfört med tidigare Contingent valuation studier. Eftersom tidigare resultat även visat på att individer har svårigheter att förhålla sig till risker och riskförändringar har vi i det genomförda projektet valt att istället för traditionella riskmått använda exponering för att beskriva olika transport scenarios. Studiernas resultat verkar lovande och vi ser det som önskvärt att utveckla denna metod ytterligare för att hitta ett alternativt sätt att kommunicera risk.

Sammantaget tyder projektets resultat på att Choice experiment metoden är mycket tillämpbar speciellt då separata värderingar erhålls på de i valen ingående attributen. Med fortsatt forskning där exponering istället för traditionella riskmått används, kommer vi att ha möjligheten att skatta värden som i framtiden kan ersätta alternativt komplettera de riskvärden som nu används.

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LUNDS TEKNISKA HÖGSKOLA
Lunds universitet
Institutionen för Teknik och samhälle

Lund 2002-11-18

Undersökning kring transporter av farligt gods på järnväg

På institutionen för Teknik och samhälle vid Lunds Tekniska Högskola pågår ett forskningsprojekt som undersöker hur boende i närheten av en järnväg uppfattar godstågens trafik och deras last. Vi är speciellt intresserade av hur ni uppfattar transporter av s.k. farligt gods på järnväg.
Genom att svara på denna enkät har ni chansen att göra era röster hörda och säga vad ni tycker om transporter av farligt gods. Enkätens svar kan sedan användas för att bestämma vilka investeringar i järnvägar och vägar som skall genomföras i framtiden.

I enkäten finns några avsnitt som beskriver vad farligt gods är och vad du skall tänka på när du besvarar enkätens frågor. Läs igenom dessa avsnitt noga så skall det inte vara så svårt att fylla i enkäten.

Dina svar kommer att behandlas helt konfidentiellt och inga enskilda personers synpunkter kommer att kunna utläsas i resultaten. Din medverkan i denna undersökning är naturligtvis helt frivillig, men det är samtidigt viktigt att vi får synpunkter från så många som möjligt. Ditt svar kan inte ersättas med någon annans.

Lägg enkäten i svarskuvertet när du är klar och posta brevet. Du behöver inte sätta på frimärke. Posta brevet så snart som möjligt!

Har du några frågor är du välkommen att ringa mig på telefon 046-222 97 48 eller skicka e-post-meddelande till lena.hiselius@tft.lth.se så kan jag ringa upp eller svara per e-post.

Tack på förhand för din hjälp!

Lena Hiselius
Doktorand, projektledare

Christer Hydén
Professor

B:_____

1) Kön Man
Kvinna

2) Ålder _____

3) Totalt antal vuxna (18 år och äldre) som bor i ditt hushåll (dig själv inräknad) _____

Totalt antal barn (17 år och yngre) som bor i ditt hushåll _____

4) Vilken är den högsta utbildning du har gått eller går?
grundskola eller motsvarande
gymnasieskola eller motsvarande
högskola eller motsvarande
annan

5) Boende
hyresrätt
bostadsrätt
villa
annat

6) Vilken är ditt hushålls samlade boendekostnad per månad (inkl. räntekostnad)?
1 – 3 000 kr/månad
3 001 – 5 000 kr/månad
5 001 – 7 000 kr/månad
7 001 – 9 500 kr/månad
9 501 kr/månad eller mer

7) Vad är ditt hushålls sammanlagda inkomst per månad (dvs. inkomst av anställning, pension och/eller rörelse) före skatt?

1 – 8 000 kr/månad
8 001 – 15 000 kr/månad
15 001 – 30 000 kr/månad
30 001 – 60 000 kr/månad
60 001 kr/månad eller mer

8) Hur långt ifrån järnvägen bor du idag?

järnvägen angränsar till min bostad
järnvägen angränsar inte till min bostad men jag kan ändå höra tågen därifrån
järnvägen angränsar inte till min bostad och jag kan inte höra tågen därifrån

9) Vistas du vanligtvis i Lund dagtid?

ja
nej

Om du svarade nej på fråga 9, gå direkt till fråga 11.

10) Hur långt ifrån järnvägen, jämfört med din bostad, ligger den plats i Lund där du vanligtvis befinner dig dagtid?

den ligger närmare järnvägen än min bostad
den ligger längre ifrån järnvägen än min bostad
den ligger på ungefär samma avstånd från järnvägen som min bostad
vet ej

11) Har du någon gång funderat på om det transporteras farliga ämnen på järnvägen nära dig?

dagligen
ibland
någon enstaka gång
aldrig

För att du skall kunna svara på de frågor som kommer är det viktigt att du läser igenom följande text innan du fortsätter.

Vad menas med farligt gods?

Cirka 3 % av det gods som idag transporteras på järnväg klassas som farligt gods. Med farligt gods menas ämnen som kan skada människor, miljö och egendom.

Hur ofta händer en olycka med farligt gods i eller i närheten av Lund?

På Södra stambanan genom Lunds tätort går idag omkring 70 godståg per dygn. Sannolikheten för att ett godståg skall spåra ur på sträckan Eslöv-Malmö är beräknad till mellan 3 och 4 olyckor på 10 år, dvs. något mindre än en olycka vart annat år.

Det är dock sällan som en urspårning drabbar ett godståg som transporterar farligt gods. Eftersom det ställs höga krav på de vagnar som används är det dessutom mycket sällan som något farligt ämne läcker ut om en olycka skulle ske. Sannolikheten för att en olycka skall ske någonstans på sträckan Eslöv-Malmö, där gas läcker ut, är till exempel beräknad till en olycka på
2 000 år.

Vad kan hända om ett farligt ämne läcker ut?

Om ett farligt ämne läcker ut kan det medföra skador på människor, egendom och miljö och även orsaka besvär för närboende om de blir evakuerade under uppröjningsarbetet. Även om inget farligt ämne läcker ut kan personer som bor i närheten få lämna sina bostäder för säkerhets skull. I vissa fall har boende blivit evakuerade i upp till en vecka.

Hur allvarliga följderna blir av ett utsläpp beror främst på vilket ämne som läcker ut, utsläppets storlek och hastighet. Även miljön runt olyckan påverkar följderna, t.ex. väderförhållanden och avstånd till bebyggelse.

Förutsatt att ett farligt ämne läcker ut vid en olycka är det störst sannolikhet att utfallet blir sådant att inga människor eller ingen egendom kommer till skada. Av 10 olyckor får 5 eller fler inte några konsekvenser alls, utöver en sanering av olycksplatsen.

Vad kan hända i värsta fall?

Det finns olyckor som i värsta fall innebär mycket svåra konsekvenser för människor, egendom och miljö. Till exempel, om ett stort utsläpp av ammoniak sker, kan ett giftigt gasmoln bildas som dödar människor i närheten och som skadar människor inom en radie av flera kilometer från olycksplatsen.
Ett stort utsläpp av en brandfarlig gas, som antänds, kan leda till en explosion som är direkt dödande för människor i närheten. Denna typ av olycka medför samtidigt stora skador på byggnader och egendom.

Sannolikheten för att olyckor av typen ”i värsta fall” skall inträffa är dock ytterst liten. Storleksordningen denna sannolikhet kan beskrivas så här:

Förutsatt att det händer 10 000 olyckor där något farligt ämne släpps ut (vilket i sig inträffar mycket sällan) är det endast i ett av dessa fall som olyckan får mycket svåra konsekvenser.

I Sverige har ingen person avlidigt vid en olycka med farligt gods under de senaste 50 åren. Sannolikheten att någon dör i en olycka med farligt gods på sträckan Eslöv-Malmö är beräknad till en på 5 000 år.

Järnvägstransporter med farligt gods genom Lund

På sista sidan av enkäten finns en karta över de två järnvägar som går genom Lund, Södra stambanan och Västkustbanan.
Cirka 70 vagnar med farligt gods passerar idag per dygn genom Lund på Södra stambanan. Transporterna sker både dagtid och nattetid.
På Västkustbanan körs däremot inga godståg alls.

Källor: 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.*

Hur ställer du dig till förändringar i transporterna av farligt gods?

I denna studie antas att transporterna av farligt gods genom Lund kan påverkas genom att krav ställs på hur transporterna utformas. Transporternas utformning antas i sin tur påverka värdet på de fastigheter som ligger i områden utmed järnvägen. Förändringen i fastighetsvärde ger då upphov till en förändring i taxeringsvärde och fastighetsskatt, uttryckt som ökad eller minskad boendekostnad per månad. Denna förändring antas ske för såväl boende i villa och bostadsrätt som i hyresrätt.

I studien antas också att den transporterade mängden farligt gods kan klassificeras efter farlighetsgrad. Den kombination av ämnen som dagens transporter utgörs av, antas ha farlighetsgraden 2 på en skala från 1 (mindre farligt) till 3 (mycket farligt).

Vi kommer nu att be dig välja mellan olika utformningar av transporter av farligt gods på Södra stambanan genom Lund. Varje alternativ beskrivs med hjälp av:

- antal vagnar med farligt gods som passerar på järnvägen
- när på dygnet godståg med farligt gods trafikerar järnvägen, dagtid avser kl. 06-22 och nattetid kl. 23-05
- farlighetsgrad på det transporterade godset
- boendekostnad för ditt hushåll jämfört med i dag

Allt annat är oförändrat jämfört med ditt boende idag. Antalet tåg påverkas inte och inte heller det buller som tågtrafiken orsakar.

Varje ruta nedan beskriver en valsituation. Valet står mellan två olika utformningar av transporter av farligt gods på järnväg genom Lund och dagens situation.

Vi vill att du för varje val kryssar för det alternativ som du väljer.

Val nr 1.

	Alternativ 1	Alternativ 2	Dagens situation
Antal vagnar med farligt gods	Inga vagnar med farligt gods	70 vagnar/dygn	70 vagnar/dygn
Tidpunkt för transport av farligt gods		Nattetid	Dagtid och nattetid
Farlighetsgrad på det transporterade godset		Klass 1	Klass 2
Boendekostnad för ditt hushåll	30 kr högre boendekostnad/mån	200 kr lägre boendekostnad/mån	Oförändrad boendekostnad

Kryssa för det alternativ som du väljer!

Alternativ 1 **Alternativ 2** **Dagens situation**

Val nr 2.

	Alternativ 1	Alternativ 2	Dagens situation
Antal vagnar med farligt gods	35 vagnar/dygn	35 vagnar/dygn	70 vagnar/dygn
Tidpunkt för transport av farligt gods	Dagtid	Nattetid	Dagtid och nattetid
Farlighetsgrad på det transporterade godset	Klass 1	Klass 1	Klass 2
Boendekostnad för ditt hushåll	150 kr högre boendekostnad/mån	30 kr högre boendekostnad/mån	Oförändrad boendekostnad

Kryssa för det alternativ som du väljer!

Alternativ 1 Alternativ 2 Dagens situation

Val nr 3.

	Alternativ 1	Alternativ 2	Dagens situation
Antal vagnar med farligt gods	70 vagnar/dygn	140 vagnar/dygn	70 vagnar/dygn
Tidpunkt för transport av farligt gods	Dagtid	Dagtid	Dagtid och nattetid
Farlighetsgrad på det transporterade godset	Klass 3	Klass 2	Klass 2
Boendekostnad för ditt hushåll	Oförändrad boendekostnad	40 kr lägre boendekostnad/mån	Oförändrad boendekostnad

Kryssa för det alternativ som du väljer!

Alternativ 1 **Alternativ 2** **Dagens situation**

Val nr 4.

	Alternativ 1	Alternativ 2	Dagens situation
Antal vagnar med farligt gods	140 vagnar/dygn	Inga vagnar med farligt gods	70 vagnar/dygn
Tidpunkt för transport av farligt gods	Dagtid		Dagtid och nattetid
Farlighetsgrad på det transporterade godset	Klass 2		Klass 2
Boendekostnad för ditt hushåll	200 kr lägre boendekostnad/mån	150 kr högre boendekostnad/mån	Oförändrad boendekostnad

Kryssa för det alternativ som du väljer!

Alternativ 1 **Alternativ 2** **Dagens situation**

Val nr 5.

	Alternativ 1	Alternativ 2	Dagens situation
Antal vagnar med farligt gods	35 vagnar/dygn	35 vagnar/dygn	70 vagnar/dygn
Tidpunkt för transport av farligt gods	Nattetid	Dagtid	Dagtid och nattetid
Farlighetsgrad på det transporterade godset	Klass 2	Klass 3	Klass 2
Boendekostnad för ditt hushåll	Oförändrad boendekostnad	30 kr högre boendekostnad/mån	Oförändrad boendekostnad

Kryssa för det alternativ som du väljer!

Alternativ 1 **Alternativ 2** **Dagens situation**

Val nr 6.

	Alternativ 1	Alternativ 2	Dagens situation
Antal vagnar med farligt gods	35 vagnar/dygn	140 vagnar/dygn	70 vagnar/dygn
Tidpunkt för transport av farligt gods	Dagtid	Dagtid och nattetid	Dagtid och nattetid
Farlighetsgrad på det transporterade godset	Klass 3	Klass 1	Klass 2
Boendekostnad för ditt hushåll	40 kr lägre boendekostnad/mån	200 kr lägre boendekostnad/mån	Oförändrad boendekostnad

Kryssa för det alternativ som du väljer!

Alternativ 1 **Alternativ 2** **Dagens situation**

Avslutande frågor

12) I de val du gjorde på föregående sidor tog du då hänsyn till någon av dessa faktorer?

	Ja	Nej	Vet ej
A. Risken för skador på mig själv eller någon annan i mitt hushåll			
B. Risken för skador på min egendom			
C. Risken att bli evakuerad			
D. Oro och obehag			
E. Risken för skador på miljön			
F. Effekter för näringslivet på orten			

13) Som tidigare nämnts har ingen människa dödats i en olycka med farligt gods de senaste 50 åren i Sverige. Hur sannolikt tror du att det är att en järnvägsolycka med dödsfall inträffar under den kommande 50 års perioden?

mycket liten liten stor mycket stor

14) Har denna undersökning påverkat din syn på transporter av farligt gods?

ja
nej
vet ej

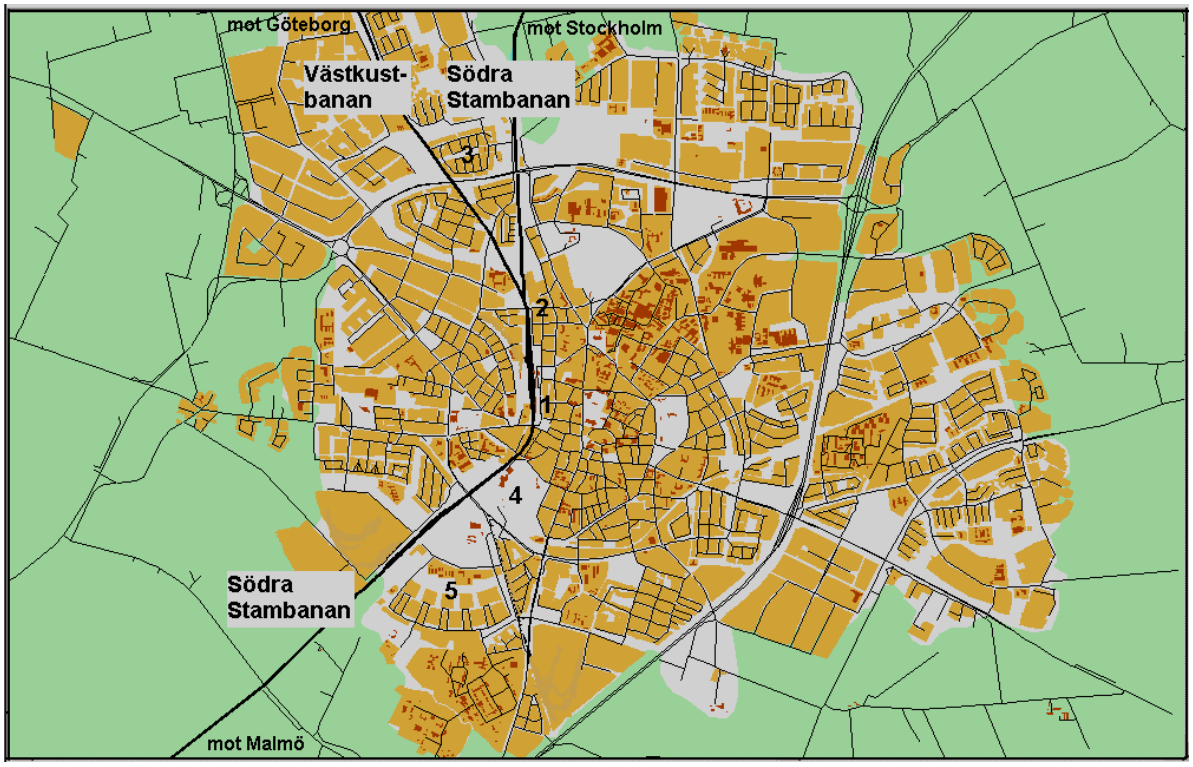
15) Om ja på fråga 14, på vilket sätt?

_____

_____

Tack för din värdefulla medverkan!

Järnvägar genom Lunds tätort



På kartan är Västkustbanan och Södra Stambanan markerad.
Vi har också markerat fem olika ställen i Lunds tätort för att du lättare skall kunna orientera dig.

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

LUNDS TEKNISKA HÖGSKOLA
Lunds universitet
Institutionen för Teknik och samhälle

Lund 2003-11-17

Undersökning kring transporter av farligt gods

På institutionen för Teknik och samhälle vid Lunds Tekniska Högskola pågår ett forskningsprojekt som undersöker hur närboende uppfattar lastbilstransporterna på stråket Norrtull/Roslagstull/Valhallavägen/Lidingövägen/Tegeluddsvägen. Vi är speciellt intresserade av hur ni uppfattar transporterna av s.k. farligt gods. Genom att svara på denna enkät har ni chansen att göra era röster hörda och säga vad ni tycker om transporter av farligt gods. Enkätens svar kan sedan användas för att bestämma vilka investeringar i vägar och järnvägar som skall genomföras i framtiden.

I enkäten finns några avsnitt som beskriver vad farligt gods är och vad du skall tänka på när du besvarar enkätens frågor. Läs igenom dessa avsnitt noga så skall det inte vara så svårt att fylla i enkäten.

Dina svar kommer att behandlas helt konfidentiellt och inga enskilda personers synpunkter kommer att kunna utläsas i resultaten. Din medverkan i denna undersökning är naturligtvis helt frivillig, men det är samtidigt viktigt att vi får synpunkter från så många som möjligt. Ditt svar kan inte ersättas med någon annans.

Lägg enkäten i svarskuvertet när du är klar och posta brevet. Du behöver inte sätta på frimärke. Posta brevet så snart som möjligt!

Har du några frågor är du välkommen att ringa mig på telefon 046-222 97 48 eller skicka e-post-meddelande till lena.hiselius@tft.lth.se så kan jag ringa upp eller svara per e-post.

Tack på förhand för din hjälp!

Lena Hiselius
Doktorand, projektledare

Christer Hydén
Professor

B:

1) Kön Man
Kvinna

2) Ålder _____

3) Totalt antal vuxna (18 år och äldre) som bor i ditt hushåll (dig själv inräknad) _____

Totalt antal barn (17 år och yngre) som bor i ditt hushåll _____

4) Vilken är den högsta utbildning du har gått eller går?
grundskola eller motsvarande
gymnasieskola eller motsvarande
högskola eller motsvarande
annan

5) Boende
hyresrätt
bostadsrätt
villa
annat

6) Vad är ditt hushålls samlade boendekostnad per månad (inkl. räntekostnad)?
1 – 3 000 kr/månad
3 001 – 5 000 kr/månad
5 001 – 7 000 kr/månad
7 001 – 9 500 kr/månad
9 501 kr/månad eller mer

7) Vad är ditt hushålls sammanlagda inkomst per månad (dvs. inkomst av anställning, sjukpenning, pension, rörelse m.m.) före skatt?

1 – 8 000 kr/månad
8 001 – 15 000 kr/månad
15 001 – 30 000 kr/månad
30 001 – 60 000 kr/månad
60 001 kr/månad eller mer

8) Angränsar din bostad till stråket Norrtull/Roslagstull/Valhallavägen/ Lidingövägen/Tegeluddsvägen?

ja
nej

9) Vistas du vanligtvis i Stockholms tätort dagtid?

ja
nej

Om du svarade nej på fråga 9, gå direkt till fråga 11.

10) Hur långt ifrån stråket Norrtull/Roslagstull/Valhallavägen/Lidingövägen/ Tegeluddsvägen, jämfört med din bostad, ligger den plats där du vanligtvis befinner dig dagtid?

den ligger närmare stråket än min bostad
den ligger längre ifrån stråket än min bostad
den ligger på ungefär samma avstånd från stråket som min bostad
vet ej

11) Har du någon gång funderat på om det transporteras farliga ämnen på stråket Norrtull/Roslagstull/Valhallavägen/Lidingövägen/Tegeluddsvägen?

dagligen
ibland
någon enstaka gång
aldrig

För att du skall kunna svara på de frågor som kommer är det viktigt att du läser igenom följande text innan du fortsätter.

Vad menas med farligt gods?

Mellan 8 och 10 % av lastbilstransporterna beräknas innehålla farligt gods. Med farligt gods menas ämnen som kan skada människor, miljö och egendom.

Vad kan hända om ett farligt ämne läcker ut?

Om ett farligt ämne läcker ut kan det medföra skador på människor, egendom och miljö och även orsaka besvär för närboende om de blir evakuerade under uppröjningsarbetet. Även om inget farligt ämne läcker ut kan personer som bor i närheten få lämna sina bostäder för säkerhets skull. I vissa fall har boende blivit evakuerade i upp till en vecka.

Hur allvarliga följderna blir av ett utsläpp beror främst på vilket ämne som läcker ut, utsläppets storlek och hastighet. Även miljön runt olyckan påverkar följderna, t.ex. väderförhållanden och avstånd till bebyggelse.

Förutsatt att ett farligt ämne läcker ut vid en olycka är det störst sannolikhet att utfallet blir sådant att inga människor eller ingen egendom kommer till skada. Av 10 olyckor får 3-4 inte några konsekvenser alls, utöver en sanering av olycksplatsen.

Vad kan hända i värsta fall?

Det finns olyckor som i värsta fall innebär mycket svåra konsekvenser för människor, egendom och miljö. Till exempel, om flygbränsle läcker ut kan pölar av bränsle bildas. Om dessa pölar antänds kan människor och byggnader i närheten skadas av flammor och värmen från branden.
Om bensin läcker ut kan ångor från bensinen samlas i t.ex. brunnar och diken. Ångor som antänds kan leda till en explosion som är direkt dödande för människor i närheten. Denna typ av olycka kan också medföra stora skador på byggnader och egendom.

Sannolikheten för att olyckor av typen ”i värsta fall” skall inträffa är dock liten. Storleksordningen på denna sannolikhet kan uttryckas så här: Förutsatt att det händer 1 000 olyckor där något farligt ämne släpps ut (vilket i sig inträffar sällan) är det endast i 1 av dessa fall som olyckan får mycket svåra konsekvenser.

Hur stor är sannolikheten att dödas i en farligtgodsolycka jämfört med andra dödsorsaker?

I tabellen nedan visas antal dödsfall per år för några olika typer av dödsorsaker i Sverige. Dödsfall i samband med farligt godsolyckor har inte tagits med i tabellen eftersom ingen människa har avlidit i en farligtgodsolycka under de senaste 50 åren.

Antal dödsfall/år	*Dödsorsak*
3.000	Lungcancer
600	Vägtrafikolycka
100	Drunkning
4	Elolycka
0,5	Blixtnedslag

Hur ofta händer en olycka med farligt gods i Stockholm?

Sannolikheten för att en olycka med farligt gods skall inträffa på t.ex. E4 genom Stockholm är beräknad till en olycka på 8 år. Sannolikheten för att en olycka skall ske med flygbränsletransporterna till Arlanda från Louddens oljehamn är beräknad till en olycka på 17 år.

Vägtransporter med farligt gods genom Stockholms tätort

Vägtransporterna av farligt gods genom Stockholms tätort består till största delen av oljeprodukter som transporteras från Louddens oljehamn. Transporterna i tätorten går på följande stråk: Norrtull/Roslagstull/Valhallavägen/Lidingövägen/ Tegeluddsvägen, se kartan på sista sidan.

Enligt uppgifter från 1998 kör cirka 140 lastbilar per dygn med olika oljeprodukter från Loudden. Transporterna sker dagtid mellan kl. 05 och kl. 22.

Källor: 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.

Hur ställer du dig till förändringar i transporterna av farligt gods?

I denna studie antas att transporterna av farligt gods på stråket Norrtull/ Roslagstull/Valhallavägen/Lidingövägen/Tegeluddsvägen kan påverkas genom att krav ställs på hur transporterna utformas. Transporternas utformning antas i sin tur påverka värdet på de fastigheter som ligger i närheten. Förändringen i fastighetsvärde ger då upphov till en förändring i taxeringsvärde och fastighetsskatt, uttryckt som ökad eller minskad boendekostnad per månad. Denna förändring antas ske för såväl boende i villa och bostadsrätt som i hyresrätt.

Vidare antas att det totala antalet lastbilar är oförändrat oavsett hur mycket farligt gods som transporteras. Eftersom antalet lastbilar inte förändras så påverkas inte heller det buller och de avgasutsläpp som lastbilstrafiken orsakar.

I studien antas också att det farliga godset kan klassificeras efter farlighetsgrad. De ämnen som ingår i dagens transporter, antas vid läckage ha farlighetsgraden 2 (måttliga skador på främst egendom) på en skala från farlighetsgrad 1 (inga direkta skador på omgivningen, dock evakuering vid sanering) till farlighetsgrad 3 (stora skador på personer och/eller egendom).

Risken för att en olycka skall inträffa antas slutligen vara densamma dagtid som nattetid.

Vi ber dig välja ...

Vi kommer nu att be dig välja mellan olika utformningar av transporter av farligt gods på stråket Norrtull/Roslagstull/Valhallavägen/Lidingövägen/Tegeluddsvägen. Varje alternativ beskrivs med hjälp av:

- antal lastbilar med farligt gods per dygn
- när på dygnet transporterna sker, dagtid avser kl. 05-22 och nattetid kl. 23-04
- farlighetsgrad på det transporterade godset
- boendekostnad per månad för ditt hushåll jämfört med i dag

Allt annat antas vara oförändrat jämfört med ditt boende idag.

Varje ruta nedan beskriver en valsituation. Valet står mellan två olika utformningar av transporter av farligt gods på stråket Norrtull/Roslagstull/Valhallavägen/ Lidingövägen/Tegeluddsvägen och dagens situation.

Vi vill att du för varje val kryssar för det alternativ som du väljer.

Val nr 1.

	Alternativ 1	Alternativ 2	Dagens situation
Antal lastbilar med farligt gods	Inga lastbilar med farligt gods	140 lastbilar/dygn	140 lastbilar/dygn
Tidpunkt för transport av farligt gods		Nattetid	Dagtid
Farlighetsgrad på det transporterade godset		Farlighetsgrad 1	Farlighetsgrad 2
Boendekostnad för ditt hushåll	40 kr högre boendekostnad/mån	250 kr lägre boendekostnad/mån	Oförändrad boendekostnad

Kryssa för det alternativ som du väljer!

Alternativ 1 **Alternativ 2** **Dagens situation**

Val nr 2.

	Alternativ 1	Alternativ 2	Dagens situation
Antal lastbilar med farligt gods	60 lastbilar/dygn	60 lastbilar/dygn	140 lastbilar/dygn
Tidpunkt för transport av farligt gods	Dagtid	Nattetid	Dagtid
Farlighetsgrad på det transporterade godset	Farlighetsgrad 1	Farlighetsgrad 1	Farlighetsgrad 2
Boendekostnad för ditt hushåll	190 kr högre boendekostnad/mån	40 kr högre boendekostnad/mån	Oförändrad boendekostnad

Kryssa för det alternativ som du väljer!

Alternativ 1 Alternativ 2 Dagens situation

Val nr 3.

	Alternativ 1	Alternativ 2	Dagens situation
Antal lastbilar med farligt gods	60 lastbilar/dygn	220 lastbilar/dygn	140 lastbilar/dygn
Tidpunkt för transport av farligt gods	Dagtid	Dagtid	Dagtid
Farlighetsgrad på det transporterade godset	Farlighetsgrad 3	Farlighetsgrad 2	Farlighetsgrad 2
Boendekostnad för ditt hushåll	Oförändrad boendekostnad	50 kr lägre boendekostnad/mån	Oförändrad boendekostnad

Kryssa för det alternativ som du väljer!

Alternativ 1 Alternativ 2 Dagens situation

Val nr 4.

	Alternativ 1	Alternativ 2	Dagens situation
Antal lastbilar med farligt gods	220 lastbilar/dygn	Inga lastbilar med farligt gods	140 lastbilar/dygn
Tidpunkt för transport av farligt gods	Dagtid		Dagtid
Farlighetsgrad på det transporterade godset	Farlighetsgrad 2		Farlighetsgrad 2
Boendekostnad för ditt hushåll	250 kr lägre boendekostnad/mån	190 kr högre boendekostnad/mån	Oförändrad boendekostnad

Kryssa för det alternativ som du väljer!

Alternativ 1 Alternativ 2 Dagens situation

Val nr 5.

	Alternativ 1	Alternativ 2	Dagens situation
Antal lastbilar med farligt gods	60 lastbilar/dygn	60 lastbilar/dygn	140 lastbilar/dygn
Tidpunkt för transport av farligt gods	Nattetid	Dagtid	Dagtid
Farlighetsgrad på det transporterade godset	Farlighetsgrad 2	Farlighetsgrad 3	Farlighetsgrad 2
Boendekostnad för ditt hushåll	Oförändrad boendekostnad	40 kr högre boendekostnad/mån	Oförändrad boendekostnad

Kryssa för det alternativ som du väljer!

Alternativ 1 Alternativ 2 Dagens situation

Val nr 6.

	Alternativ 1	Alternativ 2	Dagens situation
Antal lastbilar med farligt gods	60 lastbilar/dygn	220 lastbilar/dygn	140 lastbilar/dygn
Tidpunkt för transport av farligt gods	Dagtid	Dagtid och nattetid	Dagtid
Farlighetsgrad på det transporterade godset	Farlighetsgrad 3	Farlighetsgrad 1	Farlighetsgrad 2
Boendekostnad för ditt hushåll	50 kr lägre boendekostnad/mån	250 kr lägre boendekostnad/mån	Oförändrad boendekostnad

Kryssa för det alternativ som du väljer!

Alternativ 1 Alternativ 2 Dagens situation

Avslutande frågor

12) I de val du gjorde på föregående sidor, tog du hänsyn till någon av följande faktorer?

	Ja	Nej	Vet ej
A. Risken för skador på mig själv eller någon annan i mitt hushåll			
B. Risken för skador på min egendom			
C. Risken att bli evakuerad			
D. Oro och obehag			
E. Risken för skador på miljön			
F. Effekter för näringslivet på orten			

13) Antag att förekomsten av transporter av farligt gods i din närhet skulle avgöras i en lokal folkomröstning med verkliga konsekvenser för din ekonomi. Skulle du då välja på samma sätt som du gjort i denna enkät?

ja, säkert ja, troligen vet ej nej, troligen inte nej, säkert inte

14) Som tidigare nämnts har ingen människa dödats i en olycka med farligt gods de senaste 50 åren i Sverige. Hur sannolikt tror du att det är att en dödsolycka med farligt gods inträffar under den kommande 50 års perioden?

mycket liten liten stor mycket stor

15) Har denna undersökning påverkat din syn på transporter av farligt gods?

ja
nej
vet ej

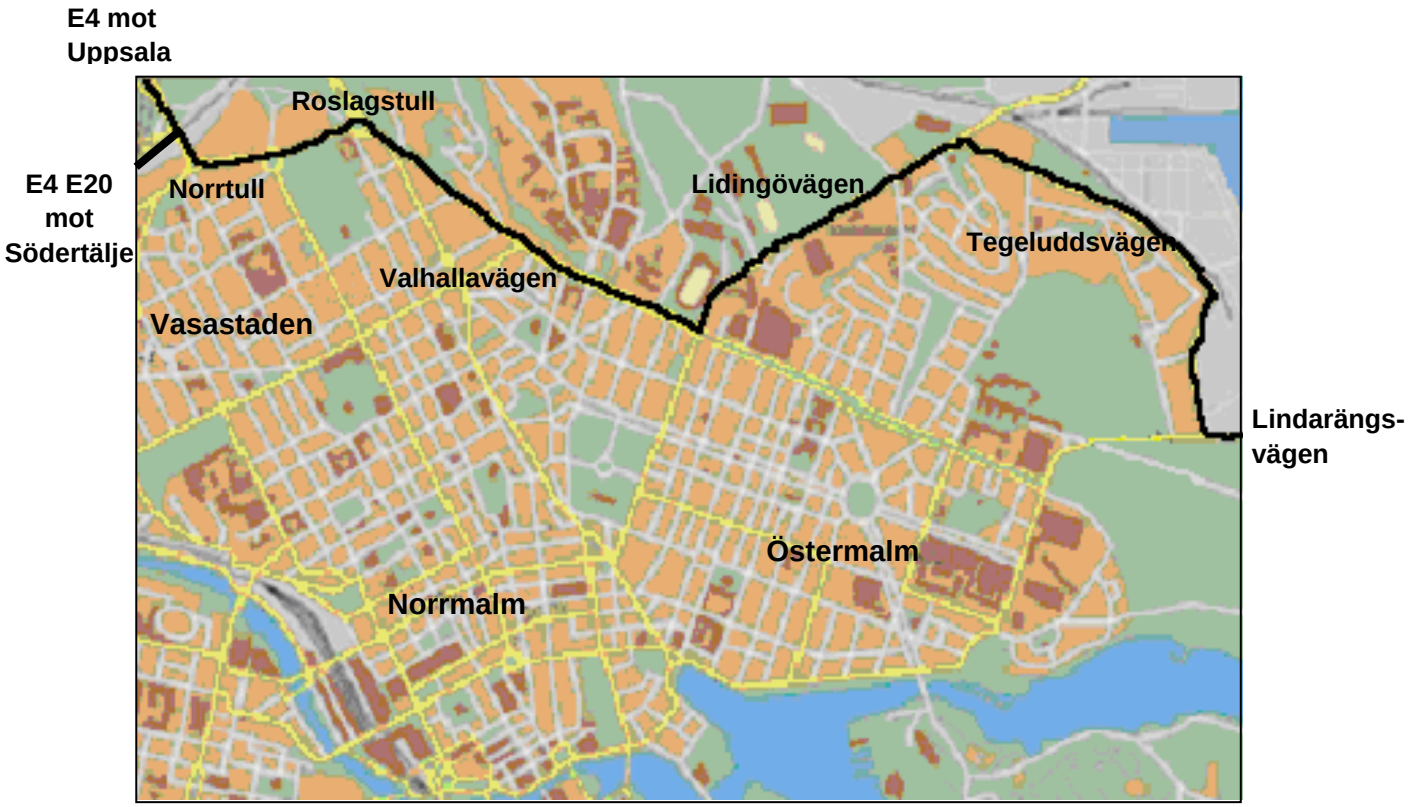
16) Om ja på fråga 15, på vilket sätt?

_____

_____

Tack för din värdefulla medverkan!

Vägar med farligtgodstransporter genom Stockholms tätort



The value of road and railway safety - an overview

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Abstract

The level of safety investments can be argued to vary between sectors. The safety investments legally required and carried out within the railway sector indicate that there is a higher implicit value in preventing a fatality within the rail sector than within the road sector. The literature overview 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 in the road traffic sector can be argued to differ from the value in the railway sector. The research discussed here indicates that the use of different values may be motivated. However, findings from studies of preference-based values of marginal risk reductions do not confirm that the value of a statistical life used in the railway sector is many times larger than that used in the road sector. 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. The result 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.

Keywords: value of safety, risk perception, willingness to pay

JEL classification: D61, D81, I10

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1. Introduction

In welfare economic theory, a fundamental premise is that the public sector allocation process should reflect, as far as possible, the preferences, and the strength of preferences of those who will be affected by the decisions concerned. It is often suggested that individual preferences are naturally provided by the individual's willingness to pay for desirable goods and improvements and the willingness to accept compensation for detrimental effects, see e.g. Beattie et al. (1998) for an overview. Under the assumption that these values reveal individual preferences, various effects can be aggregated and recalculated into units that are more comprehensive. For instance, within the risk management area, the expected loss of life can be reduced by one. The aggregate of the affected peoples' willingness to pay for reducing the risk can then be referred to as the value of saving a statistical life or simply the value of a statistical life. This value is also referred to as the value of preventing a fatality and both expressions will be used synonymously in this study. [1] The value of safety is also used in relation to various degrees of injuries as well as fatalities.

Results within the so-called psychometric literature suggest that the perceived risk varies from hazard to hazard and that the variation of perceived risk in part explains our indifference to some risks and our extreme worry for others. The level of safety investments varies indeed between different sectors. For instance, the safety investments legally required and carried out within the railway sector indicate that there is a higher implicit value of preventing a fatality within the rail sector than within the road sector, Jones-Lee (2002). It is then of interest to study whether the observed variation in the applied value of safety can be motivated and empirically established within studies of individual preferences.

The aim of this literature overview is to analyse factors that may affect individuals' valuation of a marginal risk reduction. Based on the factors presented, the study discusses whether the value of a marginal risk reduction in road sector can be argued to differ from the value in the railway sector. (The discussion here will mainly be focused on the value of a statistical life but can readily be applied to the conceptual term "the value of a marginal risk reduction".) The discussion combines results, from e.g. the field of psychological studies, with work performed by economists in order to analyse this matter. This study does not seek to give an all-embracing account of the literature but rather to point the reader to the main lines of argumentation.

[1] Similar calculations can be made for various degrees of injuries.

Another aim of this literature overview is to discuss whether the value of preventing a fatality in the road and railway contexts can be argued to vary depending on the type of hazard. Studies of railway accidents suggest that the variation in perceived risk may be substantial for the same transport mode depending on accident type and circumstances of the accident. The result of the literature overview implies that studies estimating the value of a marginal risk reduction for different traffic modes should focus not only on disparities between different transport modes *per se* but also on disparities between different accident types and circumstances.

The structure of this study is as follows. Terms used within the risk management area are presented in chapter 2. In chapter 3, a short introduction is given to different techniques used to estimate the value of a marginal risk reduction. Some examples of the value of a statistical life found in the literature are also presented. The question of whether different values of safety should be used within the road and the railway sectors is then raised. In order to answer this question, we first concentrate on theoretical arguments that can be found for why, or why not, there may be a difference. These arguments are discussed in chapter 4 and 5. In chapter 4, research on peoples' risk perception of different hazards is presented together with research on peoples' perception and understanding of risks. Chapter 5 focuses on research on the characteristics of risk reductions and their implication for risk valuation. In both chapters 4 and 5, the discussion is applied to hazards in general and on road and railway hazards explicitly in order to find arguments for the use of different values of a statistical life within different sectors and circumstances. In chapter 6, we turn to studies that estimate the value of a statistical life empirically for the road and railway contexts, among others, with the purpose of analysing whether the theoretical arguments previously discussed correspond with the empirical findings. Not all rail and road accidents are alike though, and in chapter 7 we discuss differences in individuals' risk perception depending on the specific hazard studied. The literature overview ends in chapter 8 with a discussion on arguments presented.

2. Terminology of risk

The term *hazard* will be frequently used in this study. A hazard can be defined as a potential source of danger or a situation with a potential for harm. A chance event with harmful consequences can also be defined as an *accident*.

The term *risk* is sometimes dealt with in a rather careless way in both defining the probability of an incident and the maximum negative consequence of that incident. In the literature there is, however, a fairly consensus of the definition of risk as the combination of the probability of a certain event occurring and the effects of that event.

Many studies also make a distinction between risk and *uncertainty*. Risk refers to situations where the perceived likelihood of events of interest can be represented by probabilities, whereas uncertainty refers to situations where the information available is too imprecise to be summarised by a probability measure.

Individual risk is defined as the risk a specific individual is exposed to e.g. by living near a chemical industry. The purpose of using individual risk criteria is to ensure that individuals are not exposed to unacceptably large risks. *Societal risk* relates to the risk for a group of people, a region or for the society as a whole. Societal risk is often used to complement the individual risk measure in order to account for the fact that major incidents may affect many people, e.g. accidents involving transport facilities and nuclear plants. The terms individual risk and societal risk are both used in the process of analysing risks. When focusing on investments in safety, *private* and *public risk-reducing investments* are also discussed.

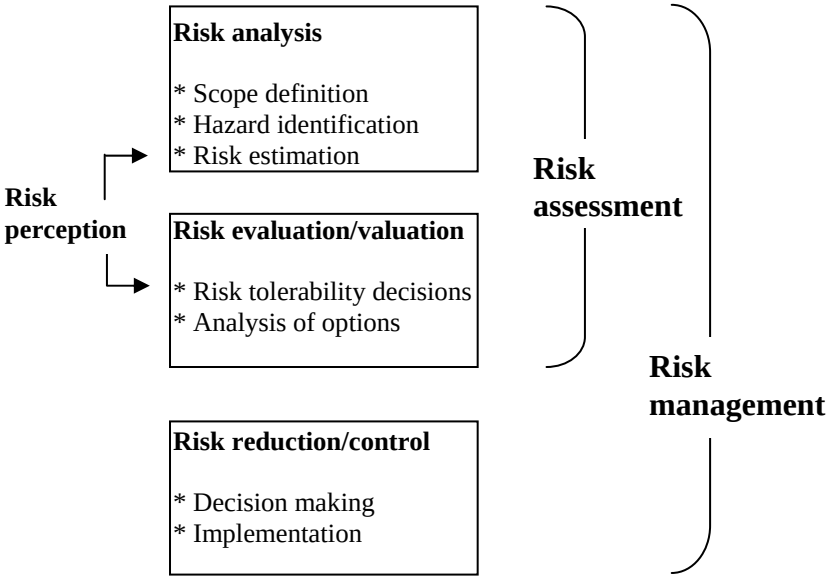
In a *public risk-reducing investment,* actions are taken to reduce the risk for a group of people or for the whole society. A public risk-reducing project may then be seen as a *public good* in that the safety arrangement, e.g. a new and safer road, is a good that is available to everyone and one person's consumption does not diminish that of others (the problem of congestion disregarded). A bicycle helmet is a typical *private risk-reducing investment,* which only reduces the risk for the person wearing the helmet. This private safety investment may then be seen as a *private good* since when consumed by one person it cannot be consumed by another.

Objective risks can often be estimated based on empirical material and according to statistical methods. The wording "objective" risk can, however, be questioned when dealing with low probability events since the empirical material may be very small or even non-

existent. Some kind of subjective risk judgement is then required. *Subjective risks*, or *perceived risks*, are based on individuals' own expressed risk beliefs and they are, in contrast to objective risks, affected by personal values and conceptual frameworks.

According to the Royal Society (1992), *risk management* may be described as the process of a number of elements, see figure 1. The process of *risk assessment* aims to determine the relationship between say the "dose" and the "response". In this way, risk assessment tries to convert an uncertainty context into a risk context. According to Turner et al. (1994), the terms risk assessment and risk management tend to embrace uncertainty. That is, even if uncertainty cannot be converted into probabilistic outcomes, the same procedure of assessing e.g. doses and responses and determining acceptability and management, applies.

Figure 1. The risk management process.



The risk assessment process can be subdivided into *risk analysis* and *risk evaluation*. Risk analysis includes identification of the outcomes, the estimation of the magnitude of the associated consequences of these outcomes and the estimation of the probabilities of these outcomes. Risk evaluation/valuation on the other hand is the complex process of determining the significance or value of the identified hazards and estimated risks for those concerned with or affected by the decision. It therefore includes the concept of *risk perception* and the trade off between perceived risks and perceived benefits. Individuals' perception of risks is also likely to influence the risk analysis process when estimating probabilities of different outcomes.

Individuals' risk perception has been studied thoroughly since the 70s when a psychometric model, e.g. Fischhoff et al. (1978), was developed. Since peoples' risk perception is part of the risk assessment procedure, there have been attempts to incorporate the results of risk perception studies directly as part of the process. This is, however, difficult to do since the risk perception methodology is not an evaluative tool but an approach for identifying public concerns about technologies and activities and lacks a formal evaluative structure. In order to use information on peoples' risk perception when estimating the value of a risk reduction, additional issues have to be defined and analysed. This problem will be discussed in chapter 5.

In this study, the term *risk valuation* will be used rather than the term *risk evaluation* in order to point out that monetary values are used in the risk valuation process. Risk evaluation is a broader concept with a wide range of measurement units.

Risk management involves, besides risk assessment, the issue of how much risk is acceptable and by what means unacceptable risks should be reduced.

3. Risk valuation

3.1 Methods

Under the willingness to pay approach, the value of a risk reduction (here a fatal risk) can be illustrated as follows. Suppose that 100.000 people enjoy a safety improvement that reduces the individual probability of death by 1/100 000. The expected number of deaths within that group is then reduced by one, i.e. the avoidance of a statistical death. If an affected individual is willing to pay say, 130 SEK for the 1/100 000 reduction, his/her marginal rate of substitution of wealth for risk is calculated as[2]:

$$\frac{130}{1/100\,000} = 13.000.000\,\text{SEK}$$

The value of a statistical life is given by the mean marginal rate of substitution of wealth for risk, calculated over the affected population of individuals, Jones-Lee (1989).

[2] See Rosen (1988, p: 287) for details.

There are two empirical approaches used to estimate people's willingness to pay for risk reductions. These are commonly labelled "revealed preference" and "stated preference". The revealed preference approach involves identifying situations where people do actually trade off money for risk, such as when they buy safety measures or when they take more or less risky jobs for more or less wages. A number of wage-risk studies have been carried out and they provide useful estimates of the value of risk in the area of occupational safety. It is however, difficult to collect sufficient data to disentangle factors other than safety, which may affect behaviour. Furthermore, individuals may not have full information on the risk level. One may also argue that the data set is not representative. Through self-selection, risk-averse individuals are not likely to be found in risky jobs. There is also an issue of cognitive dissonance in these studies. The basic premise of the theory of cognitive dissonance is that people like to hold beliefs that are mutually reinforcing and are uncomfortable if their ideas are apparently contradictory. Consequently, there is a tendency to discount new information that appears to conflict with beliefs that have already been formed, or to discount the adverse potential consequences of a course of action once that course has been chosen, Akerlof and Dickens (1982). An example of the impact of cognitive dissonance is the tendency for people, who have chosen risky jobs, to discount the risk because the cognition that it was a sensible decision to choose that job sits uncomfortably with the cognition that the job is in fact dangerous.

The stated preference approach makes it possible to collect detailed data on those safety effects that are of interest. The contingent valuation method is widely used. In this method, people are asked quite directly how much they are willing to pay for a specific reduction in the risk, or willing to accept for an increase in the risk. For instance, this can be done using questionnaires by mail or telephone interviews. The approach has mainly been used on more familiar risks of death, e.g. Carthy et al. (1999) and Persson et al. (2001) for road safety and Lanoie et al. (1995) for occupational safety. People are used to making decisions about their own safety in these areas, and the risks are relatively well-defined and objective-measured since good statistical records are available.

The stated preference approach may suffer, however, from a number of problems. Research raises serious doubts about how far in practice individuals can or do process information in the way the economic model supposes, e.g. Kahneman and Tversky (1979) and Baron (1997). There has been a growing body of evidence that contingent valuation responses are vulnerable to a number of biases and inconsistencies such as starting point biases and range effects in that the respondents are influenced by whatever information the researchers

choose to use. There is also the embedding effect, which suggests that the individual willingness to pay is approximately the same for a good evaluated on its own or as part of a more inclusive category. The quality of the response estimates is also dependent on the comprehension of small probabilities. With a risk reduction of the order 4 in 100,000 when discussing fatal risks, a modest imprecision in peoples' responses can become magnified into quite substantial differences in the corresponding value of a risk reduction. Attempts have been made to develop guidelines and criteria for good practice in contingent valuation exercises, e.g. Mitchell and Carson (1989) and Carson and Mitchell (1995).

Another problem is the question of whether hypothetical choices mimic real choices. Research suggests that hypothetical contributions exceed actual contribution rates. In order to solve this issue, studies have been carried out with the purpose to identify real yes responses among hypothetical responses, e.g. Johannesson et al. (1999) and Champ and Bishop (2001). Provision point mechanisms have then been used in order to minimize this problem, e.g. Rose et al. (2002) and Poe et al. (2002).

Beattie et al. (1998) suggest that if stated preferences are indeed to provide a direct and reliable input into regulation and/or public expenditure policy, more intensive value elicitation methods may need to be developed. Among the approaches discussed are, for instance, choice experiments, e.g. Adamowicz et al. (1998), Louviere (2000) and Ratcliffe (2000) within the field of valuing environmental goods and health effects. Rather than asking for weights or utilities directly, respondents are asked to rank, rate or choose between holistic alternatives. Weights and utilities are then inferred, using regression analysis. Other methods discussed are Risk-risk analysis and Standard gamble; see e.g. Viscusi (1995), Carthy et al. (1999), and Trawén et al. (1999).

3.2 Variation in estimated values of a statistical life

A number of studies have estimated the individual trade off between safety and money, using different approaches. In this literature overview, no attempt is made to describe the work that has been done by researchers all over the world in this matter. Instead, this section focuses on a few studies that in turn review a number of reports that estimate the value of preventing a fatality. When the economic valuations of a fatality are compiled, compared and discussed

one can conclude that though a variation exists between and within approaches, the estimated values are of the same magnitude.

Viscusi (1992) reviews different approaches valuing fatal and nonfatal risks to life and health. 23 estimates are based on labour market studies and these estimates range from $ 4 million to 9 million in 1999 prices. In Miller (1990), 47 estimates of the value of a statistical life are presented from different types of studies done in the US, of which 30 come from wage risk studies. An average value of $3.7 million in 1998 prices was calculated. Partly updated versions of the studies in Miller (1990) are to be found in Miller (2000) in addition to 21 non-US studies. The mean value of the latter is $3.45 million in 1995 prices.

There are also studies analysing consumption choices (trade offs between safety and money) in order to estimate the value of life. These tend to be lower than the estimates from the labour market. Viscusi (1993) contains 7 studies on the trade-offs outside the labour market, the average value amounting to $1.7 million 1998 prices. Blomquist (2001) presents 8 studies, carried out in 1990-2001 on self-protection and averting behaviour in consumption, that reveal the individual preference for safety. In this study the value of a statistical life for adults ranges from something less than $2.6 million to 6.8 million 1998 prices.

Estimates from studies using the contingent valuation approach tend to be somewhat higher than the revealed preference estimates. Mitchell and Carson (1989) provide an overview studies using the contingent valuation approach in the field of valuing environmental goods. In Miller (2000) the value of a statistical life estimated by the contingent valuation approach ranges from $1.1 million to 7.5 million in 1995 prices.

Since there is a variety of studies and differences have been found, there is now an increasing interest in so-called meta-analyses. These studies focus on a statistical analysis of research results attained previously in order to explain the variation among the observed estimates. In the meta-analysis of de Blaeij et al. (2003), 30 estimates from the road safety area are studied. Their result indicates that the magnitude of the value of life estimates depend on the value assessment approach (particularly stated versus revealed preferences). For studies using contingent valuation, the size of the estimate also depends on the type of payment vehicle and elicitation format.

In Elvik (1995), a meta-analysis is carried out on the value of life estimates for occupational and transport safety. The result of this study stresses the importance of high quality in the design of a study. Elvik concludes that poorly designed stated preference studies result in higher estimates than more carefully designed studies. Furthermore, estimates of studies with high validity lead to lower variation.

3.3 Should we apply different values of a statistical life within the road and railway sectors?

According to Sunstein (1997) and Beattie et al. (1998), there ought to be a discussion concerning factors that might suggest the use of different values for preventing a fatality in different sectors and circumstances. This may be seen as a controversial point of view since the use of different values in different sectors conflicts with the opinion that funds should be reallocated so that the marginal cost of death prevention is equal across programs, thus maximising the number of deaths prevented for a given outlay. The logic of this argument depends upon the view that each person's life should be considered equally valuable regardless of age or other characteristics. The same goes for the issue when death occurs. It is also notable that if we decide to spend a lot more money to prevent some types of deaths than others, we will not be able to prevent as many fatalities as we could if we spent the same amount of money per fatality prevented.

It is, however, clear from a theoretical perspective that the value of a marginal risk reduction may not be a universally transferable number. Standard economic theory readily admits that people may care about a variety of factors relating, for example, to the particular nature of the hazard which could potentially cause individuals' willingness to pay for a given risk reduction to vary. Adjustments may be made depending on the context in which the risk arises and the characteristics of the risk of concern. There are for instance no a priori grounds for supposing that the value of a marginal risk reduction is the same for road users as for passengers on public transport modes such as railway traffic. Allowing for a variation in assessing risks is perfectly legitimate if individuals' preferences are to be taken into account.

According to Railtrack (2000), the company that owns and operates Britain's railway infrastructure, safety investment policies accord a significantly greater premium to activities such as rail travel, where individuals have less choice or control over the risks and which have the potential for large-scale casualties in a single event. Hence, in its appraisal of proposed railway projects Railtrack applies two distinct values of a statistical life. The first is the current road fatality figure of the Department of Transport, Local Government and the Regions, DTLR, updated for inflation and growth to £1.20 million in 2001 prices. This figure is applied in situations in which passengers or staff can be taken to have a substantial degree of control as in the case of single fatality accidents at a level crossing or on platforms. The second value of a statistical life is employed in cases in which the risk concerned applies to

large numbers of people and those affected have little or no control. This figure amounts to £3.35 million in 2001 prices i.e. 2.8 times the DTLR roads-based figure.

The use of largely differing values for preventing railway and road fatalities is questioned in Jones-Lee (2002) though. In his article, Jones-Lee discusses the European Train Control System, ETCS, which is now required by European law, as an example. When approving this investment, it is suggested that the value of preventing a rail fatality exceeds by many times the value of preventing a road fatality. According to the author, there is no empirical support for this when studying individual preferences, and an application of such a value is then "prima facie evidence of an appalling misallocation of resources", Jones-Lee (2002, p. 7). Blomquist (2001) argues that the public trade-offs tell us little, if anything, about individuals' preferences for safety. Mendeloff and Kaplan (1990) used a survey approach to examine whether the large variation in society's investments in life-saving interventions reflects public opinion or not. The study showed that preferences expressed by public opinion could explain some variation in cost-effectiveness but the large variation in actual investments could not be accounted for.

In Sweden, the figure officially used as the value of preventing a road fatality is also used in the railway sector as the value of preventing a rail fatality, even though the figure is based on road accidents.[3] This is also the case in e.g. the US and Norway. Is this use of a single value motivated by people's preferences or should we use different values for preventing a fatality in the road and railway sectors? In order to shed some light over this question we will now discuss factors possibly influencing individuals' perception of risk and their willingness to trade risk for money.

4. Risk perception and implications for road and railway traffic

In order to understand and explain possible differences in the value of safety applied in the road and railway sectors, we need to understand the factors that influence our perception of risk and in turn affect our risk reduction preferences and possibly our willingness to pay for those reductions. In this chapter, we start off with an exposition of studies that seek to understand peoples' perception of risk and risk reductions and how different characteristics of

[3] The Swedish National Road administration uses a value of a statistical life of 16.3 million SEK in 2001 prices in their cost-benefit analyses. For a compilation of costs per fatal casualty in traffic accidents adopted by authorities in different countries, see Trawén et al. (2002).

a hazard may affect peoples' risk perception. Both hazards in general and in the road and railway context are discussed. The research presented includes inputs from e.g. psychology, sociology, decision theory, economics, and policy studies.[4]

4.1 Research based on the characteristics of hazards

The main argument for assessing risks differently is that characteristics of the individual or of the situation, in which the hazard is encountered, affect us differently. This effect is occasionally named "the context" of an accident. Some risks, e.g. in sports, are accepted voluntarily whereas some risks are a part of the requirements of everyday living, e.g. driving. The goal of psychological work on risk perception, so-called psychometric studies, has been to ascertain how different risks are represented psychologically; in terms of how accurately their quantity is represented with respect to some normative standard, and how qualitative dimensions of various risks cause the perceived risks to be similar or different from each other. Here, we will discuss some risk characteristics that can be argued to influence our perception of risks both in general and in the road and railway area.

Dread and knowledge

In order to analyse the factors that influence people's perceived risk and predict the way that individuals and society respond to hazards, researchers have asked people to judge the riskiness of diverse sets of hazardous activities and technologies. People have also been asked to indicate their desire for risk reduction and regulation of these hazards. These global judgements have then been related to judgements about the hazard's status regarding various qualitative characteristics of risk, e.g. voluntariness, dread, controllability, the benefits that the hazardous activities provide to society and the harm caused by this hazard in an average year. Since the risk characteristics judged to influence perceived risk are often highly intercorrelated, they can be reduced to 2 or 3 factors. Based on these factors a co-ordinate system, called a factor space, is created. Using the factor space, the level of perceived risk associated with a particular hazard and the attitude towards regulating this risk can be predicted quite well from knowledge of where the hazard falls in the factor space, e.g. Starr (1969), Fischhoff et al. (1978), and Slovic et al. (1980).

[4] Reviews of the field are to found in e.g. Royal Society (1992) and Slovic (2000).

In Slovic et al. (1980), 90 hazardous activities were considered. The risk characteristics were in this case clustered into three factors named *dread risk*, *unknown risk* and *the number of people exposed*. The most important factor was dread risk, i.e. a risk that cannot be thought of in a calm and reasonable way. The higher a hazard score in this factor, the higher its perceived risk, the more people want to see the risk reduced and the more they want to see strict regulation employed to achieve the desired reduction in risk. According to Savage (1993), people appear to have a great dread if death is a long drawn-out event, e.g. cancer. This period of intense difficulty might impose stress on those with the illness as well as on friends and family members. Moreover, some hazards, like pollution, often cause diseases only after many years of exposure. An unknown factor may then comprise the fact that the victims may not observe the hazard when it occurs, that they may not personally know the risk or that the probability or consequences of the hazard are not even known to scientists or experts.

These results correspond in part with those of Sjöberg (2000). In his study, a model is proposed in which attitude, risk sensitivity, and specific fears are used as explanatory variables. The model seems to explain well over 30-40% of the variance of raw data in contrast to the psychometric model where the explanatory value is only around 20% of the variance. However, Drottz-Sjöberg and Sjöberg (1991) argue that several of the dimensions used by e.g. Fischhoff et al. (1978) and Slovic et al. (1980), have not been validated. For instance, it may seem natural to ask people to rate whether they accept a risk and how much they require it to be reduced if they do not accept it, but such ratings should be validated against risk related behaviour before they can be given credibility. Furthermore, according to Drottz-Sjöberg and Sjöberg, it is well known that reactions to risk are not static but vary greatly with, e.g. the occurrence of risky events.

The results of Fischhoff et al. (1978) and Slovic et al. (1980) show that railways generally induce little dread and involve less severe consequences than other means of transportation. Factors underlying the risk perception seem to be that railways are a well-known and old technology and although they have a catastrophic potential, they compare favourably to, for example, commercial aviation. Motor vehicles are regarded as being a well-known, old technology with little catastrophic potential. Road traffic is furthermore associated with little or no dread. These results give us a better understanding of the factors people take into consideration when forming their preferences. The more dread a hazard evokes, the higher its perceived risk and consequently, the more people want to see its current risks reduced. In Fischhoff et al. (1978), motor vehicles score higher on the factor *dread* than

railways. There is then an indication that people favour a risk reduction for road users. This is, however, not the case in Slovic et al. (1980). On the other hand, in Slovic et al. railways score higher on the factor *unknown risk* indicating less knowledge of railway hazards compared to roads. Consequently, based on these factors studied we can find arguments that favour risk reductions within the railway as well as the road traffic context.

Voluntarily and controllable

The results of Slovic et al. (1980) and Savage (1993) also show that people's risk perception is related to whether victims are exposed to the hazard voluntarily and to the extent to which the victim can avoid death by personal skill or diligence, i.e. controllable. According to Sunstein (1997) it is, however, not clear what is meant by the suggestion that one activity is voluntary and the other is not. For instance, many people injured in automobile accidents are not at fault. Whether a risk is run voluntarily is often not a categorical one but instead a matter of degree, associated with information cost, risk reducing cost and the existence, or not, of accompanying benefits. Individuals' perception of a hazard being controllable may also be an illusion of control. Langer (1975) discovered that individuals often have a misplaced confidence in their own capacity to control events in life in that they exaggerate their perceived control of environmental events. This illusion of control refers to the belief that the outcome of random events can be influenced. An often-quoted example of illusion of control is that of an individual being more optimistic about outcomes when allowed to choose a lottery ticket rather than just being handed one.

When comparing the risk perception of road and railway traffic there are some distinct differences in the risk characteristics. One may argue that people in public transport modes such as railway traffic are unable to affect their situation and that the risk is to some degree involuntary. In road traffic, on the other hand, people think that they are in control over the situation and that the risk road users are exposed to is voluntary. These characteristics indicate that people may favour risk reductions within the railway context over reductions within the road traffic context.

Moral indignation and trust

The degree of moral indignation that an accident evokes is related to the judgement over who has responsibility for safety, which in its turn may affect individual's preferences for risk reductions. According to Sjöberg (1991), moral indignation appears to be a potent factor in public response to risk and ought to be analysed more closely. Accidents inducing moral

indignation in society may be argued to increase individual preferences for risk reducing investments in this area.

Accidents in the railway sector may be argued to inflict a higher degree of moral indignation in that people that are exposed to the risk have, or at least experience that they have, limited opportunity to affect the safety arrangements, e.g. Slovic et al. (1980). This result may be interpreted as, in the public opinion, accidents occur because of the railway agencies' failure to take sufficient responsibility for safety. Road traffic accidents, on the other hand, seem to induce less moral indignation on the average in that the traffic safety is closely related to personal decisions.

Research indicates furthermore that there is a relationship between trust and risk perception. Studies by Bord and O'Conner (1992), Slovic (1997) and Siegrist (2000) show that trust in public agencies is strongly correlated with risk judgements and that social distrust increases the perceived risk. Sjöberg (2001), on the other hand, suggests that there is only a weak relationship between trust and risk perception. Instead, according to this study, people believe that there are many unknown effects of technology and such beliefs are strongly related to their perceived risk.

One may argue that social distrust, like moral indignation, has a larger impact in the railway sector compared to the road traffic sector since people may experience little or no opportunity to affect their situation. There is then an indication that people may perceive railway hazards as worse and consequently favour risk-reducing actions within this area.

Equity

According to Culyer and Wagstaff (1993) and Andersson and Lyttkens (1999), people appear to have concerns regarding equity in health. The distribution of health may also relate to the distribution of safety or risk reducing actions. It is thus possible that individuals will have preferences for reducing the risk for groups that are at high risk, indicating a preference for risk reducing actions within road traffic compared to railway traffic.

Size of the accident

The perception of risk also seems to be dependent on the size of the accident, i.e. whether it is catastrophic. This effect is also frequently named "the scale" of an accident. The public appears to react more strongly to infrequent large losses of life than to frequent small losses,

so-called disaster aversion.[5] Some researchers propose a weighting factor that accommodates the greater impact of N lives lost at one time relative to the impact of one life lost in each of N separate incidents. The precise nature of the fatality-weighting factor has been the subject of some speculation and square and cubic functions have been proposed. On the other hand, in Melinek et al. (1973) in which people's attitude towards risks of fires is analysed, no disaster aversion can be detected. In the study, a question is designed to analyse whether the public, on learning of certain number of deaths in a disaster, would be more concerned than if they learned of a similar number in small incidents, the average number annually being the same in each case. The result indicates that people are equally concerned by a single fire causing a large number of deaths and a large number of fires with a single fatality in each incident. Slovic et al. (1984) also conducted an experimental test of catastrophe avoidance and found that subjects chose to minimise average lives lost rather than reduce the risk of a catastrophic accident.[6]

Keeny (1980) argues, however, that people simultaneously hold several conflicting attitudes about the fatality-weighting function. They believe that the function relating the social impact to N lives lost should be 1) convex because large losses of life have important higher order consequences and may even threaten the resilience of a community or society, 2) linear because each unidentified life is equally important and 3) concave because they recognise that the same additional number of lives lost seems more important in a small accident than in one large accident. Keeny argues that in spite of their individual appeal, the three value judgements are mutually incompatible so that a decision-maker that subscribes to one must reject the other two.

Railway accidents happen rarely, but when they do they tend to result in quite severe accidents in terms of the number of people killed or injured. Road accidents, on the other hand, occur on a daily basis with generally a limited number of people involved. Based on the research that indicates that the size of an accident affects our perception of risk, we can thus find preferences for increased risk reductions in the railway area compared to the road traffic area. As was shown, these arguments are not unchallenged though.

[5] Zeckhauser (1996) provides an extensive discussion on the mechanism to prevent or ameliorate catastrophes. In his study liability, insurance and government regulations are considered.

[6] The results of Melinek et al. and Slovic et al. may also be interpreted as an effect of the Allais paradox since a possible interpretation of this paradox is that individuals tend to reduce the dimensions of a problem by focusing on either the outcome or the probability of an occurrence. The Allais paradox is discussed further on in the next section.

Socio-economic variables

Socio-economic variables are not much discussed by the early psychological literature in that the study-design is relatively insensitive to the analysis of group differences. There might be a correlation between risk evaluations and measures of general attitudes, experience of accidents and socio-economic variables such as age, education, and gender. For instance, Greenberg and Schneider (1995) indicate that women are more concerned about environmental risks than men are. Beattie et al. (1998) review studies that analyse whether socio-economic variables influence evaluation of risk. There are results indicating that gender, age, occupational affiliation, and ethnic group membership influence the evaluation of risk. However, there are also studies, e.g. Gardner and Gould (1989) that report very little relationship between socio-economic variables and risk perception. Sjöberg (2001) concludes that while significant differences can sometimes be found between e.g. gender and risk appraisal, correlations are usually very weak and therefore explain only a very small amount of the variation in perceived risk scores. If any differences can be detected between the groups of people using railway transport compared to road transport, this can, according the literature, be an indication that risks are perceived differently between the two transport modes.

To sum up, we can find quite a few characteristics of railway hazards, e.g. that they are involuntary and uncontrollable, that they induce high degrees of social distrust and moral indignation and that the accidents are large-sized. These characteristics indicate a preference for reducing risks in the railway sector compared to the road traffic sector. We will now turn to researchers that do not focus on the characteristics of the hazard. Instead, they try to explain how we perceive risks more generally.

4.2 Research based on peoples' perception and understanding of risks

Heuristics and over/under assessments

In Tversky and Kahneman (1974), a number of heuristics (mental short cuts or rules of thumb) which people use in simplifying the task of estimating probabilities are presented. Two heuristics are discussed here, availability and representativeness. The *availability* heuristic has special relevance for risk perception. People who use this heuristic judge an event as likely or frequent if instances of it are easy to imagine or recall. In addition, Fischoff

et al. (1978) found that vivid, imaginable causes of death receive similar estimates to non-vivid ones, which occur with much higher frequency. According to the *representativeness* heuristic people neglect general information and are too impressed by the concrete details of a case at hand. The use of these two heuristics may lead to systematic bias in risk estimation and are thus of special interest.

Furthermore, 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. Since experimental evidence suggests that a subjectively given probability often differs from the statistical one, i.e. the probability calculated as the number of a certain outcome divided by the number of trials, one might argue that subjective risk perceptions ought to be corrected. There are, however, studies arguing that a perfect risk perception is not identical to the actual risk level but rather reflects the rational use of incomplete information sets. The typical starting point for an analysis of risk perception biases is simply to link perceived population death risks with actual death risks and to note any systematic difference in this relationship. Instead, Benjamin and Dougal (1997) and Benjamin et al. (2001) make the assumption that it is the set of age-cohort risks that is the principal source of risk information.[7] In their model, it is the rationality with which respondents perceive death risks, based on information on their own age cohort, that is the test of accuracy of risk perceptions. They suggest that risk beliefs may not be erroneous at all. The expressed risk beliefs may rather be the rational expectations of the actual values given the age-specific accident rates facing the respondents' group. People are well informed about the risks they themselves face, but relatively uninformed about aggregated, population-wide fatality rates. Their basic point is that information about accident rates, especially those currently faced by an individual's own age-cohort, is likely to be both more available and more relevant to that individual than population wide averages. Population death frequencies, on the other hand, are unlikely to be known to most people because they are costly to obtain and essentially worthless to know. When viewed from this perspective the relation between perceived risk and true age-specific risk is not significantly different from the statistical correlation between actual population risks and the age-specific risk level.

[7] The study by Benjamin and Dougal (1997) is based on a reanalysis of the data in Lichtenstein et al. (1978), and in Benjamin et al. (2001) new data are collected and analysed.

Hakes and Viscusi (1997) argue furthermore that people form their risk beliefs using two other sources besides the age-specific accident rate. They reanalyse the data of Lichtenstein et al. (1978) using a Bayesian learning approach. According to their study, people also use information on the actual population mean death risk level and the discounted lost life expectancy when founding their risk beliefs. Their conclusion coincides with the result of Benjamin and Dougan in that the appropriate criterion for judging the validity of risk perceptions is not the perfect information case, but rather whether people form their risk beliefs in a rational manner given a world of costly and limited risk information. The authors also suggest that the difficulties people have in making judgements about low probability events stem in part from the limited guidance that the usual sources of information provide to them in their thinking about the level of rare accidents. In a world of costly information, there will be stronger incentives to learn about large risks than small ones.

Since railway accidents are low-probability events, with catastrophic potential, people are likely to attach great importance to these events. Railway accidents may then be judged as being more likely than they are. However, people probably do not over assess railway accidents in such a way that these events are judged as being as likely as road accidents. Road accidents that happen frequently may be under assessed, on the other hand. Peoples' tendency to over and under-assess risks, may accordingly lead to smaller differences in the perceived risk of road and railway accidents.

Risk aversion and uncertainty aversion

An important ingredient in the analysis of risk is that of the individual's attitude to risk. Risk loving individuals may prefer to take risks, while risk averts, may prefer to avoid or minimise risk taking. According to the psychometric literature, dread seems to have an important impact on peoples' risk perception. If dread is related to (as described in the psychometric analysis) risk aversion as well, the perception of risk is also related to the degree of risk aversion. Thus, as the amount of dread that a hazard evokes seems to vary depending on the hazard studied, it is likely that peoples' risk attitude varies as well.

Risk aversion is a subject very much discussed in the economic literature within the area of decision under risk, i.e. the expected utility theory.[8] However, over the years, experimental tests of the expected utility theory have shown a violation of the assumptions that the expected utility theory builds upon. One test that has some interesting interpretations is the Allais paradox and the fanning-out hypothesis, Allais (1979). The implication of this

hypothesis is that people act as if they become more risk averse when they choose among gambles with increasing probability weights and more-preferred consequences. There is then a systematic relationship between the attitude towards risk and the degree of uncertainty. The hypothesis can also be interpreted as a tendency to exaggerate the probability of extreme outcomes. Applied to our discussion in this chapter on issues influencing peoples' perception of risk and possibly the value of a risk reduction, the fanning out hypothesis suggests that we need to have a better understanding of the nature of peoples' risk aversion. If an individual's perception of risk is correlated with his/her risk aversion, then the risk perception is also correlated with the degree of uncertainty of the outcomes.

For some hazards, the information available is too imprecise to be summarised by a probability measure. As mentioned in chapter 2 this situation is rather described as an uncertainty than a risk. The economic theory describing decisions under uncertainty is called the subjective expected utility theory, e.g. Anscombe and Aumann (1963). Criticism of the subjective expected theory has been concentrated to tests of its axioms. One violation of the subjective expected utility theory is that individuals behave as if they have uncertainty aversion, i.e. they prefer facing risks (or objective probabilities) as opposed to uncertainty, Ellsberg (1961). Ellsberg showed that people are less willing to bet based on ambiguous probabilities than on point estimates of the same mean value. Hence, the individual would rather draw a ball from the urn with a known proportion of red and black balls, than draw a ball from an urn in which the proportion of red and black balls was unknown. If individuals have uncertainty aversion, they prefer risks to uncertainties. Hazards with unknown probabilistic properties are consequently perceived as worse than hazards with known probabilities. This may in part explain individuals' indifference to some hazards and the extreme worry for others. The aversion may be interpreted as a preference for risk reducing investments in areas with unknown probabilistic properties. Under the assumption that the value of a marginal risk reduction can be calculated for a hazard characterised by uncertainty, the aversion towards uncertainties is likely to be mirrored in the value of risk.[9]

Accidents within the railway sector occur infrequently. One may argue that railway accidents are characterised both by uncertainty regarding the consequences of an accident 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 good knowledge of both the probability

[8] An overview of the expected utility theory and its pros and cons are to be found in Machina (1987).
[9] There are obvious and severe methodological problems estimating the value of a risk reduction for an uncertainty since the probabilities by definition cannot be calculated.

and the outcome of this type of accident. Based on the theory of risk aversion and uncertainty aversion, one may then argue that individuals prefer risk-reducing investments in the railway sector to investments in the road traffic sector.

Certainty effects

Another demonstration of risk aversion is the certainty effect, Kahneman and Tversky (1979). This effect suggests that individuals prefer a given outcome to a gamble even if the expected outcome is the same. The certainty effect can be interpreted as a higher willingness to pay for a complete elimination of risk compared to a reduction of the same magnitude where the resulting risk is not zero. Viscusi et al. (1987) have explored this effect empirically and found indeed a premium for a total reduction in risk.

Large sums are invested in order to increase safety in both the road and railway sectors. Even if the Swedish National Road Administration has launched a long-term vision of a road traffic system in which nobody is killed or sustains lasting impairment, Tingvall (1997), we are far from experiencing a complete elimination of risks in this sector. Furthermore, even though railway transports can be considered safe, zero risk is most unlikely to be achieved.

According to the research presented in this section, we can again find arguments why people may assess risks within the road and railway areas differently. Heuristics and our tendency to prefer risks to uncertainties seem to be interesting factors of explanation.

4.3 Conclusion

The research suggests that a whole range of social and psychological factors may play a far more significant role in people's perception of risks and their preferences for reductions in those risks than economists have initially assumed. The research helps us identify factors that tend to affect our preferences for risk reductions systematically in one direction or the other. We should, for instance, expect a general trend of higher preferences for safety in those cases where the hazard evokes a particular uncertainty, unease or dread.[10]

Research based on peoples' perception of risk as well as characteristics of hazards seems to indicate that people's preferences for risk reductions vary between road and railway

[10] This is shown in e.g. MacDaniels et al. (1992) and Savage (1993). Gregory and Lichtenstein (1994) report higher values of safety when a general description of uncertain, unknown, long-term consequences is added to two otherwise familiar risk scenarios (new bicycle brakes and plastic material in motor vehicles).

traffic. The question to be asked at this stage is whether individuals' risk perception also reflects the values that should influence public expenditure and/or regulation. As a basis for guiding the allocation of safety resources, the factor space has important limitations according to Beattie et al. (1998). They state that it may be tempting to superimpose some form of expenditure contour map on the Dread/Unknown diagram in such a way that the value of a marginal risk reduction gets progressively higher as one moves from bottom left to top right. There are, however, a number of reasons for doubting whether such an approach would be valid and/or reliable. This view coincides with the work of Gregory and Mendelsohn (1993) and Gregory and Lichtenstein (1994). They state that the risk perception methodology is not an evaluative tool but an approach for identifying public concerns about technologies and lacks a formal evaluative structure. The insights of risk perception have no obvious translations to quantifiable evaluative measures and give little guidance regarding how public concerns should be weighted against other sources of cost and benefits. Consequently, additional factors have to be taken into consideration before we get the overall picture.

5. Risk valuation and implications for road and railway traffic

In the previous chapter, we considered factors that affect our perception of risk disregarding the actual risk reduction in order to find arguments why the value of safety may vary between different contexts in general and between the road and railway sectors. We will continue with a discussion on the characteristics of a risk reduction and in what way they possibly affect our preferences and preference-based values of risk reductions.[11] Since we are now discussing risk reductions, we will focus on effects on peoples' willingness to pay for the risk reduction rather than the effects on peoples' perception of the risk of concern.[12] We will discuss both hazards in general and in the road and railway context explicitly.

[11] We are here excluding a discussion concerning increases of risk since the value of preventing a fatality is mostly connected to risk reducing activities. It is, however, worth noting that theoretical studies, e.g. Kahneman and Tversky (1979), suggest that there is a difference between peoples' stated willingness to accept increases in risk and willingness to pay. This has also been shown in empirical studies, reviewed in e.g. Horowitz and McConnell (2002).

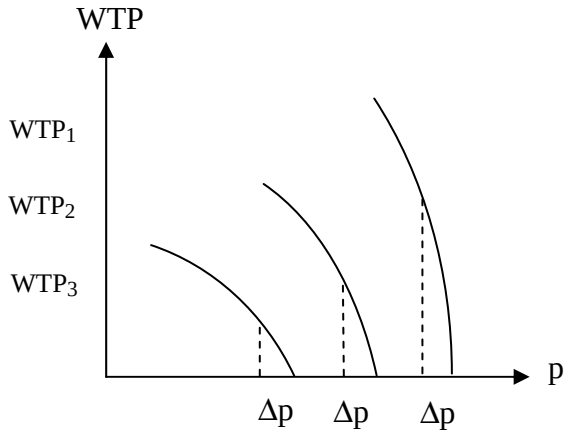
[12] Problems connected with the elicitation methods as such will not be considered.

5.1 Research based on characteristics of the risk reduction

Baseline risk/ratio

The level of baseline risk in the exposed population has also been found to influence people's valuation of a risk reduction. The typical model of individual's attitudes towards risk to life suggests that an individual's willingness to pay (WTP) for a reduction in mortality risk increases with the baseline risk, Hammerton et al. (1982), Jones-Lee (1989). This is illustrated in figure 2. In the figure, the willingness to pay for a risk reduction at a high baseline risk, WTP_1, is larger than the willingness to pay for a risk reduction at a low baseline risk, WTP_3, though the size of the risk reduction (Δp) is the same.

Figure 2. The relationship between individual willingness to pay (WTP) for a risk reduction and the baseline risk (p).



A number of empirical studies analysed this subject with mixed results. Smith and Desvousges (1987) studied the value of a reduction in the risk of premature death due to hazardous waste exposures and they could reject the conventional hypothesis that people prefer reductions in risk where baseline risk is higher. Instead, their findings suggest that the estimated marginal valuation of a risk change decreases with increases in the level of risk. Weinstein et al. (1980), on the other hand, show that the marginal valuation of risk changes increases with the baseline level. This study offers an intuitive reason why changes in risk are valued more at higher levels of probability: because marginal assets are valued more highly in life than in death.

Also in Covey (2001), the program targeted at the higher baseline number of deaths was evaluated as more beneficial than the program that offered the larger proportional reduction.

The study discusses the possibility that the factor influencing peoples' evaluations of risk reduction efforts is not the baseline risk *per se*. Favouring the program with high baseline risk, respondents seemed to perceive that they would benefit more from a safety program that targeted a higher baseline risk, than from a program that addressed an area with lower baseline risk. The situation occurred even though the nominal risk reduction was the same. A higher number of deaths was then seen as an indicator that more lives would be saved, and/or more people were at risk, and/or more people would benefit. Covey concludes that the number of deaths matters, although not always for reasons strictly consistent with the conventional hypothesis.

This is also the result obtained by Horowitz and Carson (1993). Their study presents a situation where subjects do prefer to reduce environmental risks for which the baseline is higher, though for altruistic reasons. The authors argue that there is a baseline effect since the subjects believe that more people can be saved by risk reduction efforts when risks are higher. In Van Houtven (1997), individuals were asked to state their preference for equally costly life-saving programs that would only affect others' level of risk. Controlling for the number of lives saved, the individuals preferred programs that affected smaller populations facing higher levels of baseline risk. According to this study, increases in baseline risk of one order of magnitude doubled the value of death avoided.

According to Jenni and Loewenstein (1997) people value a reduction from a higher baseline risk more, but on the other hand evaluate effectiveness by whichever intervention offers the bigger ratio reduction in risk. There are consequently some indications, e.g. in Gyrd-Hansen et al. (2002), that people prefer interventions in which a bigger ratio of the lives at risk can be saved even though the number of lives saved may be the same. This means that they are willing to pay more to save 900 lives from a disease causing 1,000 deaths per year than to save the same number of lives from a disease causing 10,000 deaths per year. This diminished sensitivity to valuing life-saving interventions against a background of an increasing number of lives at risk is coined "psychophysical numbing" by Fetherstonhaugh et al. (1997). In their study an intervention saving a fixed number of lives was judged significantly more beneficial when fewer lives were at risk overall. The authors suggest that the human cognitive and perceptual system is sensitised to small changes in our environment, possibly at the expense of making us less able to detect and respond to large changes. This

argument is also in line with the certainty effect discussed in chapter 5.2 indicating that we have preferences for eliminating risks.[13]

Even though the results are mixed, a majority of studies suggest that an individual's valuation of a risk reduction increases with the baseline level of risk, indicating that the value of a risk reduction estimated for a low risk level is not necessarily the same as the value estimated for a high risk-level. Consequently, when studying the value of a risk reduction for road and railway traffic, the value may differ due to differences in the baseline risk. To what extent can the risk level for different contexts be considered to vary and still be alike? For instance, Mattson (2000) argues that the risk of dying or being injured in road traffic, aviation and in major parts of the labour market is in general very small and almost alike. The same value of a marginal risk reduction should therefore be used in the appraisal of investment projects in these areas.

Risk perception data show that train travel is generally perceived as safer than road traffic.[14] In Fischhoff et al. (1978) respondents were asked to rank 30 different hazards with respect to perceived risk and benefit. Road traffic was ranked as the second most risky activity and railway traffic was ranked as 24. Alhakami and Slovic (1994) show that among 40 technologies, motor vehicles were ranked as fifteenth most risky and railways as number 32. In Slovic et al. (1980) railways were ranked 61 of 90 activities studied. Motor vehicles were perceived as more risky, ranked as number 17. Also based on objective data from the Swedish National Rail Administration (2000), railway traffic may be regarded as being safer than road traffic. The average number of persons being killed per year in the railway sector is 15 whereas 600 persons on average are killed per year in the road sector. There is also a difference in risk when calculated per number of fatalities per kilometres travelled. The average risk level for railway passengers is 0.17 fatalities per billion kilometres travelled compared with 4.5 fatalities per billion kilometres travelled for a road user.

As was illustrated in figure 2 economic theory suggests that an individual's willingness to pay for a reduction in mortality risk increases with the baseline risk, Hammerton et al. (1982), Jones-Lee (1989). The value of a marginal risk reduction based on individual preferences in the railway area may therefore be lower than the value of risk used for road

[13] Another way of describing this tendency is that we have preferences for "topping up the bucket" rather than "filling the bottom".

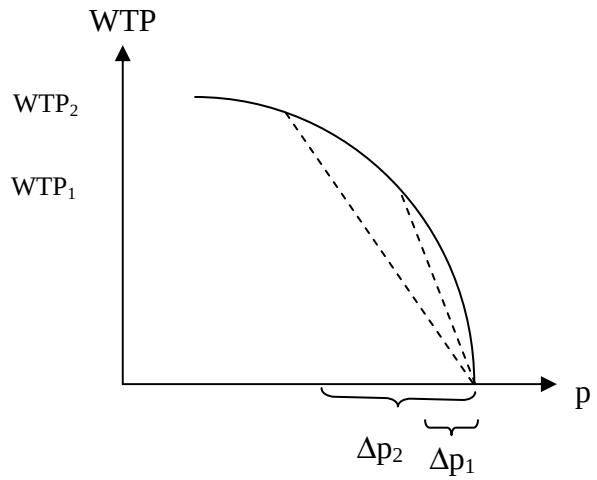
[14] According to Blomquist (2001), studies estimating the value of a risk reduction should be based on the risk level perceived by the affected individuals. In comparison with objective data the railway risk is somewhat underestimated, e.g. in Slovic et al. (1980). The average risk in road traffic is, on the other hand, often more or less correctly estimated when people are asked. However, when asked about their own personal risk the majority

investments. This difference in the value of safety is based, however, on the assumption that the same magnitude of the absolute reduction in risk is studied. Since there are differences in the baseline risks of railway and road traffic, we are not likely to find safety projects that reduce the risk to the same magnitude. Furthermore, although the relative risk reduction is the same (e.g. 20 % risk reduction), the absolute reduction in risk, i.e. the actual number of deaths and injuries avoided, may differ since the baseline risk in the railway sector is lower than in the road sector.

Size of the risk reduction

Standard economic theory predicts that there is a diminishing utility of a reduction in risk, e.g. Hammerton et al. (1982) and Jones-Lee (1989) and empirical studies do suggest such a relationship, e.g. Persson et al. (2001) and de Blaeij et al. (2003). The results indicate that although the willingness to pay increases for increased risk reduction, the marginal willingness to pay per unit of risk decreases, $\frac{WTP_2}{\Delta p_2} < \frac{WTP_1}{\Delta p_1}$ in figure 3. This indicates that the size of a risk reduction may be of interest when studying different hazards. However, if studying hazards with very small baseline risks, e.g. rail and road hazards, the curve is approximately linear suggesting that the willingness to pay should be near proportional to the magnitude a risk reduction, Hammitt (2000).

Figure 3. The relationship between individual willingness to pay (WTP) and marginal changes in risk (Δp).



state that their risk is lower than the average. Thus, the personal risk is underestimated; see e.g. Svensson (1981) and Sjöberg (1991).

Baseline cost

Carlsson et al. (2004) analyses differences in people's willingness to pay for a given risk reduction when travelling by air and by taxi and their findings suggest that the baseline cost affects the amount people are willing to pay for a safety improvement. The study indicates that people are willing to pay more for a given risk reduction if the baseline cost is higher. The willingness to pay that is stated may be framed by the cost given in the survey, though. However, follow-up questions included in the survey indicate that people are affected by the baseline cost in real life as well.

Since the costs connected with travelling by road or by railway are of the same magnitude, people's willingness to pay for safety improvements within the road and railway sector may be similar within this respect.

Private or public safety actions

The psychometric literature pays relatively little attention to the distinction between risks affecting one's own person and risks affecting other people as well, a distinction that is fundamental according to Sjöberg (1991). Sjöberg concludes that just asking people to rate a risk without specifying to whom the risk pertains is an unfortunate practice since risks are perceived in a different manner depending on to whom they pertain. For instance, Gyrd-Hansen et al. (2002) studied whether the effect of the baseline risk is different when respondents are faced with own risk profiles as opposed to general risk profiles for groups of the public. The study indeed found a difference in that people preferred a risk reduction in the area with lower baseline risk when the risk was expressed as an individual risk, and that they preferred a risk reduction in the area with higher baseline risk when the risk was expressed as a general risk.

Discussing the value of a marginal reduction in risk, there may be an important difference between a risk reduction achieved by an investment in private safety arrangements and a risk reduction achieved by a public safety project. At the beginning of chapter 3 we defined the value of a statistical life as the population mean of the marginal rate of substitution of wealth for probability of death over the affected population of individuals, Jones-Lee (1989). The definition is based on the assumption that people are concerned solely for their own safety. Beattie et al. (1998), however, states that an individual's willingness to pay for a public safety project may not only reflect the value of the personal reduction in the risk of death, but also the value they may place upon other considerations such as the reductions in the risk to other people (altruism) and the equality of the distribution of those

reductions. Altruism has its origin in the fact that besides an individual's willingness to pay for his/her own safety, many people may also be concerned, and therefore presumably willing to pay, for improvements in the safety of others. It has therefore been argued that the value of a statistical life should be augmented by a sum reflecting this additional willingness to pay. However, Bergstrom (1982) and Jones-Lee (1992) showed that inclusion of such a component is appropriate if and only if altruism is exclusively safety-focused and other dimensions of welfare are ignored. This means that safety is the only aspect of a person's well being that is of concern for another individual. On the other hand, if people's concern for others' well being relates to any aspects of quality of life, i.e. a pure form of altruism, it is not appropriate to include additional willingness to pay for others' safety when estimating values of safety. The intuition behind this result is that the pure altruist values both benefits and costs that accrue to others. At the margin, a person's concern for other people's safety will be precisely balanced by his concern for the reduction in their consumption that will be required to finance the extra safety by public funds. Adding values of others' safety to peoples' willingness to pay for their own safety would result in an overvaluation of safety relative to other determinates of their utility. Jones-Lee (1989) concludes that in the end it appears that the legitimacy of augmenting the value of a statistical life to reflect concern for other people's well being depends on the precise form that this concern takes. In the study of Lindberg (1999), the value of a statistical life is estimated including an additional cost component since relatives and friends may be willing to pay for increased safety for their road user. The findings suggest that this cost component is significant.

Studies estimating the value of a statistical life have reported a willingness to pay for a public safety project that exceeds the willingness to pay for a private safety device, e.g. Jones-Lee et al. (1985), Viscusi et al. (1988) and Strand (2002). Strand consequently states that the elicitation of the value of a marginal risk reduction as a purely private good may then be misleading in public policy contexts where mortality risk reduction is usually of the public good kind. In Johannesson et al. (1996), however, the estimate of the willingness to pay for a private safety device is higher than the willingness to pay for a public safety program.

In both the road and railway areas, investments are made in public safety projects and, in this respect, there are no differences between the traffic modes. However, when studying private safety arrangements there are several within the road sector, for instance airbags and different types of tyres and vehicles whereas within the railway sector there are no personal safety arrangements at all. Hence, if there is a difference between the individual willingness to

pay for private and public safety arrangements, it is important to consider the type of safety investment of concern.

5.2 Conclusion

Research suggests that the individual willingness to pay for a risk reduction may vary depending on baseline risk, the size of the risk reduction, the baseline cost and whether we are discussing private or public safety investments. The characteristics discussed indicate no clear-cut evidence of whether risk reductions in the railway area are preferred to reductions in the road traffic area. The summed result of the research presented may go either way. Differences in the baseline risk favour risk reductions in road traffic. (Here we are assuming the same magnitude of risk reduction in different transport areas, which can be questioned though.) Different sizes of the risk reduction favour risk reductions in the railway area and, if we are only discussing public safety arrangements in both transport areas, no differences can be found.

According to the previous chapter, there are indications that people prefer risk-reducing investments in the railway sector to investments in the road sector and in the view of chapter 4 and 5, altogether, there seems to be more indications suggesting that the value of safety is higher for railway traffic than for road traffic than vice versa.

5.3 Adjusting preferences?

When applying preference elicitation methods an implicit assumption is made that peoples' decisions are a true reflection of their preferences. The individuals are also assumed to have access to well-formed preferences and that they are able to form such preferences based on information they either have or is given out to them. However, research into risk perception raises the question of whether people can make accurate judgements about risks or whether there are systematic biases in their evaluation.

What if the theory is not supported by empirical results and what if preferences do not accord with rational behavior? According to the studies reviewed here there may be substantial inconsistencies in the way people view risks due to the presence of heuristics,

psychological numbing, preferences for eliminating risks, risk aversion, etc. One finding suggests that preferences for relative risk reductions rule over preferences for absolute risk reductions. This result indicates that people go after the small problems, not optimizing life expectancy. In Slovic et al. (1980), the risk judgements of non-professionals were only moderately related to annual death rates. Accordingly, public fears appear to be driven by perceptions of the worst possible outcome rather than by any assessment of the expected number of deaths. Is this acceptable? If not, can we draw a line between acceptable and unacceptable preferences?

Beattie et al. (1998) argue that if people rank the importance of the risks of various activities in a different order from their ranking of the frequencies of fatalities, this cannot be attributed to a lack of information or awareness concerning those relative frequencies. This in turn suggests that the notion of risk means something more to people than just expected fatalities. Furthermore, Beattie et al. state that public perceptions matter. Public judgments should, however, not be the only input to decisions regarding valuation and regulation of health and safety. According to the authors there are clearly cases when the public is likely to be error prone or biased. Psychological theory can then be used to predict such cases. Beattie et al. also suggest that, e.g. group discussions, varying elicitation techniques and decision structuring may serve as tools for debiasing the judgments.

Peoples' limited ability to make accurate judgements about risks is a problem irrespective of elicitation method, i.e. the stated preference or the revealed preference approach. If there is a disparity in the level of risk assessed by the affected individuals and the objective risk level, the estimate of the value of a statistical life can be adjusted. If the individual risk estimate is known to be 20% lower than the expert judgement of risk, the value of a marginal risk reduction can then be recalculated based on the lower risk. For instance, Miller (1990) scaled the estimates with the ratio of perceived to actual risk levels based on the work of Slovic et al. (1980), obtaining the values of a statistical life implied by the perceived risk.[15]

Is this the way to go? One point of view may be yes, if people are given obviously biased information and/or have no ability to assess the information correctly, leading to inconsistencies and anomalies, and no, if individuals' risk assessment is based on fairly objective information, have reasonably stable and well-defined preferences and consider other attributes than probability and size of loss. This point of view is perhaps easy to put but less

[15] However, Miller (1990) was criticised due to the relatively limited study that it relied on in order to estimate the risk misperception ratios. In Miller (2000), unadjusted values were presented.

easy to decide upon. Even if we could adjust the estimated values, we have no assurance that expert judgements are immune to biases, and in many cases, effective risk management requires the co-operation of a large body of non-experts. One problem lies in how people deal with very small probabilities. For high frequency cases where the outcome is well defined, the accuracy of individuals' judgements can be explored by relating the subjective probability for an event predicted by the individual to the actual outcome frequency. However, in many cases objective measures of the risks of technologies, against which the accuracy and rationality of public perceptions can be judged, do not exist. Especially for novel technologies, true risks must be predicted not with historical statistics but by using complex analytic techniques such as fault-tree analyses, which usually require subjective or intuitive judgements on the part of the experts performing them. This means that all risk perceptions are subjective, since even expert estimates involve some amount of judgement, Sjöberg (1991).

Blomquist (2001) suggests that future projects should be encouraged to combine analysis of the risk perception associated with the activity of concern with the basic study estimating the value of a statistical life. Yet, Blomquist stresses that the risk level of interest is the one the individuals base their behaviour and trade-offs upon. If the objective is to estimate people's willingness to pay for a risk reduction, it is then the value of a statistical life implied by the perceived risk that should be estimated

A short remark may be that we should be careful in what we conclude from preference elicitation methods and choice behavior. Further effort should be made in order to give a better understanding of underlying motivations to ensure that we are indeed eliciting individual preferences for risk reductions.

6. Values of safety empirically estimated for road and railway traffic

6.1 Values of safety empirically estimated for road traffic relative to other contexts

A number of studies estimate the relative value of a risk reduction, the majority including road traffic but excluding railway traffic. There is nevertheless an interest in discussing these studies since they give an *indication* of whether the value of a risk reduction is likely to vary between road and railway traffic.

Mendeloff and Kaplan (1990) found up to approximately twice a difference in the relative valuation of the benefits of preventing a given number of deaths in different contexts. 8 prevention programs were studied, each addressed to a different hazard, e.g. bicycle and automobile accidents and fatal crib-slat accidents to young children. The authors argue that although research does not support very large differences in spending per death prevented, it also indicates that not all deaths are valued equally.

MacDaniels et al. (1992) studied both familiar and well-defined hazards, such as automobile and aviation accidents and less familiar and more poorly understood hazards, such as nuclear power and electromagnetic fields. Comparing the mean value of the willingness to pay for a reduction in the numbers of deaths in automobile accidents, the willingness to pay for a reduction in the risk of death in commercial aviation was 7 times lower and for hazardous chemical waste 5 times lower. In turn, Savage (1993) found differences in the mean willingness to pay to reduce risks of road and aviation accidents, domestic fires and stomach cancer. The willingness to pay was significantly affected by various psychological factors including perceptions of death and unknown attributes of the hazard concerned. The study concludes that people are willing to pay significantly more to contribute to lowering the risks of cancer than they are willing to contribute to lowering the risks posed by automobile accidents, home fires and aviation. The indication is that the implied underlying valuations of life vary across the hazards. The estimated value of life for automobile accidents was 5% higher than that for aviation accidents and 3% higher than that for fires in the home.

The issue in Subramanian and Cropper (2000) is whether observed disparities in cost-per-life saved reflect public preferences for environmental and public health programs. Environmental regulations often have much higher costs than other health and safety programs, which implies that the marginal social utility of saving a life via an environmental

program may be higher than the marginal social utility of saving a life through other health and safety programs. The study analyses the public choices between life saving programs. Respondents were confronted with pairs of saving programs that differed in number of lives saved and asked which program in each pair they would choose to implement. Each pair consisted of one public health program and one environmental health program. The latter included programs for reducing air pollution from automobiles and factories, drinking water treatment, regulations to limit pesticide residues in food and workplace smoking. The public health programs included colon cancer screening, smoking education and pneumonia vaccinations as well as regulations requiring passenger side airbags and radon tests in homes. Subramanian and Cropper suggest that the great majority of people do not favour rates of trade-off between preventing deaths from different hazards that are dramatically different from 1:1. The study concludes that while people's priorities are indeed sensitive to the combined influence of the number of deaths, the psychological characteristics of hazards and social amplification effects following a major accident in practice, it is the number of deaths that appears to dominate the quantitative judgements people give.

Carlsson et al. (2004) study differences in the value of safety for people travelling by air and by taxi. Their result suggest that people's willingness to pay for a given risk reduction is much larger, more than two times, when travelling by air. Follow-up questions reveal that many experience a higher mental suffering when flying and in order to reduce this suffering they are willing to pay a higher price. The result implies a value of safety that is two times as high when travelling by air than by taxi.

The findings suggest that there is no significant disparity in the value of a statistical life based on individuals' risk reducing preferences for a variety of hazards, which indicates that we are not likely to find differences within one and the same area, e.g. the transport area.

6.2 Values of safety empirically estimated for railway traffic relative to road traffic

Due to the comparatively low baseline risk in the railway context, a direct estimation of the value of a marginal risk reduction is problematic and prone to error, Jones-Lee and Loomes (1995). As preference-based values of a statistical life are estimated by dividing the reported willingness to pay for a given risk reduction by the risk reduction itself, even small errors in the responses will escalate to unacceptable error bands if the risk reduction of concern is minuscule. This is inevitably the case if the baseline risk is very small, as in the case of the railway sector. Therefore, a relative valuation method is often used. Based on this "relative method" a premium is estimated for a railway fatality relative to a road fatality. The value of preventing a railway fatality can then be calculated by applying the premia to the value of preventing a road fatality.

Jones-Lee and Loomes (1995) studied the value of a statistical life for the Underground in London compared to the value of a statistical life for road traffic. Their study showed a clear context premium in relation to road safety. There was, however, no evidence in favour of a significant positive scale premium. The premium appeared to derive entirely from considerations of control, voluntariness, and responsibility and owed nothing to the possibility of large-scale catastrophic accidents on modes such as the Underground. The arithmetic mean scale and context premium that emerged from the study pointed towards a willingness to pay based value of statistical life for Underground safety risks that was some 50 % larger than its road counterpart was. This figure was thereafter revised to about 18 % due to new methods for aggregating the results, Jones-Lee (2001).

Chilton et al. (2002) present the results of two studies carried out in the UK that analyse the relative valuation of safety in railway transports and fire safety (domestic and in public places) compared to the value of road traffic safety. The first of the two studies was carried out in autumn 1998. The second study was carried out in early 2000 in the aftermath of a major rail accident at Ladbroke Grove near London's Paddington station in which 29 passengers and 2 train-drivers died. In the first relativities study, the responses were such as to entail discounts for the value of a statistical life relative to the figure for roads in all the studied contexts. Consequently, railway safety was given a lower priority than road safety. The figure estimated for railways was 80% of the value for roads. One explanation is that the sample did not contain a representative proportion of rail users. In the second relativities

study, called a follow-up study, the proportion of regular rail users was increased and a major rail accident had recently occurred. The result also indicated, as one might expect, a rise in the concern for railway safety. However, the safety preferences did not change dramatically. Instead, the relative value of railway safety was fairly close to one for the sample as a whole. Furthermore, a premium of about 16 % was shown for preventing a rail fatality relative to the road figure for those who were regular rail users. According to the authors, this result contradicts the current safety investment policy in the UK and elsewhere which often accords a significantly greater premium to activities such as rail travel. However, one problem discussed in the article is that the contexts studied can be regarded as being spread over a rather limited area of the psychological characteristic space. It may be that risks with rather different features show larger trade-off differentials.

Bäckman (2002) builds upon the two studies presented in Chilton et al. (2002). However, in this case the study is carried out for Swedish conditions. Three hazard contexts were studied, railway risks, underground risks and risks from fires. The reference point in the comparisons was road risks. On the average for the whole sample, only a small premium of 2-3 % favouring rail and underground relative to road risks could be detected. Safety measures aiming at preventing small-scale accidents received a higher value than safety measures aiming at preventing large-scale accidents. When studying the values of the individuals using public transports frequently, a premium of around 10-15 % was found for railway and underground safety. Bäckman consequently concluded that “there is no support in the public’s preferences for valuing railway, metro or fire safety at two, three or four times the value of road safety, as is currently the practice”, (p. 142).

The result of the studies estimating the relative value of a marginal risk reduction within the railway context compared to the road traffic context coincide with the result of the empirical reports previously presented in that there is only a limited difference. The findings do not correspond to the use of a value of a statistical life in the railway sector many times larger than in the road sector.

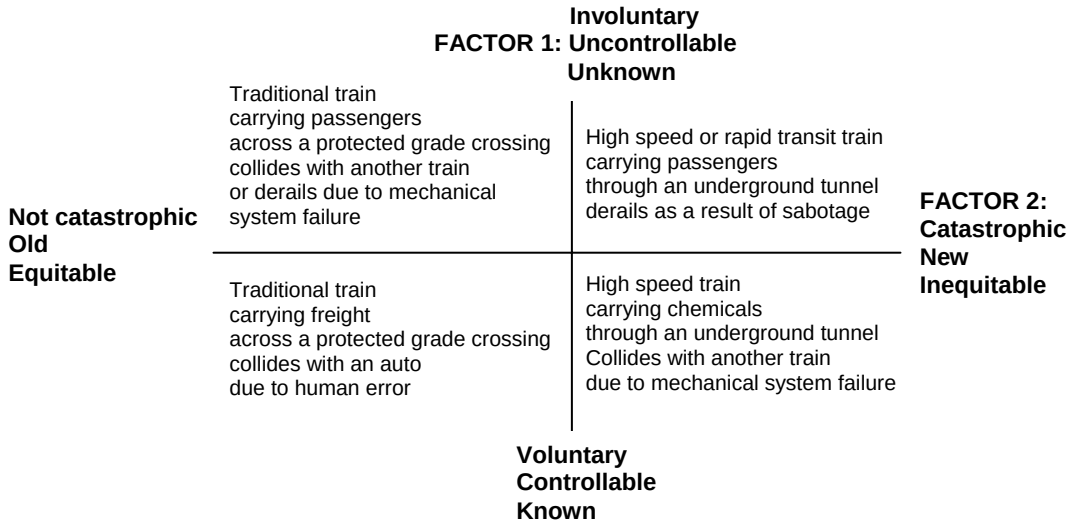
7. Diversity of road and railway accidents

This overview has so far concentrated on differences in the value of preventing a fatality in the railway context compared to the road context. Having discussed possible differences between different traffic modes, one may also discuss whether different hazards can be perceived differently when focusing solely on one transport mode. Research indicates that the variation within the context of one traffic mode may be as large as, or even larger than, the variation between transport contexts.

In some psychometric studies, e.g. in Fischhoff et al. (1978) and Slovic et al. (1980), comparisons are made of large hazard sets containing items as diverse as bicycles and nuclear power plants. The activities/technologies studied in the factor space concern some kind of an average hazard, which means that important implications may be left out. There may be considerable differences in aspects and characteristics of a hazard depending on e.g. location, type of accident, and time of day. Consequently, there may be differences in individuals' risk perception depending on the specific hazard studied. In Fischhoff et al. (1978) and Slovic et al. (1980), railways and motor vehicles were also studied disregarding the fact that not all road and railway accidents are alike. They may for instance differ with respect to type of train or vehicle involved, the potential type and cause of the accident, the nature of the consequences in the event of a mishap and so on.

Kraus and Slovic (1988) argue that railway accidents are really quite diverse, with some approaching nuclear reactors in their perceived seriousness. In their study, 49 railway accident scenarios are constructed. Each scenario is made up of the following components: type of train involved (traditional train, high speed train or urban rapid-transit system); type of cargo (passengers, benign freight or explosive chemicals); location of the train at the time of the accident (underground tunnel, underwater tunnel, on a bridge, in a city, in the mountains, on a protected grade crossing or on an unprotected grade crossing); type of accident (two-train crash, train-car crash, derailment or fire); and the cause of the accident (sabotage, mechanical failure, human error, earthquake or rock slide). The railway space is well represented by two factors in which knowledge and catastrophic potential play a defining role. The higher an accident score in catastrophic potential (the further to the right it appears in the space) the higher its perceived risk and the more people want to see the risk reduced. Figure 4 is derived from Kraus and Slovic and shows a "representative" railroad accident from each quadrant.

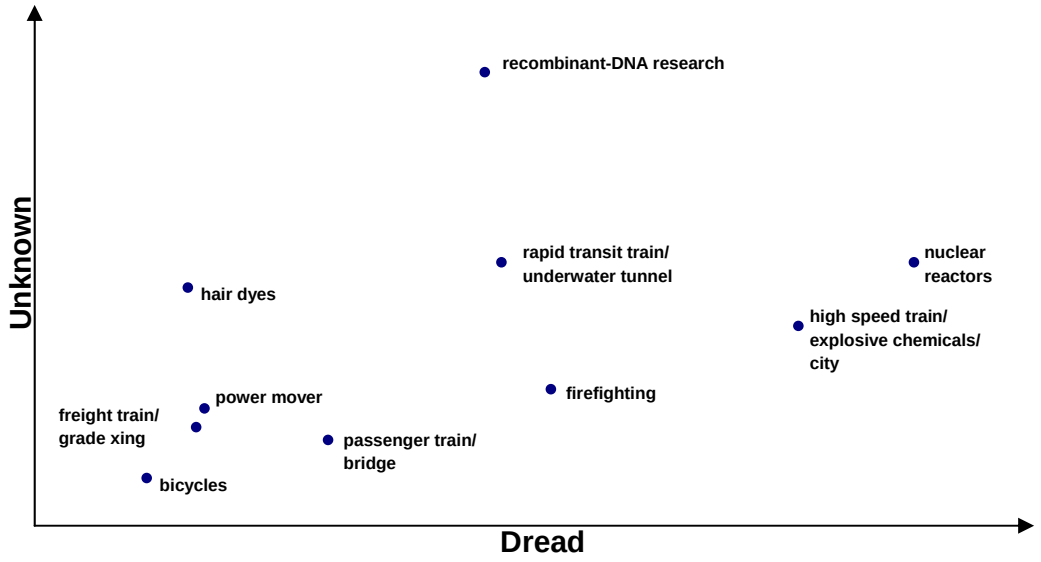
Figure 4. Two-dimensional factor space with representative railway accidents, Kraus and Slovic (1988, p. 451). Reprinted with permission from the Society for Risk Analysis.



In e.g. Slovic et al. (1980), the dread component was categorised as the most important factor in the factor space. In Kraus and Slovic, however, the dread component had little impact on determining the structure of the data. Furthermore, newness replaced involuntary and vice versa. As a result, catastrophic potential and newness where loaded on the same factor. The accidents perceived as both new and potentially catastrophic all involved trains with explosive chemicals as their cargo. Control too loaded differently in this study, relating more to the knowledge dimension than to the risk-size dimension. Again, this relationship may be a function of the specific set of accidents being considered. Uncontrollability and lack of knowledge characterise quite appropriately the nature of threats from hazards involving sabotage and earthquakes.

In Kraus and Slovic the respondents were also asked to rate the risks of several railroad accidents embedded in a diverse set of non-railroad accidents. This was done to calibrate different types of railroad hazards in relation to other hazards. Four railway scenarios were analysed. 1) A high-speed train carrying explosive chemicals in a city. 2) A rapid-transit train carrying passengers through an underwater tunnel. 3) A traditional train carrying freight over a protected grade crossing. 4) A traditional train carrying passengers over a bridge. The other accidents were nuclear reactors, fire fighting, power lawn mower, hair dyers, bicycles and recombinant-DNA research. Figure 5 is derived from Kraus and Slovic (1988) and shows the relationship between railway accidents and non-railway accidents.

Figure 5. Railway accidents and other non-railway accidents. Figure redrawn from Kraus and Slovic (1988, p. 453). Reprinted with permission from the Society for Risk Analysis.



According to Kraus and Slovic, accidents involving a traditional train carrying freight over a protected grade crossing or a traditional train carrying passengers over a bridge are much like the general railway point in Slovic et al. (1980). In contrast, an accident involving a high-speed train carrying explosive chemicals near a city is perceived to be much more like accidents associated with nuclear reactors than other railway accidents. The results of this study indicate that even though there is no larger variation in the risk preferences of the public when general accidents of different transport modes are studied, there might be substantial variation in the perception of risk when studying a single traffic mode depending on the attributes and circumstances of the hazard. An interesting conclusion drawn from Kraus and Slovic is that the railway accidents are spread over the factor space in much the same manner as in Slovic et al. (1980) when 90 different technologies were studied.

The discussion concerning the diversity of hazards connected with one transport mode focuses on railway accidents simply because no other research has been found. It is likely though that a similar discussion can be applied to other areas, e.g. the road traffic context.

The above stresses the importance of taking the characteristics and circumstances of the hazard of concern into consideration. Based on the assumption that peoples' risk perception affects their willingness to pay for safety, one universal value of preventing a fatality is unlikely to be found. Kraus and Slovic, suggests that even if only small differences can be

found in the estimated values of safety for different contexts, there are indications that the value of safety may vary for different hazards *within* the same context.

8. Concluding remarks

This study concentrated on possible differences in the value of railway and road safety. The discussion has mainly been carried out by economists but there is now an increasing understanding that other disciplines have to be considered in order to understand what individuals respond to, how risk beliefs are formed etc. The literature includes inputs from e.g. psychology, sociology, decision theory, economics, and policy studies.

Legislated safety standards within the railway sector imply that the value of prevention of a rail fatality greatly exceeds its road counterpart. This disparity is also supported 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. This indicates that some risks are perceived as being more dreadful than others. Besides the psychometric literature, a number of other issues are discussed that suggest the use of difference values of a marginal risk reduction for different circumstances. Consequently, an individual's preferences for safety investments may differ from one transport mode to another. Based on the research presented 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.

When preference-based values of marginal risk reductions have been estimated empirically within the railway and road context, 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 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. The use of such a value will furthermore lead to a misallocation of recourses that in the end may lead to premature deaths that otherwise would have been avoided. 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). The crucial point is whether we believe in estimated values of a marginal risk reduction or not. Future research has to be carried out in order to assess data for decision-making.

Furthermore, the findings indicate that, for each transport context, there ought to be an interest in studying different accidents types since there may be a substantial variation in the value of a marginal risk reduction between a general accident and, for instance, an accident involving hazardous goods. This type of study has not yet been conducted and the subject deserves a further exploration in the future.

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Using Choice Experiments to Assess People's Preferences for Railway Transports of Hazardous Materials

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This article investigates whether the choice experiment approach can be used to assess people's preferences and the determinants of these preferences in order to estimate the costs and benefits of different configurations of the transport of hazardous materials by rail. Changes in the exposure to hazardous materials that people are subjected to are used rather than changes in accident risk. To the best knowledge of the author, this has not been done before in a study of people's preferences toward hazardous materials. A mail survey, carried out in two cities in Sweden, is used to obtain tentative estimates of the willingness to pay for a reduction in exposure as well as the willingness to accept an increase in exposure. Special attention is given to viability, since the complexity of the activity studied, transport of hazardous materials, and the method used pose particular challenges. The response rate and tests of validity and consistency indicate that this method can be applied. Moreover, the results suggest that studies of this kind may provide guidance on changes in the transport of hazardous materials, especially because policymakers may influence the attributes presented here. Referring to the exposure of hazardous materials highlights the importance of providing the respondents with adequate information regarding hazardous transports. An important finding is that the amount of background information may have some effect on the stated preferences.

KEY WORDS: Choice experiments; hazardous materials; transportation; risk

1. INTRODUCTION

The transport of hazardous materials (hazmat) is an economic activity of concern to society. In Sweden, 12–15 million tons of hazmat are transported by road and 2 million tons by rail on a yearly basis.[1,2] Although the probability of a hazardous material accident is very small, the consequences could be severe for humans and environment. Thus, the level of risk should be taken into account in decisions regarding such transports,[3] and in determining the costs and benefits of various transport configurations. In decisions concerning transports, there is an interest in the value of a marginal change in the risk of an accident, and this value may be obtained by studying individuals' preferences toward changes in accident risk. However, in discussing the transportation of hazmat we are dealing with very small probabilities that may be hard to understand and relate to other risks. Furthermore, outcomes in the case of an accident involving hazmat may be quite diverse depending on the specific circumstances around the accident. Consequently, it may be an awkward task to estimate people's willingness to pay (WTP) for, or willingness to accept (WTA), a specific change in the risk of an accident. Since the risk faced by people is closely related to the degree of exposure to hazmat, a more suitable approach may be to investigate preferences with respect to changes in this kind of exposure.

Two main instruments are available for determining individual preferences, contingent valuation (CV) and choice experiments (CEs). For long, the CV method has been the standard procedure for

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eliciting individuals' preferences by asking respondents to state their WTP for different goods and scenarios.[4] Recently, there has been increasing interest in the CE method, though.[5,6] Using this method, subjects are asked to choose between two or more scenarios in a sequence of choice sets. Each scenario is described by a number of attributes and their associated levels. Since the individuals reveal their preferences by their choices, it is possible to estimate the relative weight of each attribute, i.e., the marginal rate of substitution (MRS). Furthermore, given that a cost attribute is included, the marginal WTP or WTA can also be calculated for the selected attributes.

There are weaknesses in all methods analyzing individual preferences. Problems often discussed are, e.g., hypothetical biases, sensitivity to study design or so-called framing effects, and insensitivity to scope.[7,8] The CE approach has been argued to possess some advantages relative to the CV method by being more informative, avoiding yeah-saying behavior, and simulating a real life choice context in a better way.[9,10] Furthermore, from a management/policy perspective, tradeoffs between the attributes of a transport configuration may be of particular interest. The CE approach is then well suited since it separates and values the different attributes of a scenario directly. However, the choice task within a CE study can be seen as cognitively demanding, since the research from experimental economists and psychologists suggests that there is a limit to how much information respondents can meaningfully handle while making a decision.[14] Studying people's preferences toward the transport of hazmat poses particular challenges since this activity may be seen as complex and unfamiliar, and connected with feelings of unease. These circumstances may lower the respondents' inclination to participate and to carefully imagine the scenarios presented.

The main purpose of this article is to investigate the potential of CE for modeling preferences for changes in the exposure to hazmat transported by rail in order to assess the costs and benefits of different transport configurations. To the best knowledge of the author, this is the first time a CE study, using exposure as a proxy for probabilities and accident outcomes, has been carried out.[1] 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 discussed to assess whether the CE method can be usefully applied. Furthermore, the preferences of people exposed to the transportation of hazmat 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 hazmat 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 article is then to study the effect of background information on the preferences being stated.

[1] There are some CE studies from various areas that include risk in the choice sets but do not express exposure as a source of risk.[11–13]

2. THE SURVEY

Since people's preferences for a change in the exposure to hazmat may be influenced by numerous factors such as former experiences of accidents and the amount of hazmat being transported, the survey is conducted in two cities, Lund and Borlänge in Sweden. These two cities are characterized by rail traffic with transport of hazmat through the city center. The City of Lund has no experience of accidents involving hazmat. Transports mainly pass through and there is an ongoing debate concerning a new rail track outside the city. Seventy railway wagons with hazmat pass through the city center per day. On the other hand, the City of Borlänge experienced an accident involving hazmat in the year 2000. There was no leakage but people living in the city center were evacuated for a week. Local industries are dependent on the supply of liquefied petroleum gas and other materials classified as hazardous. There are no plans for a new rail track in the near future. One hundred and forty wagons with hazmat pass through the city center per day.

A postal survey was conducted with a questionnaire consisting of four parts. The first part contained various attitudinal questions, and questions regarding the respondent's socioeconomic status, as well as distance to the railway from their homes. In the second part of the questionnaire, information was given on the likelihood of accidents involving hazmat and the possible consequences. The information also stressed that even if there was no leakage people could still be affected and evacuated for a couple of days. A short description was also given of the transport of hazmat on the railway nearby, together with a city map with the railway marked out. The third part contained the

	Alternative 1	Alternative 2	Current situation
Number of wagons with hazardous materials	No wagons	70 wagons/day	70 wagons/day
Time of transport		Nighttime	Daytime and nighttime
Classification of hazardous materials		Class 1	Class 2
Altered housing cost per month	30 SEK higher	200 SEK lower	Unaltered
Which alternative would you prefer?	□ **Alternative 1**	□ **Alternative 2**	□ **Current situation**

Fig. 1. Example of choice set for the Lund subsample.

CE and the fourth part had questions regarding costs and consequences to be considered when stating their answers.

Six hundred individuals in Lund and 400 in Borlänge were randomly selected. In order to test whether the amount of information on hazmat that a respondent received affected his or her preferences, 200 individuals living next to the railway in Lund and 200 living next to the railway in Borlänge received a questionnaire with little information regarding hazmat. Correspondingly, 200 individuals living next to the railway in Lund and 200 living next to the railway in Borlänge received substantial information regarding hazmat. Furthermore, in Lund, respondents living at two different distances from the railway were also randomly selected: living near but not next to the railway (100), living on the outskirts of the city and not within earshot of the train traffic (100). The respondents received a reminder card after two weeks. After another two weeks, those who did not respond to the questionnaire were sent a new one. A "dropout" questionnaire was finally sent out to those not responding in order to collect information regarding socioeconomic status and general attitude toward the transportation of hazmat and the questionnaire itself.

3. THE CHOICE EXPERIMENT

The effect of hazmat transports may be seen as a passive use value arising from a change in environmental quality that is not necessarily reflected in any observable behavior. In the CE method used in this study, the respondents are asked to choose one preferred alternative from two hypothetical transport configurations of hazmat and the current transport situation. See Fig. 1 for an example of a choice a respondent is asked to make. The respondents are asked to make six such choices and, based on these answers, people's preferences for changes in the exposure to hazmat are analyzed.

3.1. Attributes and Levels

The hypothetical alternative that is preferred by a respondent is assumed to depend on the attributes of the alternatives and the levels of these attributes. The first three attributes of this CE study jointly describe exposure to the hazmat being transported, whereas the fourth attribute is a cost variable. Everything else is assumed to be unaltered compared to today's situation. See Appendix C for exact wording.[2]

Attribute 1: Number of wagons per day transporting hazardous materials. Based on the number of wagons transporting hazmat today, three alternative levels are defined: twice as many as today, half as many as today, and none at all. In total four levels including the status quo.

Attribute 2: Classification of hazardousness. To facilitate the description of the hazmat being transported, we employ a simplistic representation of its hazardousness. The current mix of hazmat is assumed to be of Class 2, hazardous. Two other levels are defined, Class 1, less hazardous than today's mix, and Class 3, more hazardous than today's mix. With the purpose of minimizing the amount of information given and its complexity, limited information is given on the hazardousness of the goods. Instead, a number of follow-up questions are asked in order to control for effects that the respondents may be considering, e.g., damages to personal health and property and the environment. There are thus three levels of the hazardousness attribute. In a way, there is also a fourth level, no danger at all. This level appears in those cases where the

[2] In the questionnaire it was especially mentioned that the frequency of trains was assumed to be unaltered and thereby the level of noise that the railway causes would not change.

presented alternative describes a situation with no transport of hazmat at all.

Attribute 3: Time of transport. In the current situation, hazmat is being transported both day and night. Two other levels are defined, transport of hazmat in either daytime or nighttime only. Thus, there is a total of three levels. However, in the same way as the previous attribute, there is also a fourth level, no transport of hazmat at all.

Attribute 4: Housing cost per month. The text section preceding the choice sets states that the value of houses located near the railway is assumed to be affected by the transport of hazmat. For instance, a change in the number of wagons transporting hazmat is supposed to affect the market value. This change in the value of the property is in its turn assumed to affect the property taxation, expressed as an increase or decrease in the housing cost per month. The text also states that the housing cost is assumed to be altered for all types of housing. The following eight levels are used, where decreases in housing cost per month are defined as negative values: −200, −100, −40, ±0, 30, 50, 150, 250 SEK (108 SEK equals 10 EUR, November 2004).

3.2. Design of the Choice Sets

When designing a CE, it is important to combine the levels of the attributes into different alternatives in an optimal way. Limited sample sizes and the use of large numbers of attributes and levels have led the vast majority of CE studies to use fractional factorial designs as opposed to full factorial designs. In the task of designing a CE, there is also an important aspect in the way alternatives are combined into choice sets. For most combinations of attributes, levels, and alternatives, it is difficult to create a design that is optimal in every way, though. The design of this study is consequently a mix of fractional factorial design recommendations found in Louviere *et al.*,[15] two pilot studies, and simulations based on pilot data. Within each choice set, the respondent is asked to choose one of the three alternatives (see Fig. 1): two hypothetical transport alternatives (defined by varying levels of the four attributes presented in the previous section) and a constant comparator, the current transport situation (defined by current attribute levels). Some alternatives describe a situation where there is no transport of hazmat, see Alternative 1 in Fig. 1. In these cases, there is no data on time of transport and classification of the material, for obvious reasons. These conditions, together with the use of a constant comparator (the current situation), complicate the task of creating and combining the scenarios, without one alternative dominating another. As a result, full orthogonality, i.e., independent variation of all attribute levels, could not be achieved. No major imbalances were detected in the scenarios, though.[3] Furthermore, since respondents of the first pilot study generally expressed difficulties answering the questionnaire, the choice sets were reconstructed so that the level of one attribute was always identical for two of the alternatives presented. Given the complexity of the choices, it was decided that each respondent would be presented with six choice sets in the main study. Thirty-six choice sets were created and separated into six blocks of questionnaires, each consisting of six choice sets.[4]

3.3. Internal Consistency and Validity

When using the CE method it is of importance to include tests to study whether individuals appear to understand the technique and are taking it seriously. Internal consistency is often tested with a given *a priori* theory on which alternative is best. If an alternative is chosen in one choice set, an even better alternative should be chosen in another choice set. The test for internal consistency is carried out within one of six blocks of questionnaires, since an overall inclusion reduces the efficiency of the choice design. Carried out this way, the test gives an indication of the problem and cannot be used as a tool for sorting out irrational responses.

We use regression techniques to estimate a utility function with presented attributes as explanatory variables. Since there is no secondary data to compare real and stated behavior, the results of the regression analysis are used to study the internal validity of this study, i.e., the extent to which the results are consistent with *a priori* theoretical expectations. Assuming diminishing marginal utility of income, we would expect higher income groups to have a lower marginal valuation of cost. The disutility of an increased housing cost is therefore assumed to be lower for higher

[3] See Fig. A1. in Appendix for cross-plots of the three attributes describing exposure versus altered housing cost per month.

[4] Due to limited space, only 1 out of the 36 choice sets is presented (Fig. 1). A complete presentation, including a questionnaire in English, can be obtained from the author on request.

income groups. Given that reduced exposure is to be preferred, we would expect levels describing less (more) exposure than the current situation to have a positive (negative) sign in the regression analysis. Furthermore, it may be reasonable to expect the preferences of a household to be influenced by distance to the railway, so that households living next to the railway are expected to place a higher value on reduced exposure. Preferences and choices may also be affected by the information given.[16] In order to test the effect of information on the transport of hazmat, two types of questionnaires were created, one with substantial information regarding the consequences of an accident with hazmat and the size of the accident risk, and one with considerably less information. See Appendix B for exact wording. According to Slovic *et al.*,[17] people tend to overrate the risk of low probability events. Under the assumption that substantial information partly corrects this attitude, we expect the value of a reduction in exposure to hazmat to be higher for those respondents receiving little information than for those respondents receiving substantial information. Householders owning their residences may have stronger incentives to accept an increased housing cost in exchange for reduced exposure to hazmat than people renting their housing, since the increase in cost for residence owners is compensated for by an increased price once the property is sold. Consequently, we would expect higher values of reduced exposure for residence owners. However, other factors may correlate with owning one's residence, e.g., age, number of persons in the household, and the number of years the occupants expect to live at the same address. These factors may also increase the incentive of the household to accept higher housing costs in exchange for reduced exposure. Optimally, one would like to control for all other factors correlated with owning one's residence. The number of observations in this study, however, is too limited. Segmenting the data on owning one's residence will reveal whether this is a factor of relative importance. Finally, there are no *a priori* assumptions made about time of transport. At first glance, one may argue that people living close to the railway only prefer transport of hazmat in the daytime, since they are likely to spend their days at another location further away from the railway. Their exposure would then decrease compared to the current situation if transportations were restricted to the daytime only. Accordingly, transport of hazmat at nighttime would increase their exposure. However, one may also argue that the railway traffic is generally less heavy at night, which lowers the risk of an accident involving hazmat. Transportations at nighttime only are then to be preferred.

4. EMPIRICAL SPECIFICATION

4.1. Theoretical Framework

CEs, like many other environmental valuation approaches, share a common theoretical framework in the random utility model.[18] The representative individual is assumed to have an indirect utility function of the form:

$$U_{in} = U(Z_{in}, S_n),$$

where for any individual n, a given level of utility will be associated with the choice of any alternative i. Alternative i will be chosen over some other option j if $U_i > U_j$. Utility derived from any option is assumed to depend on the attributes, Z, of that option. These attributes may be viewed differently by different agents whose socioeconomic characteristics, S, will also affect utility.

While the individual knows the nature of his or her utility function, the researchers do not. This introduces the concept of random utility, where an error term, ε, is included in the utility function to reflect unobservable factors. Assume now that the utility function can be partitioned into two parts, one deterministic and in principle observable, and one random and unobservable. The indirect utility function can then be rewritten as

$$U_{in} = V_{in}(Z_{in}, S_n) + \varepsilon_{in}(Z_{in}, S_n).$$

The probability that individual n will choose option i over option j is given by

$$\text{Prob}(i \mid C) = \text{Prob}\{V_{in} + \varepsilon_{in} > V_{jn} + \varepsilon_{jn}, \text{ all } j \text{ in } C\},$$

where C is the complete choice set. Depending on the analysis model used, ε can be specified to take into account multiple observations from the same respondent as well as heterogeneity among respondents and correlation between alternatives, see, e.g., Reference 19. Assumptions must also be made about the distribution of the error term. The usual assumption is that the errors are Gumbel-distributed and independently and identically distributed. This implies that the probability of choosing alternative i is given by

$$\text{Prob}(i) = \frac{\exp^{\mu V_i}}{\sum_{j \in C} \exp^{\mu V_j}}.$$

Here, μ is a scale parameter, which is set to be equal to 1 (implying constant error variance).

4.2. Model

The multinomial logit model (MNL) is frequently used to estimate the utility function. There is, however, a debate concerning the use of this model since it assumes that selections from the choice set follow the independence from irrelevant alternatives (IIA) property, i.e., the relative probabilities of two options being selected are unaffected by the introduction or removal of other alternatives. This property follows from the independence of the error terms across different options contained in the choice set. Violations of the IIA hypothesis are often observed, resulting in the need for more complex statistical models. In this study, the data are analyzed using both the MNL and the random parameter logit model (RPL). The RPL model is a less restrictive model and is often used when the MNL is shown to violate the IIA property. Even if there is no violation of IIA property, there may be arguments for the use of a RPL model since taste variation among individuals is explicitly treated, as are correlations between parameters and repeated choices from each respondent.[19] Using the MNL and the RPL models, the following linear and additive utility function is estimated with a common alternative-specific intercept α for Alternatives 1 and 2 and k independent variables, x (see Table I):

$$U = \alpha + \beta_l x_l + \varepsilon \quad \text{for } l = 1, \ldots, k.$$

Altered housing cost/month is treated as a continuous variable for which negative values correspond to decreases in the housing cost. In order to study the way in which income affects the parameter for this cost variable, separate parameters are estimated for population segments based on monthly household income per consumption unit.[5] Three income groups are used for the Lund subsample. Since household income is less spread in the Borlänge subsample, two income groups per consumption unit are defined in this case.[6] Variables for number of wagons, classification of hazardousness, and time of transport are dummy coded with the levels of the current situation as reference category. In order to study how individual characteristics affect the preferences for a change in the exposure to hazmat, the respondents are segmented using dummy variables for (1) the respondent owns his/her residence, (2) the respondent received a questionnaire with substantial information regarding hazmat, and (3) the respondent is not living next to the railway. Interaction variables are thereafter created between the dummy variables for segmentation and each variable for the number of wagons, classification of hazardousness, and time of transport. The interaction variables give the effect of the characteristics mentioned, in addition to the estimated parameters of the baseline segment, i.e., respondents not owning their residences, receiving limited information in the questionnaire, and living next to the railway. In the model, there are no interactions included between the number of wagons, the classification of hazardousness, and the time of transport, assuming additive parameters. This can be discussed since people are likely to regard, for instance, twice as many wagons differently, depending on whether the materials being transported are classified as Class 1, less hazardous than today, or as Class 3, more hazardous than today.

Table I. Independent Variables

Continuous variable	
Altered housing cost/month:	Ranging from −200 to 250 SEK, segmented by Income L, Income M,[a] and Income H
Dummy variables describing attributes	
Number of wagons:[b]	Twice
	Half
	None
Hazardousness:[b]	Class 1
	Class 3
Time of transport:[b]	Daytime
	Nighttime
Segmentation of respondents, interacting with dummy variables presented above:[c]	
	Owning one's residence
	Receiving substantial information in the questionnaire
	Not living next to the railway

[a] Not defined for the Borlänge subsample.
[b] The reference category equals: the number of wagons of today, hazardousness of Class 2, and transports both daytime and nighttime.
[c] The baseline segment of respondents is: not owning one's residence, receiving limited information in the questionnaire, and living next to the railway.

[5] The consumption units used by Statistics Sweden are applied: single = 1.16, married/cohabitants = 1.92, additional adult = 0.96, and children = 0.66.

[6] In the Lund subsample, income groups are defined by Income L (<10,000 SEK per month), Income M (>10,001 and <20,000), and Income H (>20,001 SEK per month), and in the Borlänge subsample, Income L (<15,001 SEK per month) and Income H (>15,001 SEK per month).

The number of observations of this study is limited, however, and we therefore concentrate on estimating main effects, which should indicate viability of the method.[7]

One common alternative-specific intercept term is estimated for Alternatives 1 and 2, reflecting the preferences for these alternatives over the current situation when all attributes included in the model are the same. This coefficient can also be regarded as an endowment effect or status quo effect.[20] According to this theory, we are most likely to find a negative intercept, which may be interpreted as a disutility of moving away from the current state due to strong preferences for an unaltered situation. Individuals may also choose the current situation when the task of selecting options is considered too complex or when they are uncertain about the tradeoffs they would be willing to make. Choosing the current situation could also be a form of protest response. In some studies, the CE analysis is carried out both on a full sample, including respondents constantly choosing one alternative, and a reduced sample excluding these respondents.[20,21] This study will, however, include respondents constantly choosing the current situation due to uncertainty regarding their underlying motives. Important information may then be lost if these answers are disregarded.

When using the RPL model, assumptions are made regarding the distribution of the random coefficients. The cost parameters are treated as nonrandom in that the distribution of the marginal WTP for an attribute is then simply the distribution of that attribute's coefficient. To simplify the model the intercept term is also treated as nonrandom. Variables estimated for the baseline segment and describing the number of wagons and the classification of hazardousness are assumed to be log-normal distributed, restricting all respondents to the same sign of the coefficient. Remaining variables are assumed to be normally distributed since we have no prior knowledge regarding their preference structures. As the log-normal distribution gives positive coefficients, variables whose coefficients are necessarily negative are entered as the negative of the variable. Models using log-normal distributions often fail to converge, though.[22] In this study, as a second best solution, we also use the normal distribution for all variables of the RPL model. To the extent that the model converges, correlations between parameters and multiple observations from respondents are accounted for. Regression analyses using the MNL and the RPL model are conducted with Nlogit 3.0.[8] Due to limitations in the data set, the full model, i.e., all variables presented in Table I, is only estimated using the MNL model. Excluding insignificant parameters, a final estimation is made using both models.

Once parameter estimates have been obtained, a compensating variation measure is derived. The monetary value of a marginal change in any attribute is expressed as the ratio between the coefficient of the attribute and the coefficient of the cost parameter. The levels presented in the CE range from above to below the situation of today for all attributes, which allows us to examine situations where people are willing to pay for improvements as well as situations where people are willing to accept deteriorations for which they are compensated.

5. RESULTS

In the Lund subsample, the response rate was 45–60% depending on selection area, which is admirable given the complexity of the survey. The response rate was lower in the Borlänge subsample, however, 45%. This may have been a result of an older population (average age of 46 in Borlänge compared to 39 in Lund), and lower level of education (32% with academic education in Borlänge compared to 80% in Lund). There is a possibility that the response rate of Borlänge was also negatively affected by an incorrect questionnaire being sent out.[9] The response rate in the dropout study was 27%. The individuals were asked to state the reasons for not responding to the main questionnaire. The most common reasons for not answering were that they were too busy, forgot to answer, or just did not want to participate. The dropouts were generally younger.

[7] Even if main effects can be argued to explain the major part of respondent behavior, disregarded interactions may bias the variables, possibly leading to incorrect estimates.[15] However, the design of this study does allow interactions to be studied between the number of wagons, classification of hazardousness, and time of transport. Analyses (not presented here) do not suggest any differences in sign when such parameters are included in the model.

[8] When estimating the RPL model, Halton draws with 250 replications are used.

[9] The first version of the questionnaire that was sent to the Borlänge subsample contained an error in the CE, so a revised questionnaire was sent to the whole sample the same week. Fifty-nine individuals answered both versions of the questionnaire, making comparisons possible. The majority answered the second questionnaire in the same way as the first incorrect one and there were no signs of an increasing rate of protest answers.

As discussed in Section 3.3, a test of internal consistency was carried out within one of six block choice sets in order to study whether the respondents understood the questions and answered them consistently. The test analyzes whether a respondent who chooses an alternative in one choice set also chooses an even better alternative in another choice set. In the Lund subsample, all 25 respondents answered consistently, whereas 3 of 12 respondents answered inconsistently in the Borlänge subsample. One of the respondents answering inconsistently chose Alternative 1 in all questions, which may be a sign of protest, whereas the other two varied the chosen alternatives and no pattern could be detected.

5.1. Estimates

Results of the regression analysis are presented in Table II. For the Lund subsample, the coefficient of cost is significantly lower for the segments of average and high income per consumption unit compared to the segment of low income, suggesting that respondents with higher income have a lower marginal valuation of cost, i.e., a diminishing marginal utility of income. This effect cannot be found when comparing the results for the segments of average and high income, though. There is also a slight indication of diminishing marginal utility of income in the Borlänge subsample, albeit not significant. In the Lund subsample, the majority of the estimated coefficients for the baseline segment are significant at the 5% level (two-tailed), suggesting that the chosen attributes have been taken into account. In the Borlänge subsample, 2 out of 7 coefficients are significant. For both subsamples, the coefficients of the number of wagons and classification of hazardousness have the theoretically expected sign, confirming internal validity within the study. However, in the baseline segment, the estimated coefficients of time of transportation differ from the other coefficients in that they are all but one insignificant and of different sign when comparing the results of the Lund and Borlänge subsamples. In Lund, the estimated coefficients are positive, suggesting that any change from the current situation, i.e., transport of hazmat both daytime and nighttime, increases utility, whereas in Borlänge the coefficients are negative, suggesting that any change is considered a disutility.

Turning to the additional parameters for the segments of respondents owning their residences, respondents receiving substantial information, and respondents living next to the railway, the level of significance is much lower. Indeed, in the Lund subsample only 6 out of these 21 parameters are significant at the 5% level (two-tailed) and 2 out of 7 in the Borlänge subsample. There is no apparent pattern to the significant coefficients and there is no similarity in the pattern of significant coefficients between the two subsamples. These parameters are presented nevertheless, since they, when studied all together, add to the general picture. The parameters of distance, information, and residence-owning are generally of expected sign, in favor of the internal validity test. The study suggests that individuals owning their residences have a stronger preference for reducing the exposure to hazmat than individuals not owning their residences.[10] In Table II it is also suggested that, in the Borlänge subsample, utility increases for individuals owning their residences if the time of transport is changed to daytime only. The result implies, furthermore, that if the respondent receives more information regarding the probabilities and outcomes of accidents involving hazmat, reducing the exposure may become less important. In Lund, the value of a reduction in the exposure to hazmat is lower for those respondents receiving substantial information than for those receiving little information. In the Borlänge subsample, there were no significant effects of information whatsoever, and these parameters were excluded from this presentation.[11] The study also suggests that people living close to a railway transport route with hazmat benefit more from a reduction in their exposure to hazmat than people living further away and vice versa.

Though the IIA restriction is not rejected by the Hausman and McFadden statistic,[23] there is still an

[10] As mentioned previously, there are incentives for people owning their residences to answer this way since any increase in housing cost is compensated for when the house is sold. A telephone survey was therefore carried out of respondents that fulfilled the following criteria: answering within two weeks, owning their residences, not choosing the current situation in all choices, having the use of a telephone. Excluding 7 individuals in Lund and 5 in Borlänge who we could not get in touch with, the sample consisted of 30 respondents in Lund and 34 in Borlänge. The question that was asked was "When you made your choices in the questionnaire, did you consider changes in the market value of your estate?" In Lund the figure was 20% and in Borlänge 23%. This gives us an indication of this strategic problem. We have no information, however, on the degree to which this strategic behavior affects the results of this study.

[11] The effect of substantial information as opposed to little may be limited in Borlänge since it has experienced an accident with hazmat. People living near the railway, in areas from which the random selection for this study were made, were affected by evacuations and roped-off areas.

Table II. Multinomial Logit Estimates for the Lund and Borlänge Subsamples

	Lund		Borlänge	
Parameters	Coefficient	*p*-Value	Coefficient	*p*-Value
Intercept	−0.807	0.000	−0.496	0.022
Altered housing cost/(month × 100)				
Cost (Income L)	−0.543	0.000	−0.374	0.000
Cost (Income M)	−0.350	0.000		
Cost (Income H)	−0.397	0.000	−0.366	0.000
Baseline segment[b]				
Number of wagons				
Twice	−1.061	0.000	−0.655	0.008
Half	0.568	0.002	0.158	0.444
None	2.035	0.000	0.441	0.164
Classification				
Class 1	0.645	0.001	0.348	0.110
Class 3	−1.911	0.000	−0.579	0.034
Time of transport				
Daytime	0.631	0.003	−0.372	0.112
Nighttime	0.302	0.150	−0.244	0.294
Additional for segments				
Own residence				
Twice	−0.192	0.451	−0.514	0.073
Half	0.452	0.028	0.053	0.830
None	0.983	0.000	0.091	0.715
Class 1	0.448	0.027	−0.200	0.409
Class 3	−0.073	0.808	−0.951	0.004
Daytime	−0.137	0.556	0.663	0.016
Nighttime	0.123	0.604	0.204	0.475
Substantial information				
Twice	0.142	0.543	–[a]	
Half	−0.286	0.132	–[a]	
None	−0.782	0.000	–[a]	
Class 1	−0.436	0.020	–[a]	
Class 3	0.124	0.663	–[a]	
Daytime	0.105	0.623	–[a]	
Nighttime	0.085	0.702	–[a]	
Not next to				
Twice	−0.246	0.310	n.a.	
Half	−0.132	0.512	n.a.	
None	−0.680	0.001	n.a.	
Class1	−0.198	0.314	n.a.	
Class 3	0.436	0.134	n.a.	
Daytime	−0.232	0.500	n.a.	
Nighttime	−0.121	0.606	n.a.	
N	1,914		1,049	
Log-likelihood	−1,841		−1,052	
Likelihood ratio index	0.12		0.09	

[a]Excluded parameters due to overall insignificance.
[b]Not owning one's residence, receiving limited information in the questionnaire, and living next to the railway.
Note: n.a. = not available.

interest in using the RPL model since we have repeated choices from the same respondents. Moreover, we may have heterogeneous preferences and correlation within preferences. Two restricted MNL and RPL models are then estimated, excluding the interaction variables that are highly insignificant in the full MNL model. For the Lund subsample, the estimates of altered housing cost per month, segmented for average and high monthly household income per consumption unit, are not significantly different in the MNL

model. Segment Income M and Income H are consequently pooled into Income MH. In the Borlänge subsample, there is no significant difference between the two segmentation groups used for the cost parameter. Altered housing cost per month is therefore estimated without segmentation for this subsample. A likelihood ratio test for the restricted models implies that we cannot reject the null hypothesis that the coefficients are jointly zero. Furthermore, the IIA restriction cannot be rejected according to the Hausman and McFadden statistic. As mentioned in Section 4.2, models using the log-normal distribution often fail to converge and the regression models of this study are no exception. In addition, the regression models allowing for correlations between parameters fail to converge. Consequently, the resulting RPL models for the Lund and Borlänge subsamples are estimated taking repeated choices and normally distributed heterogeneous preferences into account, using the normal distribution for all parameters except the cost parameters and the intercept term. The results are presented in Table III for Lund and Table IV for Borlänge. There is an increase in the likelihood ratio index compared to the MNL models (Column 1), suggesting a better fit for the RPL models (Column 2). The estimates are generally lower for the MNL compared to the RPL models, which corresponds to the results of other studies.[24] The significance of the estimated standard deviations in the RPL models (Column 3) is a sign of heterogeneity in the preferences of the respondents. The standard deviation for variables interacting with owning one's residence is generally insignificant, though, indicating more homogenous preferences within this segment. The standard-deviation coefficients in the RPL models are unreasonably large, indicating problems that may be due to disregarded correlations in the heterogeneity of preferences.

5.2. Marginal Rate of Substitution

The interpretation of the coefficient values is not straightforward, except for significance and relative size. We therefore calculate the MRS between the attributes using the coefficient for cost as a numeraire. This implies that we can interpret the ratios as the average marginal WTP and WTA per household and month. The marginal rates of substitution based on the estimates of the MNL (Column 4) and the RPL (Column 5) models are presented in Tables III and IV. MRS totals, including the baseline values for respondents owning their residences, receiving substantial information, and living next to the railway, are given within brackets.[12] The ratios of estimated parameters in the MNL model are similar to those of the RPL model. The same result is found in, for instance, Train.[25]

Using the results in Tables III and IV, different transport configurations can be analyzed. For example, based on the results from Table III, Column 4, and using the estimates for Income L and the baseline segment, the total MRS for reducing the number of wagons by half, lowering the degree of dangerousness to Class 1, and transporting hazmat in the daytime only suggests a WTP per household and month of: 147 SEK (Intercept) − 88 SEK (Half) − 131 SEK (Class 1) − 97 SEK (Daytime) = −169 SEK.[13]

The intercept term is a determining factor for the result of a proposed transport configuration. In this study, the intercept is negative, which indicates that any change from the current situation is negative. Since there is uncertainty regarding this behavior, the inclusion of the intercept can be discussed. Adamowicz *et al.*[20] argue that such an inclusion is a reasonable option for models estimated for samples not containing individuals who constantly choose the current situation. They state that the intercept effect may be more of a real phenomenon in this case, since individuals who may have protested are excluded. In our point of view, it may also be reasonable to include the intercept term when carrying out the CE analysis on a full sample in order to limit the risk of neglecting interesting information. The question of how to deal with behavior concerning the current situation and the inclusion of the intercept term, which is beyond the scope of this study, ought to be discussed and analyzed more thoroughly in future research.

5.3. Estimates Constitute an Upper Bound?

It is plausible that the estimates presented here represent an upper bound for a number of reasons. A bias may arise since the survey is focused on one problem, transport of hazmat, exaggerating the importance of this problem without relation to other

[12] For instance, using the estimates of the MNL model for the Borlänge subsample, in this case residence owners, the change in MRS due to twice as many wagons as today is given by 163 SEK + 158 SEK = 321 SEK per household and month. Consequently, the households have to be compensated by this amount in order to maintain their utility.

[13] The total MRS is calculated under the assumption that the proposed transport configuration is the only one realized, i.e., a "state-of-the-world" model.[26]

Table III. Estimates Using MNL and RPL Models and MRS for Income L and Income MH, SEK—Lund Subsample

	MNL Coefficient (p-Value)	RPL Coefficient (p-Value)	RPL Coefficient Std (p-Value)	MNL, MRS[a] Income L/Income MH	RPL, MRS[a] Income L/Income MH
Parameters (nonrandom)					
Intercept	−0.802	−0.597	–	147/213	37/42
	(0.000)	(0.047)			
Altered housing cost/(month × 100)					
Cost (Income L)	−0.545	−1.606	–	n.a.	n.a.
	(0.000)	(0.000)			
Cost (Income MH)	−0.376	−1.416	–	n.a.	n.a.
	(0.000)	(0.000)			
Parameters (random RPL)					
Baseline segment[b]					
Number of wagons					
Twice	−1.173	−3.943	2.472	215/312	246/278
	(0.000)	(0.000)	(0.000)		
Half	0.480	1.201	1.395	−88/−128	−75/−85
	(0.001)	(0.000)	(0.000)		
None	2.031	2.688	7.313	−372/−540	−167/−190
	(0.000)	(0.002)	(0.000)		
Classification					
Class 1	0.713	0.986	2.091	−131/−190	−61/−70
	(0.000)	(0.016)	(0.000)		
Class 3	−1.594	−6.145	4.459	292/424	383/434
	(0.000)	(0.000)	(0.000)		
Time of transport					
Daytime	0.527	0.745	2.780	−97/−140	−46/−53
	(0.000)	(0.011)	(0.000)		
Nighttime	0.335	0.191	1.561	−61/−89	−12/−13
	(0.006)	(0.432)	(0.000)		
Additional for segments					
Half (own res)	0.401	1.040	0.403	−73/−107	−65/−73
	(0.007)	(0.012)	(0.703)	(−161/−235)	(−140/−158)
None (own res)	0.100	5.061	2.617	−183/−266	−315/−357
	(0.000)	(0.007)	(0.016)	(−555/−806)	(−482/−547)
Class 1 (own res)	0.461	1.542	1.094	−85/−122	−96/−109
	(0.003)	(0.006)	(0.160)	(−216/−312)	(−157/−179)
Half (subst. info)	−0.258	−0.628	1.936	47/68	39/44
	(0.077)	(0.082)	(0.000)	(−41/−60)	(−36/−41)
None (subst. info)	−0.807	−1.573	10.294	148/214	98/111
	(0.000)	(0.001)	(0.000)	(−224/−326)	(−69/−79)
Class 1 (subst. info)	−0.362	−0.544	2.479	66/96	34/38
	(0.011)	(0.253)	(0.000)	(−65/−94)	(−27/−32)
None (not next to)	−0.651	−1.727	2.001	121/176	108/122
	(0.001)	(0.165)	(0.348)	(−251/−364)	(−59/−68)
Class 1 (not next to)	−0.414	−0.722	1.903	76/110	45/51
	(0.003)	(0.132)	(0.002)	(−55/−80)	(−16/−19)
Log-likelihood	−1,847		−1,541		
Likelihood ratio index	0.12		0.25		

[a]Negative sign = WTP, positive sign = WTA.
[b]Not owning one's residence, receiving limited information in the questionnaire, and living next to the railway.
Note: n.a. = not available.

Table IV. Estimates Using MNL and RPL Models, and MRS, SEK—Borlänge Subsample

	MNL	RPL		MRS[a]	
	Coefficient (*p*-Value)	Coefficient (*p*-Value)	Coefficient Std (*p*-Value)	MNL	*RPL*
Parameters (nonrandom)					
Intercept	−0.494	−0.296	–	133	26
	(0.023)	(0.437)			
Altered housing cost/(month × 100)					
Cost	−0.372	−1.147	–	n.a.	n.a.
	(0.000)	(0.000)			
Parameters (random RPL)					
Baseline segment[b]					
Number of wagons					
Twice	−0.607	−2.094	3.359	163	182
	(0.010)	(0.001)	(0.000)		
Half	0.194	0.129	2.254	−52	−11
	(0.181)	(0.713)	(0.000)		
None	0.494	1.256	7.120	−133	−109
	(0.078)	(0.149)	(0.000)		
Classification					
Class 1	0.227	0.176	2.501	−61	−15
	(0.157)	(0.635)	(0.000)		
Class 3	−0.646	−3.653	3.436	174	318
	(0.013)	(0.000)	(0.000)		
Time of transport					
Daytime	−0.332	−1.356	2.159	89	118
	(0.118)	(0.012)	(0.000)		
Nighttime	−0.127	−0.623	1.841	34	54
	(0.439)	(0.067)	(0.000)		
Additional for segment					
Twice (own res)	−0.589	−1.469	0.457	158	128
	(0.021)	(0.041)	(0.646)	(321)	(310)
Class 3 (own res)	−0.849	−1.303	1.997	228	114
	(0.006)	(0.166)	(0.228)	(402)	(432)
Daytime (own res)	0.589	1.362	0.011	−158	−119
	(0.007)	(0.022)	(0.990)	(−69)	(−1)
Log-likelihood	−1,053	−894			
Likelihood ratio index	0.09	0.19			

[a]Negative sign = willingness to pay, positive sign = willingness to accept.
[b]Not owning one's residence, receiving limited information in the questionnaire, and living next to the railway.
Note: n.a. = not available.

hazards. It is also possible that the survey suffers from a budget constraint bias since the respondents may not consider that increases in expenditure mean that less money is available for other expenditures. These biases suggest that the estimates constitute an upper limit on the value attached to transport of hazmat. A bias may also arise since the respondents are faced with hypothetical alternatives, giving cause to stated choices that are hypothetical as well. The obtained estimates may then be overstated. However, studies carried out on differences between actual and hypothetical preferences and using the CE approach differ in that some indicate a difference and others do not.[27,28] Furthermore, in Wheeler and Damania,[29] it is argued that the accuracy of responses is improved when respondents are asked to value real-world scenarios. Although the respondents know that they are not actually being asked to pay here and now, the situation should be realistic enough for them to believe that this could happen. In this study, we try to minimize the problem of hypothetical bias by presenting a realistic and familiar payment vehicle and realistic alternatives describing the transport of hazmat. Besides, we are addressing an affected population.

6. DISCUSSION

This article suggests that the CE approach can be used to estimate people's preferences for different configurations of transport of hazmat by rail despite the complexity in the activity studied and in the CE method used. The response rate, 45–60%, was admirably high given the difficulty of the study. A test carried out within one of the six blocks of questionnaires indicated internal consistency. In the Lund subsample, all 25 respondents answered consistently, whereas 3 of 12 respondents answered inconsistently in the Borlänge subsample. This discrepancy may be due to differences in age and education, affecting motivation and ability to respond. The application of this method is also supported by the internal validity, i.e., the estimated parameters are of expected sign. Some parameters are insignificant, though. We have nevertheless chosen to discuss these results since they may, when studied all together, add to the general picture. A reduction in the number of wagons with hazmat 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 owning one's residence. The effect of time of transportation is inconclusive. This is not necessarily surprising, as a change in the time of transportation of hazmat can be interpreted as affecting people's exposure and safety both negatively and positively, leaving the summed effect insignificant. In this situation, we can only speculate on the origin of the differences between the subsamples. One explanation may be differences in the background data such as daytime distance to the railway and prior experiences of incidents with hazmat.[14]

The estimates can be seen as contextual, i.e., being time- and site-specific, even though objective information is given concerning the transport of hazmat. Characteristics of the city and the socioeconomic parameters of the subsamples are likely to affect the results and the appropriateness of an application of the results to other areas even if the settings are similar. Are the respondents able to understand the questions? Are their answers valid and consistent? According to Smith,[30] one may argue that only those who have experienced the problem being studied should be assessed. In this study, the majority of the selected samples consist of people living next to or close to the railway. Since these respondents experience the exposure to hazmat today, there is a reasonable possibility that their preferences are relatively well founded.

The major result of the study is that the CE method seems applicable even in this kind of setting with numerous difficulties. Furthermore, the analysis reveals that the CE approach may provide a rich description of people's preferences and the determinants of their preferences. In the future, results of this and similar studies may provide guidance on different transport configurations (e.g., with hazmat), especially since policymakers may influence the attributes presented here. However, the feasibility of the CE method when studying people's preferences toward transport of hazmat cannot be established until future research is conducted. It is important to test the external validity by incorporating real payments and by making consistency and validity tests with larger samples. Furthermore, in this study, exposure is used as a proxy for risk as an attempt to incorporate risk attributes into CEs in a meaningful way. Future research is required to analyze whether this is practical. It is also plausible that the estimates presented here represent an upper bound due to a number of biases and more research is required to address these biases.

[14] In the Lund subsample, 23% of the respondents not owning their residences state that they spend their day at the same distance or closer to the railway compared to their nighttime place. This figure is 57% in the Borlänge subsample. For respondents not owning their residences, the figure is 59% in both subsamples.

APPENDIX A: CROSS-PLOTS

Fig. A1. Cross-plots of number of wagons/day, classification of hazardousness, and time of transport versus altered housing cost/month used in the choice sets.

APPENDIX B: INFORMATION

The following information section is given in questionnaires providing substantial information for the Lund subsample. Passages in italic indicate the information given in questionnaires providing limited information. For the Borlänge subsample, necessary adjustments are made in the text.

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.

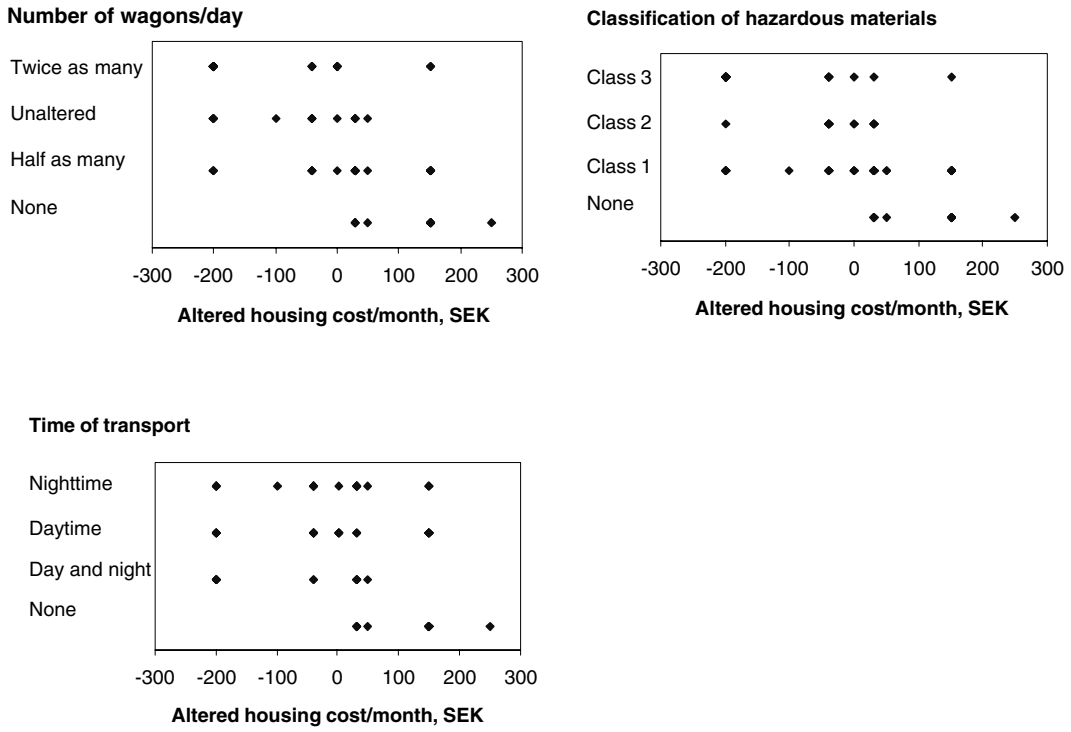

Fig. A1.

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 center of Lund everyday. The probability of a goods train being derailed on the Eslöv-Malmö stretch is estimated to be 3–4 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 2,000 years.

What can 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 kilometers 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 hazardous 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.

APPENDIX C: INTRODUCTION TO THE CHOICE EXPERIMENT

The following introduction to the choice experiment is given in all questionnaires for the Lund subsample. For the Borlänge subsample, necessary adjustments are made in the text.

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

This study assumes that the transport configuration of hazardous materials goods 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 ratable 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.

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Preferences regarding road transports of hazardous materials using choice experiments – any sign of biases?

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Abstract

This paper uses the choice experiment approach to assess people's preferences regarding road transports of hazardous materials. In a mail survey, carried out in Stockholm, the capital of Sweden, changes in exposure to hazardous materials are used as a proxy for changes in accident risk. The results are analysed in the light of an earlier study on transports of hazardous materials by rail. Special attention is given to biases associated with the choice experiment method. The presence of hypothetical bias is studied by the use of self-reported degree of confidence that the respondent would vote the same way in a real referendum. The presence of a focusing effect is studied by an inclusion of information on other fatal risks. The indication is that there are no major differences in individual preferences regarding hazmat transported by rail or road. The estimates are also dependent on the confidence of stated choices and interpreting this dependence as a hypothetical bias, suggest that this type of bias tends to push estimated values downwards. The findings show that individual background data regarding transports of hazardous materials affect individuals in expected ways and there is no focusing effect.

Keywords: Biases; Hazardous materials; Risk; Choice experiments.

JEL classification: C25; D61; D81; R41

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1. Introduction

By restrictions and regulations, efforts are made to ensure that transport of hazardous materials (hazmat) is a safe activity. Although the probability of a hazardous material accident is very small, the consequences could be severe for humans and the environment. The level of risk is therefore essential in decisions regarding such transports, and in determining the costs and benefits of various transport configurations. In decisions concerning transports, there is also an interest in the value of a marginal change in the risk of an accident, and this value may be obtained by studying individuals' preferences towards changes in accident risk. However, in discussing the transportation of hazmat we are dealing with very small probabilities that may be hard to understand and relate to other risks. Furthermore, outcomes in the case of an accident involving hazmat may be quite diverse depending on the specific circumstances around the accident. Consequently, it may be an awkward task to estimate people's willingness to pay (WTP) for, or willingness to accept (WTA), a specific change in the risk of an accident.

Since the risk faced by people is closely related to the degree of exposure to hazmat, a more suitable approach may be to investigate preferences with respect to changes in this kind of exposure. With this approach, we may also capture effects that are not directly connected with a leakage of hazardous substances. For instance, people living nearby may be anxious also in cases when there has only been an incident. In this situation, people are often very distressed 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, see Adler (2004) on fear assessment.

In Hiselius (2005), exposure is used as a proxy for probabilities and accident outcomes when modelling preferences regarding changes in the exposure to hazmat transported by rail. The findings indicate that this is a practicable way to describe different transport alternatives.

This paper uses the choice experiment (CE) method in order to analyse and estimate people's preferences towards exposure to road transports of hazmat. The CE method is one out of two main instruments available within the stated preference approach for determining individual preferences. The other one is the contingent valuation method (CV). For long, the CV method has been the standard procedure for eliciting individuals' preferences by normally asking

respondents to state their willingness to pay for different goods and scenarios, Mitchell and Carson (1989). There is an increasing interest in the CE method, though, e.g. Hanley et al. (2001) and Alpizar et al. (2001). In this method, subjects are asked to choose between two or more scenarios in a sequence of choice sets. Several attributes and their associated levels describe each scenario. Since the individuals reveal their preferences by their choices, it is possible to estimate the relative weight of each attribute, i.e. the marginal rate of substitution (MRS). Furthermore, given that a cost attribute is included, the marginal willingness to pay or accept, can also be calculated for the selected attributes.

Stated preference methods are sometimes considered to be biased to various degrees. Biases associated with the CV method have been explored in a number of studies but analyses of biases when using the CE method are so far limited in number. One general problem concerns the hypothetical nature of the stated preference approach. Since the whole setting is hypothetical we do not know whether what an individual says she would do match what she will do when actually given the opportunity to do so. There may be cognitive as well as strategically reasons for individuals to misrepresent their true opinions giving rise to a hypothetical bias, Mitchell and Carson (1989). An additional source of a hypothetical bias may be the so-called warm glow effect, Andreoni (1989) and Kahneman and Knetsch (1992). They suggest that people may be purchasing moral satisfaction rather than expressing a value of, for instance, environmental changes and since the cost of acting ethically correct is much lower in a hypothetical situation than in a real, the hypothetical WTP may be overstated.

Meta-analyses of mainly CV studies suggest that a hypothetical bias problem exists and that it results in overstated WTP estimates, e.g. Murphy et al. (2005a) and Harrison and Rutström (forthcoming). There are mixed results when using the CE approach, though. Carlsson and Martinsson (2001) cannot detect any differences in preferences between a hypothetical and an actual choice experiment analysing various environmental programs. Furthermore, Cameron et al. (2002) compare six hypothetical choice formats with actual purchase behaviour and cannot reject the hypothesis of the same indirect utility function across question formats. Telser and Zweifel (2002) compare WTP for hip protectors, derived from a choice experiment with actual choices made by the same respondents later, and show that the predicted WTP corresponds to the actual WTP. On the other hand, Johansson-Stenman and Svedsäter (2003) conducting a similar experiment to Carlsson and Martinsson, suggest that hypothetical WTP exceeds actual WTP in cases which involve an important perceived ethical dimension, and where a high WTP is considered ethically commendable. In addition, Lusk and Schroeder (2003) find that the hypothetical total WTP for the good

exceeds the real WTP but fail to reject the equality of marginal WTPs for changes in the single attributes.

Several studies have attempted to find a method to detect hypothetical biases and to predict the level of real WTP responses. Using the CV method some have shown that the level of real donations to public goods can be predicted from hypothetical responses by the use of a self-reported degree of confidence. In Champ et al. (1997) hypothetical dichotomous choice questions about donating a specified amount are compared to actual donation responses on a 1-10 scale ranging from very uncertain to very certain. They show that hypothetical donations significantly exceed real donations, but that there is no significant difference if only subjects that are very certain of their yes responses (10 on the scale) are counted as real yes responses. Champ and Bishop (2001) and Poe et al. (2002) report similar results. There are also CV studies giving the respondents options when answering WTP questions, ranging from "yes, definitely" to "no, definitely not". Based on the responses a conservative interpretation is used when only "yes, definitely" responses are interpreted as real yes-responses. This calibration method is used in Johannesson et al. (1998) and Blumenschein et al. (1998) when comparing hypothetical WTP responses to real WTP responses. The effect of the calibration differs however. In the study of Blumenschein et al., there is no longer a significant difference between real and hypothetical WTP responses when only "definitely sure" responses are used. When the same approach is used in Johannesson et al., the "definitely sure" responses significantly underestimate the real yes responses and thus provide a lower bound for the real WTP. Eckerlund et al. (1995) and Kartman et al. (1996) use the same method when calibrating hypothetical CV data. In these two studies there are no real WTP responses, though, making comparisons between real and hypothetical responses unfeasible. Using the conservative interpretation, it is simply shown that the mean WTP is significantly reduced.

Calibrating responses for hypothetical bias can be a delicate matter, though. Nape et al. (2003), studying the presence of hypothetical bias in WTA responses, suggest that the hypothetical bias is not a simple scalar that can be used to adjust all hypothetical responses down, but varies with observable socio-demographic characteristics such as race and age. According to Carson et al. (1996), one may also discuss whether the hypothetical setting of the CV and CE method give overstated vales as a rule. In contrast to other findings, Carson et al. suggest that the CV method give smaller estimates on the average than the revealed preference method, which uses observations on actual choices and behaviour.

Instead of calibrating for hypothetical bias, the outcome can be adjusted by using a "cheap talk script". In this method, the respondents are asked to read a script describing the bias problem and they are explicitly asked not to overstate their true willingness to pay. This method has been applied together with various stated preference techniques, e.g. the contingent valuation method in Cummings and Taylor (1999) and the Provision Point Mechanism in Murphy et al. (2005b). The cheap talk script has also been used to calibrate for hypothetical biases in CE data. In Carlsson et al. (2004), it is shown that the script has an effect on the result, and according to List (2001), the CE responses are quite similar to choices in the actual treatment when a cheap talk script is used.

Another problem connected with the stated preference approach is that it tends to exaggerate valuations of the intervention that respondents are asked about, relative to interventions not asked about, Saelensminde (1999) and Cookson (2003). This focusing effect is sometimes known as budget constraint bias, since the sums people are willing to pay, for the intervention in question, may be far in excess of what they are willing to pay for the same intervention when other interventions are also assessed. When studying public goods there is also a discrepancy between the maximum WTP for an intervention and the minimum compensation in order to forego the intervention, WTA, Horowitz and McConnell (2002). Besides an income effect, this divergence has been explained both by the degree of substitutability of the good or intervention, Haneman (1991), and by an endowment effect, e.g. Kahneman et al. (1990). Hanemann showed that the WTA/WTP disparity could be large when there were few substitutes for the studied public good. Thus, when a good has few substitutes, a gain may be moderately valuable, but a loss could be irreplaceable, causing a disparity between estimated WTA and WTP. Kahneman et al., on the other hand, propose that preferences are reference-dependent. According to this theory, individuals are shown to display loss aversion for reductions from a reference point, typically status quo, so that losses are weighted more heavily than gains. Once a good becomes part of one's endowment, the value one places on it increases, making WTA greater than WTP. Another effect discussed by Kahneman and Tversky (1979) is the certainty effect or certainty premium. This premium emerges when an outcome is for certain, e.g. when a risk is totally eliminated. There are few studies studying both utilities and disutilities using the CE method, though. One rare example is Adamowicz et al. (1998).

Psychologists have provided extensive evidence indicating that the public's perceptions of, and attitudes to, risk may vary substantially over different hazards and transport modes, e.g. Fischhoff et al. (1978), and Slovic et al. (1980). Transports of hazardous materials by rail and road are, for instance, associated with various characteristics that are likely to affect people's preferences differently. This paper uses the CE approach to assess people's preferences regarding changes in the exposure to hazmat transported by road. The influence of whether the respondent owns his residence is examined together with various individual background data regarding transports of hazmat. Furthermore, due to the novelty of this method and the complexity of the activity investigated, special attention is given to the validity of the approach. A test of internal consistency is carried out within one block of questionnaires and the estimates are furthermore compared with *a priori* theoretical expectations, giving an indication of the internal validity.

In this paper, special attention is given to hypothetical bias and focusing effect. So far, there have been no clear-cut results of hypothetical biases in CE estimates and "the cheap talk script" is, to the knowledge of this author, the only method that has been applied to adjust for a possible hypothetical bias in CE data. Since the cheap talk method involves additional sections of text, we use a question concerning with which confidence the respondent would vote the same way in a real referendum. This type of self-reported confidence has previously been used in CV studies. Since there is no reference group to compare the obtained estimates with, the result is used as a sensitivity analysis. Observed differences may be interpreted as an indication of hypothetical bias. The presence of a focusing effect is also studied by the inclusion of information on other fatal risks in half of the questionnaires that are used in the study. There are surprisingly few CE analyses of the WTA-WTP disparity, and in order to contribute to the knowledge of this area both WTP and WTA values are assessed and discussed in this paper. The outcome indicates that the CE method can be applied and that the estimates for hazmat transports by road do not differ greatly from those calculated for railway transports, Hiselius (2005). The use of self-reported degree of confidence gives high utility estimates rather than lower bound. Furthermore, no focusing effect is detected.

2. Survey

The survey was conducted as a mail survey in the fall of 2003, in Stockholm, the capital of Sweden. Two thousand individuals were randomly selected from a population of individuals between 18 and 75, who were living next to a transport route for hazardous goods that runs through central parts of Stockholm. The respondents received a reminder card after 2 weeks. After another 2 weeks, those who did not respond to the questionnaire were sent a new one. A "dropout" questionnaire was finally sent out to those not responding in order to collect information regarding socio-economic status and general attitude towards the transportation of hazmat and the questionnaire itself.

The questionnaire consisted of four parts. The first part contained various attitudinal questions and questions regarding the respondent's socio-economic status. In the second part of the questionnaire, information was given on the likelihood of accidents involving hazmat and the possible consequences. The information also stressed that even if there was no leakage, people could still be affected and evacuated for a couple of days. A short description was also given of the transports of hazmat nearby, together with a city map with the transport route marked out. The third part contained the choice experiment and the fourth part questions regarding costs and consequences considered when stating their answers, questions regarding the certainty of stated choices, and attitudinal questions regarding transports of hazmat.

3. Method

3.1. The choice experiment

The effect of hazmat transports may be seen as a passive use value arising from a change in environmental quality that is not necessarily reflected in any observable behaviour, Adamowicz et al. (1998). In the CE method used in this paper, the respondents are asked to choose one preferred alternative from two hypothetical transport configurations of hazmat and the current transport situation. See Figure 1 for an example of the choice a respondent is asked to make. The respondents are asked to make six such choices and, based on these answers, people's preferences regarding changes in the exposure to hazmat are analysed.

Figure 1. Example of choice set.

	Alternative 1	Alternative 2	Current situation
Number of lorries with hazardous materials	No lorries	140 lorries/day	140 lorries/day
Time of transport		Nighttime	Daytime
Classification of hazardous materials		Class 1	Class 2
Altered housing cost per month	40 SEK higher	250 SEK lower	Unaltered
Which alternative would you prefer?	**Alternative 1**	**Alternative 2**	**Current situation**

Attributes and levels

The hypothetical alternative that is preferred by a respondent is assumed to depend on the attributes of the alternatives and the levels of these attributes, Louviere et al. (2000). The first three attributes of this CE study jointly describe exposure to the hazmat being transported, whereas the fourth attribute is a cost variable. Everything else is assumed to be unaltered compared to the present day situation.

Attribute 1: Number of lorries per day transporting hazardous materials. 220, 140 (status quo), 60, and 0 (no transport of hazmat at all). In total 4 levels including the status quo.

Attribute 2: Classification of hazardousness. To facilitate the description of the hazmat being transported, we employ a simplistic representation of its hazardousness. The current mix of hazmat is assumed to be of Class 2, hazardous. Two other levels are defined, Class 1, less hazardous than today's mix, and Class 3, more hazardous than today's mix. With the purpose of minimising the amount of information and its complexity, limited information is given on the hazardousness of the goods. Instead, several follow-up questions are asked in order to control for effects that the respondents may be considering, e.g. damages to personal health and property and the environment. There are thus 3 levels of the hazardousness attribute. In a way, there is also a fourth level; no danger at all. This level appears in those cases where the presented alternative describes a situation with no transport of hazmat at all.

Attribute 3: Time of transport. In the current situation, hazmat is being transported in the daytime only. Two other levels are defined; transports of hazmat in both daytime and nighttime, and nighttime only. Thus, there is a total of 3 levels. However, in the same way as the previous attribute, there is also a fourth level; no transport of hazmat at all.

Attribute 4: Housing cost per month. The text section preceding the choice sets states that the value of houses located near the transport route is assumed to be affected by the transports of hazmat. For instance, a change in the number of lorries transporting hazmat is supposed to affect the market value of the property. This change in the value of the property is in its turn assumed to affect the property taxation, expressed as an increase or decrease in the housing cost per month. The text also states that the housing cost is assumed to be altered for all types of housing.[1] The following 8 levels are used where decreases in housing cost per month are shown as negative values: SEK -250, -130, -50, ±0, 40, 70, 190, 310. (SEK 108 equals EUR 10, November 2004.)

Design of the choice sets

Within each choice set, the respondent is asked to choose one of three alternatives (see Figure 1): two hypothetical transport alternatives (defined by varying levels of the 4 attributes presented in the previous section) and a constant comparator, the current transport situation (defined by current attribute levels). Some alternatives describe a situation where there is no transport of hazmat; see Alternative 1 in Figure 1. In these cases, there is no data on time of transport and classification of the material for obvious reasons. These conditions, together with the use of a constant comparator (the current situation), complicate the task of creating and combining the scenarios without one alternative dominating another. As a result, full orthogonality, i.e. independent variation of all attribute levels, is not achieved. No major imbalances are detected in the scenarios though. Given the complexity of the choices, the choice sets are constructed so that the level of one attribute is always identical for two of the alternatives presented. Each respondent is provided with six choice sets. Thirty-six choice sets are created and separated into six blocks of questionnaires, each consisting of six choice sets.

3.2. Internal consistency and validity

When using the CE method it is of importance to include tests to ascertain whether individuals appear to understand the technique and are taking it seriously. Internal consistency is often tested with a given *a priori* theory on which alternative is best. If an alternative is chosen in one choice set, an even better alternative should be chosen in another choice set. The test for internal consistency is carried out within one of six blocks of questionnaires,

since an overall inclusion reduces the efficiency of the choice design. Carried out this way, the test gives an indication of the problem and cannot be used as a tool for sorting out irrational responses.

We use regression techniques to estimate a utility function with presented attributes as explanatory variables. Since there is no secondary data to compare real and stated behaviour, the results of the regression analysis are used to assess the internal validity of this study, i.e. the extent to which the results are consistent with *a priori* theoretical expectations. Assuming diminishing marginal utility of income, we would expect higher income groups to have a lower marginal valuation of cost. The disutility of an increased housing cost is therefore assumed to be lower for higher income groups. Given that reduced exposure is to be preferred, we would expect levels describing less (more) exposure than the current situation to have a positive (negative) sign in the regression analysis. In examining individuals' preferences regarding exposure to transports of hazmat by rail, Hiselius (2005) shows that residence owners value reduced exposure more than non-owners. One explanation for this may be that householders owning their residences have stronger incentives to accept an increased housing cost in exchange for reduced exposure to hazmat than people renting their housing, since the increase in cost for residence owners is compensated for by an increased price once the property is sold. Segmenting the data on owning one's residence will reveal whether this is a factor of relative importance when studying road transports of hazmat as well. Finally, there are no *a priori* assumptions made about time of transport. At first glance, one may argue that people living close to the transport route only prefer transports of hazmat in the daytime, since they are likely to spend their days at another location further away from the route. Transports of hazmat at nighttime would accordingly increase their exposure. However, one may also argue that traffic is generally less heavy at night, which lowers the risk of an accident involving hazmat. Transportations at nighttime only are then to be preferred.

3.3. Hypothetical bias and focusing effect

When studying the problem of transportation of hazmat (or environmental applications in general), there may be difficulties finding data on actual behaviour in order to make comparisons between hypothetical preferences and actual preferences.[2] Instead, as mentioned

in the introduction, different calibration methods have been used. In, e.g. the CV studies of Eckerlund et al. (1995) and Kartman et al. (1996) the respondents are allowed to choose from five alternatives when responding to the suggested bid: yes, definitely; yes, probably; don't know; no, probably not and no, definitely not. Based on the answers, it is analysed whether the estimated result is dependent on how certain the respondents are in their answer. Under the assumption that only the respondents who answer "yes, definitely" and/or "yes, probably" are actually revealing their true preferences, the presence of a hypothetical bias is investigated.

Since there is no control group in this study, we adjust the values based on a self-reported degree of confidence in the stated choices in a similar way as in e.g. Eckerlund et al. and Kartman et al. This is done as a sensitivity analysis interpreting differences as a possible hypothetical bias. The question concerns the certainty with which the respondent would make the same choices in a real local referendum regarding the configuration of the transport of hazmat nearby and with real economic consequences. The follow-up question is phrased as a referendum situation in order to imitate a choice situation of several transport alternatives for which the economical consequences are not out-of-pocket. In a first attempt, a follow-up question was included after each choice set. Since this design was considered too cognitively demanding, a single follow-up question was therefore included in the last section of the questionnaire of this study. See Appendix for exact wording. Applying the results of previous CV studies of hypothetical bias and with a calibration based on self-reported confidence, one may expect lower bound estimates to be obtained in this CE study as well.

In order to detect the presence of a focusing effect that possibly exaggerates the importance of the activity asked about, relative to other activities/fatal risks not asked about, the subjects are divided into two segments. Half of the population sample received a questionnaire, which solely include information on risks connected with transports of hazmat. The other half received a questionnaire that also reported the risk of dying due to lung cancer, motor vehicle accidents, drowning, electrocution, and lightning. For exact wording, see Appendix. Under the hypothesis that the focusing effect is lowered when other fatal risks are also mentioned, we would expect the estimated preferences regarding reduced and increased exposure to hazmat to be lower for this segment.

4. Empirical specification

4.1. Theoretical framework

CEs, like many other environmental valuation approaches, share a common theoretical framework in the random utility model, McFadden (1974). The representative individual is assumed to have an indirect utility function of the form:

$$U_{in} = U(Z_{in}, S_n)$$

where, for any individual *n*, a given level of utility will be associated with the choice of any alternative *i*. Alternative *i* will be chosen over some other option *j* if $U_i > U_j$. Utility derived from any option is assumed to depend on the attributes, *Z*, of that option. These attributes may be viewed differently by different agents whose socio-economic characteristics, *S*, will also affect utility. While the individual knows the nature of her utility function, the researchers do not. This introduces the concept of random utility where an error term, ε, is included in the utility function to reflect unobservable factors.

Assume now that the utility function can be partitioned into two parts; one deterministic and in principle observable, and one random and unobservable. The indirect utility function can then be rewritten as:

$$U_{in} = V_{in}(Z_{in}, S_n) + \varepsilon_{in}(Z_{in}, S_n)$$

The probability that individual n will choose option i over option j is given by:

$$\text{Prob}(i \mid C) = \text{Prob}\left\{ V_{in} + \varepsilon_{in} > V_{jn} + \varepsilon_{jn}, \text{all j in C} \right\}$$

where C is the complete choice set. Depending on the analysis model used, ε can be specified to take into account multiple observations from the same respondent as well as heterogeneity among respondents and correlation between alternatives, see e.g. Hensher and Greene (2003). Assumptions are also made about the distribution of the error term. The usual assumption is

that the errors are Gumbel-distributed and independently and identically distributed. This implies that the probability of choosing alternative *i* is given by:

$$\text{Prob}\,(i) = \frac{\exp^{\mu V_i}}{\sum_{j \in C} \exp^{\mu V_j}}$$

Here, μ is a scale parameter, which is set to be equal to 1 (implying constant error variance).

4.2. Model

The multinomial logit (MNL) model is frequently used to estimate the utility function. There is, however, a debate concerning the use of this model since it assumes that selections from the choice set follow the independence from irrelevant alternatives (IIA) property, i.e. the relative probabilities of two options being selected are unaffected by the introduction or removal of other alternatives. This property follows from the independence of the error terms across different options contained in the choice set. Violations of the IIA hypothesis are often observed, resulting in the need for more complex statistical models. In this study, the data is analysed using both the multinomial logit model and the random parameter logit model (RPL). The RPL model is a less restrictive model and is often used when the MNL model is shown to violate the IIA property. Even if there is no violation of IIA property, there may be arguments for the use of a RPL model since taste-variation among individuals is explicitly treated, as are correlations between parameters and repeated choices from each respondent, Hensher and Greene (2003) and Train (2003).

The following linear and additive utility function is estimated with a common alternative specific intercept α for alternatives 1 and 2 and *k* independent variables, x, (see Table I).

$U = \alpha + \beta_l x_l + \varepsilon \quad$ for $l = 1,\ldots, k$

Table I. Independent variables.

Continuous variable	**Levels**
Altered housing cost/month:	SEK -250; -130; -50; ±0; 40; 70; 190; 310 and segmented by Income L, Income M and Income H
Dummy variables describing	
Attributes	
Number of lorries:	220; 140[a]; 60; 0
Hazardousness:	class 1; class 2[a]; class 3
Time of transport:	daytime and nighttime; daytime[a]; nighttime
Segmentation of respondents, interacting with dummy variables of attributes presented above:	
Model 1	
Residence owning:	not own one's residence[b]; own one's residence
Information on other fatal risks:	not receive information[b]; receive information
Model 2	
How often a reflection is made on hazmat:	daily[b]; occasionally; never
Model 3	
Probability of a fatal accident with hazmat:	high or very high[b]; low or very low
Model 4	
Impact of questionnaire on view of hazmat:	no or don't know[b]; yes
Model 5	
Degree of confidence to vote the same way:	yes, definitely[b]; yes probably; don't know; no, definitely not; no, probably not

[a] Baseline level of attribute = status quo.
[b] Baseline segment.

Altered housing cost/month is treated as a continuous variable for which negative values correspond to decreases in the housing cost. To find out how income affects the cost parameter, separate parameters are estimated for three population segments based on monthly household income per consumption unit.[3] Parameters for number of lorries, classification of hazardousness, and time of transport are dummy coded with the baseline levels equalling the current situation. With the use of dummy variables, the respondents are segmented to assess the way in which individual characteristics affect the preferences regarding a change in the exposure to hazmat. Due to a lack of observations in some sub-samples, we are not able to analyse the considered individual characteristics jointly. Instead, three types of models are used. [4] In Model 1, dummy variables are used for residence owning and receiving a questionnaire with information on fatal risks in addition to hazmat risks. In Model 2-4, dummy variables are used for different individual background data regarding towards transports of hazmat. Finally, in Model 5, dummy variables are used for the self-reported degree of confidence that the respondent would vote the same way in a real local referendum. Interacting parameters are thereafter created between the dummy variables for segmentation and each variable for the number of lorries, classification of hazardousness, and time of transport. In addition to the estimated parameters of the baseline segment, these interacting

parameters give the effect of the characteristics mentioned. The models do not contain interactions of the number of lorries, the classification of hazardousness and the time of transport, assuming additive parameters.

One common alternative specific intercept term is estimated for alternatives 1 and 2, reflecting the preferences regarding these alternatives over the current situation when all attributes included in the model are the same. This coefficient can also be regarded as a reflection of an endowment effect or status quo effect, e.g. Samuelsson and Zeckhauser (1988) and Adamowicz et al. (1998). According to this theory, we are most likely to find a negative intercept, which may be interpreted as a disutility of moving away from the current state due to strong preferences for an unaltered situation. Individuals may also choose the current situation when the task of selecting options is considered too complex or when they are uncertain about the tradeoffs they would be willing to make. Choosing the current situation could also be a form of protest response. In some studies, the CE analysis is carried out both on a full sample including respondents constantly choosing one alternative, and a reduced sample excluding these respondents, Adamowicz et al. and McIntosh and Ryan (2002). The analysis of this paper includes all respondents, though, due to uncertainty regarding the underlying motives of respondents constantly choosing the current situation. Important information may be lost if these answers are disregarded. The regression analysis is conducted with Nlogit 3.0.

Once parameter estimates have been obtained, a compensating surplus measure is derived. The monetary value of a marginal change in any attribute is expressed as the ratio between the coefficient of the attribute and the coefficient of the cost parameter. The levels presented in the CE range from above to below the current situation for all attributes, which allows us to examine situations where people are willing to pay for improvements as well as situations where people are willing to accept compensations for deteriorations.

5. Results

The response rate was 47% in the main study, excluding questionnaires undelivered or individuals who were not able to answer.[5] The response rate was 16% in the dropout study. Here the individuals were asked to state the reasons for not responding to the main questionnaire. The most common reasons were that they were too busy, forgot to answer, or just did not want to participate. The dropouts were generally younger and did not own their residences.

The test for internal consistency was carried out within one block to assess whether the respondents understood the questions and answered them consistently. Three out of 136 respondents answered inconsistently.

The analysis is carried out in three parts, which contain the results of Model 1, Model 2-4, and Model 5, respectively. The IIA restriction is not rejected by the Hausman and McFadden statistic when MNL regressions are used, Hausman and McFadden (1984). Nevertheless, the RPL model is also applied in order to take panel structure of the data and heterogeneous preferences among individuals into account. Only the results of the MNL model are presented in this paper, though, since the estimates are not significantly different.

5.1. Results considering residential owning and focusing bias

Model 1 is estimated for the whole sample and a pooled sample of respondents answering that they would respond the same way in a real referendum regarding transports of hazmat nearby. The estimated coefficients of the two samples are not significantly different. The coefficient of cost suggests that respondents with higher incomes have a lower marginal valuation of cost, i.e. a diminishing marginal utility of income. The cost parameter for the high-income group is insignificant in both samples, though, indicating that the respondents are unaffected by the cost attribute given in the choice sets. This is analysed in more detail later on. The majority of the estimated coefficients for the baseline segment are significant at the 5% level, suggesting that the chosen attributes have been taken into account. The coefficients of the number of lorries and classification of hazardousness have the theoretically expected sign, confirming the internal validity of the study. A positive coefficient indicates that an increase in the value of the attribute has a positive effect on utility, whereas a negative

coefficient involves a negative effect on utility. In the baseline segment, the estimated coefficients of time of transportation differ from the other coefficients in that they are all insignificant. A change from transportation in the daytime only to either daytime and nighttime or nighttime only is considered as a disutility. The finding is furthermore that the segment owning their residences, experience a higher utility from decreases in the number of lorries than those not owning their residences. This corresponds to Hiselius (2005) when studying hazmat transports by rail. A related finding of this segment is that residence owners experience a disutility when time of transportation is altered from the current situation.

Table II. MNL estimates of Model 1 with segmentation based on residence owning.

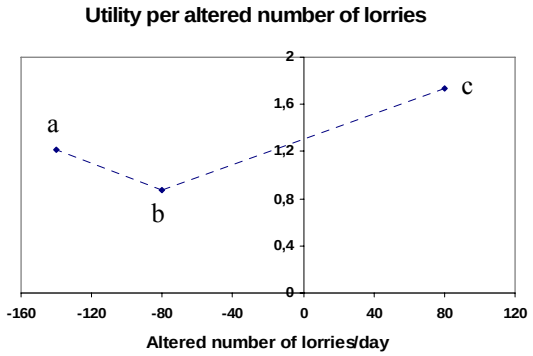
Parameters	**Sample**			
	Yes, definitely or Yes, probably		**Whole sample**	
	Coefficients	P-value	Coefficients	P-value
Intercept	-0.194	0.074	-0.187	0.059
Altered housing cost/(monthx1000)				
Cost (Income L)	-3.992	0.000	-4.122	0.000
Cost (Income M)	-2.301	0.000	-2.562	0.000
Cost (Income H)	-0.667	0.118	-0.714	0.071
Baseline segment[a]				
Number of lorries				
220 lorries/day	-1.391	0.000	-1.357	0.000
60 lorries/day	0.702	0.000	0.665	0.000
0 lorries/day	1.703	0.000	1.591	0.000
Classification				
Class 1	0.379	0.002	0.366	0.001
Class 3	-1.372	0.000	-1.403	0.000
Time of transport				
Daytime and nighttime	-0.065	0.537	-0.070	0.471
Nighttime	0.045	0.655	0.070	0.453
Additional for own residence				
220 lorries/day	0.158	0.352	0.040	0.796
60 lorries/day	0.522	0.000	0.452	0.000
0 lorries/day	0.565	0.000	0.496	0.000
Class 1	0.057	0.639	0.053	0.632
Class 3	-0.096	0.563	-0.101	0.513
Daytime and nighttime	-0.271	0.056	-0.251	0.054
Nighttime	-0.278	0.032	-0.232	0.052
n	4303		5014	
Log likelihood	-3826		-4550	
Likelihood ratio index	0.19		0.17	

[a] Respondents not owning their residences.

All interacting parameters estimated for the segment of respondents receiving a questionnaire with information on fatal risks in addition to hazmat risks are highly insignificant, indicating that the inclusion of this information has no impact on utility. These parameters are therefore excluded from the model and hence from Table II. The hypothesis that including information on other fatal risks could lower the focus effect is thus not supported.[6]

Based on the estimated coefficients for number of lorries/day in Table II, we look at differences in the utility associated with different levels of altered number of lorries. The estimated utilities of reducing/increasing the number of lorries are divided by the altered number of lorries that each level implies.[7] The utility ratios, presented in Figure 2, show a varying marginal utility for altered number of lorries. In *point a*, where the number of lorries per day is reduced by 140, the marginal utility of a reduction is higher than in *point b*, where the number of lorries per day is reduced by 80. This difference may be explained by the fact that *point a* represents a total elimination of transports of hazmat, possibly resulting in an added value or an certainty effect for this situation. The result also varies depending on whether an increase or decrease is studied even though the alteration is of the same magnitude. In the figure, it is shown that the marginal utility of a reduction of 80 lorries/day, *point b,* is lower than the marginal disutility of an increase of 80 lorries/day, *point c*. This difference corresponds to the WTP/WTA disparity discussed in the introduction of this paper.

Figure 2. Marginal utility per increased/decreased number of lorries per day. All differences are significant at the 5% level, one tailed.



5.2. Results considering background data on transports of hazmat

In the second part of the analysis, Model 2-4 are estimated in order to study whether individual background data regarding transports of hazmat affect the utility in an expected way. The analysis is based on a pooled sample of respondents answering that they would respond the same way in a real referendum regarding transports of hazmat nearby. The results are presented in Table III. In order to save space, p-values are not presented, but significant estimates (at the 5% level) are marked out. The findings are logical. The results of Model 2 suggest that respondents who never or occasionally reflect on transports of hazmat nearby value a reduced number of lorries and hazardousness less than the respondents that think about hazmat daily. This result is, however, mixed with respect to increased exposure. The outcome is similar for Model 3. Respondents considering the probability of a fatal accident with hazmat occurring within the next 50 years to be low, value a reduction in the number of lorries or the hazardousness less than respondents considering the probability to be high. The lack of significant coefficients in Model 4 suggests that whether the questionnaire has an impact or not on the respondent's view on transports of hazmat has little importance for the preferences being stated.

5.3. Results considering stated degree of certainty in choices

In Model 5, used in the third part of the analysis, the segments are based on stated degree of certainty that the respondent would vote in the same way if a real local referendum concerning transports of hazmat nearby where held. The baseline segment in the model is respondents answering "yes, definitely". Estimated parameters for the segments give the additional effect on individuals choosing any of the other four responses.[8] The results, presented in Table IV, show that the majority of the coefficients estimated for the different segments are significant, indicating an additional effect besides the estimated utility for the baseline segment, i.e. respondents answering that they would definitely vote the same way in a local referendum. The results suggest that respondents who are less sure that they would vote the same way in a real referendum generally value increases and reductions of exposure less than respondents who are definitely sure.

Table III. MNL estimates of Model 2-4 considering various individual factors for the sub-sample of respondents answering "yes, definitely" and "yes, probably".

	Model 2		**Model 3**		**Model 4**
Parameters	**Coefficients**		**Coefficients**		**Coefficients**
Intercept	-0.155	Intercept	-0,169	Intercept	-0.173
Alt. housing cost/ (monthx1000)		*Alt. housing cost/ (monthx1000)*		*Alt. housing cost/ (monthx1000)*	
Cost (Income L)	-4.222*	Cost (Income L)	-4,227*	Cost (Income L)	-4.185*
Cost (Income M)	-2.612*	Cost (Income M)	-2,521*	Cost (Income M)	-2.312*
Cost (Income H)	-0.802	Cost (Income H)	-0,488	Cost (Income H)	-0.320
Baseline segment[a]		*Baseline segment*[b]		*Baseline segment*[c]	
220 lorries/day	-1.754*	220 lorries/day	-1,438*	220 lorries/day	-1.268*
60 lorries/day	1.489*	60 lorries/day	1,113*	60 lorries/day	0.871*
0 lorries/day	3.365*	0 lorries/day	2,604*	0 lorries/day	1.951*
Class 1	0.914*	Class 1	0,752*	Class 1	0.392*
Class 3	-1.170*	Class 3	-1,520*	Class 3	-1.283*
Day- and nighttime	0.017	Day- and nighttime	-0,204	Day- and nighttime	-0.126
Nighttime	-0.358*	Nighttime	-0,104	Nighttime	-0.047
Additional for reflect on hazmat occasionally		*Additional for low prob. for fatal acc*		*Additional for impact of questionnaire*	
220 lorries/day	0.308	220 lorries/day	0,124	220 lorries/day	-0.204
60 lorries/day	-0.634*	60 lorries/day	-0,308*	60 lorries/day	0.179
0 lorries/day	-1.552*	0 lorries/day	-1,103*	0 lorries/day	-0.081
Class 1	-0.527*	Class 1	-0,584*	Class 1	0.004
Class 3	0.437*	Class 3	0,161	Class 3	-0.441*
Day- and nighttime	-0.265	Day- and nighttime	0,007	Day- and nighttime	-0.207
Nighttime	0.288	Nighttime	0,017	Nighttime	-0.117
Additional for never reflect on hazmat					
220 lorries/day	1.097*				
60 lorries/day	-1.158*				
0 lorries/day	-2.669*				
Class 1	-1.107*				
Class 3	-0.167				
Day- and nighttime	-0.300				
Nighttime	0.566*				
n	4303		4303		4303
Log likelihood	-3719		-3791		3843
Likelihood ratio index	0.21		0.20		0.18

***** Significant at the 5% level

[a] Respondents reflecting on transports of hazmat on a daily basis,.

[b] Respondents considering the probability of a fatal hazmat accident to be high or very high.

[c] Respondents stating that the questionnaire had no impact on his/her view on transports of hazmat or that they don't' know.

Table IV. MNL estimates of Model 5 with segmentation based on stated degree of certainty that the respondent would vote in the same way in a real local referendum.

Parameters	**Coefficients**	**P-value**
Intercept	-0.203	0.042
Altered housing cost/(monthx1000)		
Cost (Income L)	-4.379	0.000
Cost (Income M)	-2.800	0.000
Cost (Income H)	-1.065	0.008
Baseline segment[a]		
Number of lorries		
220 lorries/day	-1.642	0.000
60 lorries/day	1.238	0.000
0 lorries/day	3.131	0.000
Classification		
Class 1	0.802	0.000
Class 3	-1.174	0.000
Time of transport		
Daytime and nighttime	-0.379	0.003
Nighttime	-0.309	0.008
Additional for "yes, probably"		
220 lorries/day	0.381	0.034
60 lorries/day	-0.424	0.000
0 lorries/day	-1.631	0.000
Class 1	-0.523	0.000
Class 3	-0.449	0.009
Daytime and nighttime	0.259	0.080
Nighttime	0.292	0.029
Additional for "don't know"		
220 lorries/day	0.032	0.910
60 lorries/day	-0.756	0.000
0 lorries/day	-2.031	0.000
Class 1	-0.508	0.011
Class 3	-0.472	0.087
Daytime and nighttime	0.284	0.234
Nighttime	0.714	0.000
Additional for "no, definitely not" or " no, probably not"		
220 lorries/day	0.930	0.007
60 lorries/day	-1.024	0.000
0 lorries/day	-2.682	0.000
Class 1	-0.680	0.018
Class 3	-0.101	0.803
Daytime and nighttime	0.466	0.132
Nighttime	0.558	0.104
n	5014	
Log likelihood	-4430	
Likelihood ratio index	0.19	

[a] Respondents answering "yes, definitely".

In order to explore the issue of hypothetical bias further, a model is also estimated for each sub-sample, including the whole sample for a comparison. Table V indicates that for the sub-samples of respondents answering "yes, definitely" and "no, probably not" or "no definitely not", some cost parameters are insignificant, suggesting that the respondents with high or medium household incomes are unaffected by the cost attribute given in the choice sets.

Table V. MNL estimates for sub-samples based on stated degree of certainty that the respondent would vote in the same way in a real local referendum.

Parameters	**Sample**				
	Yes, definitely (P-value)	**Yes, probably** (P-value)	**No, probably not or No, definitely not** (P-value)	**Don't know** (P-value)	**Whole sample** (P-value)
Intercept	-0.091 (0.632)	-0.279 (0.037)	-0.880 (0.075)	0.067 (0.823)	-0.182 (0.066)
Altered housing cost/(monthx1000)					
Cost (Income L)	-1.651 (0.047)	-5.052 (0.000)	-5.656 (0.004)	-5.940 (0.000)	-4.370 (0.000)
Cost (Income M)	-0.794 (0.280)	-3.390 (0.000)	-4.432 (0.013)	-3.850 (0.000)	-2.608 (0.000)
Cost (Income H)	-0.347 (0.617)	-1.671 (0.002)	1.076 (0.547)	-2.876 (0.050)	-0.381 (0.331)
Number of lorries					
220 lorries/day	-1.365 (0.000)	-1.328 (0.000)	-0.574 (0.197)	-1.903 (0.000)	-1.337 (0.000)
60 lorries/day	1.037 (0.002)	0.897 (0.000)	0.472 (0.186)	0.468 (0.025)	0.861 (0.000)
0 lorries/day	2.616 (0.000)	1.683 (0.000)	0.989 (0.076)	1.115 (0.001)	1.803 (0.000)
Classification					
Class 1	0.513 (0.001)	0.378 (0.000)	0.487 (0.233)	0.276 (0.259)	0.383 (0.000)
Class 3	-1.083 (0.000)	-1.658 (0.000)	-1.017 (0.062)	-1.992 (0.000)	-1.992 (0.000)
Time of transport					
Daytime and nighttime	-0.211 (0.149)	-0.154 (0.147)	0.284 (0.444)	-0.293 (0.224)	-0.179 (0.021)
Nighttime	-0.086 (0.541)	-0.077 (0.456)	0.374 (0.354)	0.169 (0.459)	-0.029 (0.701)
n	1729	2574	186	525	5014
Log likelihood	-1323	-2422	-182	-488	-4573
Likelihood ratio index	0.30	0.14	0.08	0.14	0.17

Based on the results in Table V, individual estimates for WTP or WTA can be calculated as the ratio between each of the estimated parameters of the number of lorries, classification of hazardousness, and time of transportation, and the cost parameters. The ratios are presented in Table VI together with the standard deviation.[9] The standard deviation is generally large, especially in those cases the WTP/WTA ratios are based on insignificant cost parameters. The differences between the sub-samples are only significant in a few cases, but we can see some general tendencies. The findings suggests that respondents stating that they would vote the same way in a local referendum, as they have done in the choices sets presented, express higher WTA/WTP in the choices than respondents stating that they would not. The sub-sample of respondents answering, "yes, definitely" generally displays the highest WTA/WTP estimates compared to the other sub-samples. For the low-income group, the sub-sample of respondents answering "yes, definitely" shows the highest WTA/WTP estimates. Furthermore, for the same income group, the sub-sample answering “no, definitely not”, and “no, probably not” shows the lowest WTA/WTP estimates. In the same way, the WTA/WTP estimates are generally highest in the sub-sample of respondents answering “yes, probably” and lowest in the sub-sample of respondents answering no for the medium income group. The results for respondents answering “yes, probably” are again generally highest for the high-income group.

6. Discussion

This paper suggests that the CE approach can be used to estimate people’s preferences regarding different configurations of transports of hazmat despite the complexity in the activity studied and in the CE method used. The response rate was 47%. A test carried out within one of the six blocks of questionnaires indicated a high degree of internal consistency. Only 3 of 136 respondents answered inconsistently. The application of this method was also supported by the internal validity, i.e. the estimated parameters are of expected sign. For instance, a reduction in the number of wagons with hazmat 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. This paper is also generally logical when examining individual attitudes towards transports of hazmat. Respondents reflecting on transports of hazmat on a daily basis, or considering the probability of a fatal accident

involving hazmat to be high or very high, value reduced exposure more highly than other respondents. Furthermore, individual preferences do not differ between individuals stating that the questionnaire had an impact on their views regarding transports of hazmat and individuals stating that the questionnaire had no impact.

It is also interesting to discuss the result of this paper on road transport of hazmat in the light of Hiselius (2005) where transport of hazmat by railway is studied. Direct comparisons of estimated values are not possible, though, since the situations analysed differ with respect to the amount and type of hazmat transported. However, we can make some comprehensive comparisons of sign and size of estimated effects. Interestingly, the results of this study do not differ very much from that of Hiselius (2005) even if there are obvious differences between the situations analysed. The estimated parameters are generally of the same sign and of the same magnitude. Furthermore, the individual factor, owning one's residence, influences the individual preferences towards hazmat in the same way. In Hiselius, the estimated WTP is SEK 65 for a reduction in the hazardousness of the materials being transported, while the estimated WTA for an increase in the hazardousness is SEK 292. These values are estimated for the sub-sample from the city of Lund and the segment of respondents with low incomes and not owning their residences. In this paper, the estimated WTP for a similar segment is SEK 89 for a decrease in hazardousness and the estimated WTA is SEK 340 for an increase.

The survey is focused on one problem, transports of hazmat, which may exaggerate the importance of this problem when other hazards are not related. In order to study the focus effect, two types of questionnaires were constructed; one containing information on other hazards and one excluding this information. According to the result of this study, the inclusion of additional information on other risks had no effect, which can be interpreted in two ways. Firstly, there may have been no focusing effect present and thus no exaggeration of the estimates, and secondly, the information section included may have been too short to attract any attention and to detect the presence of such a bias.

Another potential bias analysed in this study is the presence of a hypothetical bias. This type of bias arises since respondents are faced with hypothetical alternatives, giving rise to stated choices that are hypothetical as well. In Wheeler and Damania (2001), it is argued that the accuracy of responses is improved when respondents are asked to value real-world scenarios. Although the respondents know that they are not actually being asked to pay here and now, the situation should be realistic enough for them to believe that this could happen. In this study, we try to minimize the problem of hypothetical bias by presenting a realistic and familiar payment vehicle and realistic alternatives describing the transports of hazmat.

According to Smith (2003), one may also argue that only those who have experienced the problem being studied should be assessed. In this paper, the selected sample consists of people living next to the transport route of hazmat in Stockholm. Since these respondents experience the exposure to hazmat today, there is a reasonable possibility that their preferences are relatively well founded. If there is a hypothetical bias present anyway, the obtained estimates may be overstated. However, studies carried out on differences between actual and hypothetical preferences and using the CE approach differ in that some indicate a difference and others do not, e.g. Carlsson and Martinsson (2001) and Johansson-Stenman and Svedsäter (2003).

In this study, we use a follow-up question concerning the certainty with which the respondent would vote the same way if faced by a real referendum concerning transports of hazmat nearby. Based on this question, it is analysed whether the estimated result is dependent on how certain the respondents are that they would express the same preferences in a real situation. 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. Experiences from CV studies indicate that this type of question can detect respondents giving hypothetical, and possibly overstated, answers. Calibrations based on self-reported degree of confidence used in CV 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 WTP and WTA than other individuals, i.e. the calibration leads to an increase in WTA/WTP, not a decrease. Even if there are only a few significant differences between the values in Table VI, the general tendency is rather strong. The indication is that there is a difference depending on whether are used or not. Interpreting this difference as a hypothetical bias suggests that this type of bias tend to push estimated values downwards. This result is also in line with the findings of Carson et al. (1996) when comparing revealed preference studies and CV studies. Differences in expressed preferences between confident and not confident respondents may also be seen as an effect of a strategic bias. High WTP/WTA values for people stating that they are confident in their choices can potentially be interpreted as a result of a strategic behaviour as well. The CE approach has been argued to minimise strategic answers, though, since various “packages” of characteristics are used, e.g. Louviere et al. (2000) and Hanley et al. (2001).

The cost parameters are insignificant for some sub-samples and income groups in Table II and V, showing that the respondents are unaffected by the amount being charged rather than estimation problems in the model. This coincides with the findings of Slothuus Skjoldborg and Gyrd-Hansen (2003), Jan et al (2000) and Bryan et al. (1998). Ratcliff (2000) suggests that WTA/WTP may be underestimated if the highest level of cost is set too low. It is then possible that some individuals are willing to pay more than is presented in the choice sets, resulting in understatements and insignificant results. In Slothuus Skjoldborg and Gyrd-Hansen, it is also empirically shown that the levels chosen for the cost attribute influence the payment impact on utility. The insignificance of cost may thus be due to the range of cost specified in the survey. [10] Possibly, there was insufficient variation in the cost attribute to influence the choices of respondents who reported that they would vote the same way in a referendum and had a medium or high household income, see Table V. This result illustrates the problems inherent in conducting a choice experiment. The cost range specified has to be relevant for all sub-groups presented in a selected sample. The fact that cost has no significant impact on utility in the "no, probably not" or "no, definitely not" sub-sample of high-income, may also be explained by lack of degrees of freedom in the model.

The estimated models can also be used to examine the WTA/WTP disparity in the setting of a choice experiment. According to Figure 2, the disutility associated with an increase in the number of lorries is twice as high as the utility of a decrease of the same magnitude. Furthermore, the utility per unit of altered number of lorries is 38 % higher when the number of lorries is totally eliminated, compared to the case when there is no total reduction. The case when the number of lorries transporting hazmat is totally reduced displays the certainty effect. In this case, the risk and anxiety associated with an accident involving hazmat are eliminated. These results are all according to theory briefly presented in the introduction to this article. Few CE studies include attribute levels that range from above to below the current situation, though. This is surprising since the CE approach may be especially applicable when studying WTA/WTP.

The major result of this paper is that the CE method seems valid in this kind of setting despite several potential difficulties. The estimated parameters are of expected sign and individual background data regarding transport of hazmat influence individual preferences as expected. An increase in an attribute of exposure is considered deterioration, for instance, and individuals reflecting on transports of hazmat on a daily basis, value reductions in exposure more than others do. In the future, results of this and similar studies may provide guidance on different transport configurations (e.g. with hazmat) especially since policy makers may

influence the attributes presented here. However, the feasibility of the CE method when studying people's preferences regarding transports of hazmat cannot be fully established until future research is conducted. It is important to test the external validity by incorporating real payments and by conducting consistency and validity tests with larger samples.

Appendix

Information included in half of the questionnaires and regarded for segmentation in Model 1:

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 since no one has died in an accident involving hazardous materials in Sweden in the last 50 years.

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

Question regarded for segmentation in Model 1:
What is your type of housing?

rented (tenancy right) cooperative ownership of house/flat detached house other

Question regarded for segmentation in Model 2:
Have you ever reflected on the fact that hazardous materials are being transported near you?

daily sometimes once in a while never

Question regarded for segmentation in Model 3:
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

Question regarded for segmentation in Model 4:
Has this survey influenced your opinion on transports of hazardous materials?

yes no don't know

Question regarded for segmentation in Model 5:
Suppose that the configuration of transports of hazardous materials close to you is to be settled in a local referendum with real consequences for you budget. Would you then vote the same way as you have done in this questionnaire?

yes, definitely yes, probably don't know no, probably not no, definitely not

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Footnotes

[1] The use of this payment vehicle may be regarded as less appropriate for the pricing of tenancy rights. The essential question is, in our point of view, however, whether the payment vehicle is credible to the respondent. This was established in two pilot studies preceding the main study.

[2] If we could isolate the effect of transports of hazmat on property values, the passive use value might be directly observed. In small countries, like Sweden, this type of data is hardly available in any quantities, though, making this type of study unfeasible.

[3] The consumption units used by Statistics Sweden are applied: single = 1.16, married/cohabitants = 1.92, additional adult = 0.96 and children = 0.66.

[4] See Appendix for exact wording of the questions that the dummy variables are based on.

[5] One hundred and sixty individuals were excluded since they had moved to another location or were unable to participate due to illness, difficulties in understanding the language etc.

[6] The effect of additional information was also tested in Model 3 and 4 by an inclusion of interacting parameters between the dummy variables describing inclusion of additional information and dummy variables describing how often a refection is made on hazmat and the probability of a fatal accident with hazmat. All parameters considering the amount of information were highly insignificant, though, and therefore disregarded in the regressions.

[7] The utility ratios in Figure 2 are based on estimated coefficients from the sub-sample of respondents stating that they would vote the same way in a referendum (multiplied by 100).

[8] The sub-samples of respondents answering “No, probably not” and “No, definitely not” are pooled due to lack of observations.

[9] The distribution of the marginal WTP/WTA is obtained by Bootstrapping with 1.000 replications. Using this method we randomly draw new sets of data with replacement and re-estimate the model. The computation is carried out in Limdep version 8.0. Other procedures are available for obtaining the distribution of WTP/WTA ratios. These procedures tend to give similar standard deviations though, Alpizar et al. (2001).

[10] In hindsight, we ought to have carried out a pilot study in Stockholm in order to define the appropriate range of cost. However, a similar cost range to the one in Hiselius (2005) is used in order to make comparisons between transport modes possible. The range of cost in the present study is 24% higher, though, due to higher income structure and costs of living in Stockholm compared to the two cities previously studied.

Assessment of fear and anxiety-
bundled or unbundled risk valuation?

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1. Background

All kinds of accidents resulting in injuries, illnesses and deaths are welfare-setbacks and so are the mere incidents for these (and other) bad outcomes that are possible. Thus, fear (rädsla, fruktan farhåga) and anxiety (oro, ångest, ängslan, bekymmer) for deaths and injuries are also causing welfare reductions and accordingly should be accounted for when formulating different regulations and restrictions in numerous authorities and agencies in society (Ropeik 2004). The standard economic valuation technique for quantifying the arising welfare effects in monetary units, often presented as a net present value, is the cost- benefit analysis (CBA). Many agencies, as the SNRA (Banverket) and NRA (Vägverket) in Sweden and similar ones in other countries using CBA (or a form of it), typically include some quantitative risk assessment, where a measure of the reduction of physical harm is considered. For instance, deaths and non-fatal accidents avoided by different interventions are often priced in monetary units but seldom or never are fear and anxiety per se. Since risk and fear often go hand in hand it consequently raises the question of splitting possibilities in perception, quantification and valuation. The idea that the fear and anxiety assessment should be a (separate) component in CBAs for decisions where interventions and regulations influence risk is recently scrutinized by Matthew Adler in an extensive article in Chicago-Kent Law Review (2004). However, the article raises many questions e.g. regarding fear quantification, pricing (including different valuations techniques) and usefulness in societal decision making.

One of Adlers most important arguments is that his coined term fear assessment should be a part of CBA by environmental, health and safety agencies. “They should actively quantify and monetize the fear states that would result from regulatory choices” (p 986). Making a difference between fear and other harmful mental states regarding the causal linkage and welfare impacts motivates for many agencies an engagement in fear assessment in contrast for a less specified cognitive approach. Although, the cognitive component of fear and anxiety states makes the concept difficult to handle in practical evaluation, especially regarding the pricing part, it seems well worth exploring a bit further.

Adler points out three different worries about the prerequisites for a pricing which relates to *quantification, uncertainty and causality of fear and anxiety*. For instance, the pricing procedure requires a measure of say, fear-days or fear-hours (cf. days of pain relief etc. used in health economic evaluations) whose probability distribution must be estimated for different

exposure scenarios. Resulting mean values of the fear units chosen could then be combined with monetary values (prices) to estimate some total fear cost or benefit for each regulatory option in relation to baseline or status quo. Finally, in line with standard CBA procedure the causality of intervention and effects should be clear and transparent. Linking hazards and fear states must be causally modelled. Is some safety regulation reducing the risk causally inert with respect to overall fear? Is the "sum" of fear and anxiety constant for people over time so the overall level of fear is very much the same? You may always find something to be anxious about. If this is the case some specified hazard could be the target of more general fears and the estimated fear cost (or benefits) will just jump around where focus happens to be set.. This could then violate the causality linkage and may give rise to double counting of this component (or variants) in more comprehensive evaluations like CBA.

Additionally to these issues deliberation cost is of great importance. If, when and where to do a fear assessment relates back to more general aspects of policy interventions. The cost for a CBA per se must also be included for decisions of policy evaluation. As these costs never sum to zero, some guidelines for decision making must be established. The demand for an additional and explicit fear assessment could then be questioned. Adler discusses circumstances under which such an assessment will have a bearing for agencies. These are collected under the following heads (p 999) but will not further be brought up here:

1. *The balance of non-psychological costs and benefits.* If mortality and morbidity risk reductions already justify an intervention, no fear assessment has to be done.
2. *Population size.* A larger affected population means more fear which indicates that fear assessment ought to be considered.
3. *Population fearfulness.* Fear assessment may not be necessary if the affected population falls in some general category that tends not to be fearful.
4. *Dreaded hazards.* Some hazards are known to give cause to more dread than others. Fear assessment ought to be carried out for those hazardous giving cause to dread.
5. *Hazard salience.* Intensive media focus on certain hazards like mad cow-disease and poultry-borne flu, may work as a trigger and indicator for fear assessment.
6. *Causal inertness.* Some hazards may have no or unclear influence on total fear in the population suggesting a minor need for fear assessment.

However, to these factors the relative importance between actual risks and fear/anxiety could be added. This point may be seen as an extension of factor 1 above, which considers the non-necessity of incorporating fear assessment if benefits as monetised values of lives and non-fatal accidents saved already outweigh the costs for the policy under consideration. On the other hand if fear and anxiety heavily dominates over very small risks (for a fatality) and consequently a reduction of these, traditional (i.e. with no explicit fear) monetary *risk* assessments may be more or less impossible to perform (e.g. for cognitive reasons), separate and unbundled fear assessments may then be wanted. (See below for more of this). Here, it is also important to underline that it is fear and anxiety *per se* that is under consideration. It is the intrinsic benefit (cost) of being less (more) anxious and fearful that should be valued and not the instrumental effects of fear even if these may be of great importance and actually caused by the degree of fear and anxiety.

2. Risk and fear[1]- to separate or not to separate?

So, one central issue seems to be a question of possibility and necessity for risk and fear to be handled together or separately. Should the evaluation task be bundled or unbundled? It might be proposed that risk and fear can and normally are bundled together in those measures which address to valuation of e.g. safety and health regulations. Typically, average willingness to pay (WTP) for small risk reductions for different types of deaths are used to calculate a value of a statistical life (VOSL) for each type of death. These values, it could be argued, incorporate not only a value for a reduction of an often small fatal *risk per se* but also the value for avoiding the fear state associated with the imagination of each type of death. There is an extensive literature revealing a huge range of monetary values for avoidance of different kinds of deaths (and also for the same ones) (Viscusi and Aldy 2003, de Blaeij et al 2003). The explanation for these divergences besides different valuation techniques and econometric models regressed on variables like age, gender, income, baseline risk, relative risk reduction etc, could be collected under a summary context factor.

[1] In the rest of the paper we use fear and anxiety interchangeable without any clear distinction made between the concepts.

In a well-known article some deaths were considered more worse than others (Sunstein 1997) e.g. resulting in special attention to those deaths that impose, in Sunstein´s terms, high externalities, to those who are preceded by extraordinary pain and suffering and to those who are unequally distributed in the population. A plausible consequence from these findings could be to recommend different VOSLs for valuation of policies preventing fatalities under special circumstances as the above mentioned. In a recent Swedish study transport safety was estimated more valuable when travelling by air compared to by taxi controlled for the same absolute risk reduction (Carlsson et al 2004). In an evaluation study of the social benefits of a tunnel construction in southern Sweden the officially estimated value of the reduction of travel time made by the SNRA seemed more or less to disappear when considering the negative experience of the underground travelling (Ljungberg 2000). When dissecting such context factors different fear and anxieties connected to the fatalities may very well play a decisive role for the monetary value revealed or stated for avoidance of deaths. These tailored VOSLs for different types of fatalities including some fear component (if present which may not always be the case) via a context factor can then be used to price different fatalities as input values in some evaluation methods as CBA. This could accordingly make the need for a separate fear assessment redundant.

However, this reasoning does not make a clear distinction between fear concepts and in which way fear enters in individual perception and measures to reduce the influence. Besides from fear-personality characteristics (a more or less fearful person), fear and anxiety could emerge partly as an attribute or a symptom of a defined state as cancer morbidity partly as a characteristic state *prior* to some possible bad event. You may have a fear of dying in a cancer disease which is closely associated with other dreadful attributes like pain and distress. This will give rise to some outcome disutility. The other and quite different aspect of fear is related to the mere fearing of contracting cancer, a state which may be experienced more or less constantly by many persons. A similar aspect of fear is often discussed within the health economic literature. Many attempts are made to quantify non-health benefits from health care programmes such as reassurance values of the mere knowledge of negative (or positive) diagnostic tests, where the source of value is named process utility in contrast to outcome utility (Donaldson and Shackley 1997). That kind of fear states will then be present with a probability close to one (during the relevant time period) in contrast to the fear attribute when combined with the state of actual disease (the health outcome). The probability for these states is normally far below one. Adler argues that the fear component that is *caused* by the risk of a

disease or some other dreadful state is not captured in tailored VOSL estimated from risk valuation studies and consequently advocate a fear assessment separated from traditional risk assessments.

To sum up, there seems to be three aspects of fear and anxiety relevant for an assessment procedure in decision making:

1. First, every individual can (theoretically) be characterised on some fear scale revealing genuine and hopefully sufficiently stable fear preferences (e.g. I am very anxious for nuclear power). This kind of fear could be named *inherent fear*.
2. Second, that kind of fear which is a direct attribute to a well-defined state and mirrored in say a tailored VOSL (a contracted disease will incorporate much fear to me) will in the following be named *outcome fear*.
3. Third, that fear which is caused by some "underlying" state and is experienced prior to the bad outcome (I am always afraid of being smashed in a car accident when driving) may finally be named *intrinsic fear*.

The relevance of this parting can be questioned and truly rest on many factors as the framing of questions if stated preference methods are used for elicitation as well as under which circumstances revealed preference information are expressed. These three aspects of fear are fuller devoted to below with a concentration on the intrinsic fear which also seems to be the one Adler mostly refers to in his article.

3. Which welfare measures to use in CBAs?

The traditional utility measures of individual preferences used in welfare economics are compensating or equivalent variations (surpluses for public goods). These concepts are in practice measured via WTP or WTA (willingness to accept compensation) questions in different survey contexts and are also normally considered as the foundation of CBA. Adler, on the other hand, proposes that these should be exchanged in favour for a constructed "welfare equivalent" (WE) concept which is claimed as a more proper base for policy evaluations regarding the overall well-being. As Adler puts it (p 1007), "well-being and preferences do not necessarily match". As interpersonal comparisons are underlying the

societal evaluations (in a Kaldor-Hicks compensation meaning) an objective measure instead of subjective preference-based is argued for. So, the sum of WEs should be a better (objective) guide for public decision making. The underlying ground for this reasoning is the doubts which have been raised about the "truthfulness" of, particularly, stated preferences. Can you trust (and accept) what people say and express under different circumstances? To overcome this scepticism of individual sovereignty as base for public decision making many authorities correct anyhow elicited preference values referring either to

i) distorted preferences (the standing problem in CBA)
ii) distorted probabilities (especially for small risks) or
iii) non-obeying of traditionally formulated axioms of von Neumann-Morgenstern's utility theorem for rational decision making under uncertainty (lottery valuation).

Adler's argument for a more technocratic approach by use of objectively founded WE instead of stated WTP/WTAs as the proper CBA measures, seems both to be a prerequisite for and a consequence of a separate and unbundled valuation of risk and fear.

The view of Alder can be questioned, though, since the perception of the affected population may be considered as the foundation of fear assessment. If we are to analyse the intrinsic fear of a hazard it may seem erroneous to base this analysis on objective levels. The question may be seen as twofold: 1) should the *effects* that the state *of fear* gives rise to be measured subjectively or objectively? 2) should the *risk* perception of the studied hazard be measured subjectively or objectively?

The choice of whether to use objective or subjective values may be a result of the analysis method used. For instance, the stated preference method proposed in this article treats the effects as objective since both the change in state of fear and the change in risk is predetermined for the analysed option. The individual *valuation* of the stated fear and the change in risk is thereafter treated as subjective (dependent e.g. on inherent fear).

4. Tailored VOSLs as a saving grace?

Bundled valuation via tailored VOSLs (i.e. different values for different fearful deaths) as a way of estimating regulator benefits is generally problematic according to Adler. It is not a good way to capture the combined risk-fear valuation benefits because risks (the objective ones) and fear/anxiety does not appear in fix proportions over scenarios. A policy that will

result in say 5 lives saved compared to another policy saving 10 lives (at different costs) could be valued by multiplying these saved lives by a unit monetary factor estimated as a *tailored* VOSL for the fatalities saved from this regulation. For this to be an acceptable way of estimating and comparing the total value of the policies it must be assumed that the ratio of avoided deaths is equal to avoided fear (in some units). Fear must be a linear function of the risk perceived which also must be equal to the actual (objective) risk. None of these premises are normally fulfilled. For instance, fear seems more to relate to possibilities than to objective probabilities of bad outcomes. Who should carry through the values in a CBA, fearful or calm individuals? Emotion-driven choices by decision-makers may skew policies in arbitrary directions. More precisely, how should the exact tailoring process look like? From where to catch the fear tags to paste on risk values? Similarities are obvious e.g. regarding the elicitation procedure for quality weights to be adopted in a construction of a quality adjusted life year (QALY) utilised in health economic evaluations. Which kind of groups, e.g. sick or healthy persons or may be experts like doctors should be asked to value different health states for advocating health authorities in allocation of future health resources?

The mere exposure to some hazard may cause fear and anxiety which seldom are mirrored in proportion to changes in underlying risks. There is some kind of a binary relationship. You are feared or not[2] irrespective of a proposed (small) change in risk exposure. In order to remove fear (both outcome and intrinsic) completely a total elimination of the risk may be the only way. An estimated value of a certainty effect will then be wanted. However, not even such a policy will always do the trick. Ropeik (2004) refers to a recent attempt from the Bush administration to vaccinate half a million US first responder healthcare professionals against smallpox. The policy failed and only 50 000 agreed to. This because they were offered a policy with a risk for a fatal side effect of one in a million for zero benefits (smallpox is since long eradicated in the world). Risk and fear communication are central not to undermine public trust in government actions.

[2] Also dependent on inherent fear.

As fear perception appears to be still more irrational than that for risk it therefore demands some separate handling apart from more objective risk reductions. Which kind of handling is not clear and must be discussed further. Because risk and fear are cognitively but often irrationally (at least in the economic sense) related a bundled valuation like tailored VOSL is obviously not always the best way to proceed and therefore advocates a separate valuation of the fear and risk components. These separated procedures, however, require that a monetized value of a change in risk of death (and disease) can be added to a monetary valuation of a change in fear states. Generally, it must be assumed that longevity and fear reduction are mutually utility independent exhibiting a constant proportional trade-off property[3].

If this and other additivity conditions are violated Adler suggest as an alternative to the unbundled valuation, a form of bundled valuation where authorities could use contingent valuation methods (CVM) expressing WTP for lotteries of *combined* objectively predicted changes in fear and risk in relation to a baseline option asked for. A general problem with such a bundled valuation is, according to Adler, the more cognitively difficult valuation task for combined than separated WTP-questions, a highly questionable proposition to which we will return soon. Another claim from Adler is that the supposed bundled valuation gives no room for a wanted (to minimise arbitrariness) standardisation of a fear day value.

Surprisingly, the proposed CVM is the only one suggested and discussed by Adler and he e.g. states: *"..[bundled technique]…would…… require agencies to conduct separate contingent-valuation interviews for each of its options, unless a standardized valuation function for combinations of fear- and risk-reduction could somehow be developed."* (p 1023).

What he seems to inquire is a valuation technique suited for an attribute-combined valuation which can overcome the supposed difficulties with bundled and option-repeated CVMs. A kind of combined valuation technique latterly collected under names as discrete choice modelling and choice experiments, is since long used in marketing, transport, environmental economics and is increasingly more popular for valuation of safety and health economic outcomes. A typical result from this modelling is a set of implicit prices for the included attributes. So, the demanded 'valuation function' seems already somehow to exist and appears à priori well suited for this combined valuation task. To this we now continue.

[3] Compare the strict assumptions for interpreting a QALY as a utility.

5. Choice experiments - a way to proceed?

A survey method which has its roots in mathematical psychology (Luce and Tukey 1964) and marketing (Cattin and Wittink 1982) known as conjoint analysis is based on the idea that a good or service could be described by its characteristics or attributes. The levels of these attributes give the individuals different utilities and by observing the rating and ranking of e.g. new goods and services, individual preferences can be elicited. From this early approach more choice-based evaluation techniques have emerged. Increasingly popular is a family of survey-based formats named choice modelling techniques. Respondents are presented with alternative descriptions of usually a non-market good distinguished by its attributes and the levels these attributes can take. The microeconomic foundation of this is the Lancaster characteristic theory of value, where the individuals' utilities of a good can be decomposed into the utilities for each characteristic (Lancaster 1966). By asking the individuals either to rank, rate or choose their most preferred alternative their preferences are assumed to be elicited for the good in question. Several variants of these modelling techniques are described and the ones we will concentrate on are the discrete choice experiments (DCEs) originally developed by Louviere and Henscher (1982) and Louviere and Woodworth (1983).

Choice experiments are a generalisation of the dichotomous choice contingent valuation method and share the common theoretical ground in the Random Utility Theory (McFadden 1973). The basis for empirical analysis lies in limited dependent variable econometrics (Greene 2003). Typically, an indirect utility function can be decomposed into two parts, one fixed and one random. The fixed deterministic part often specified as a linear index of attributes for the different alternatives or options in the choice set is in principle observable to the researcher. The other, stochastic element represents unobservable influences on the individuals´ choices and must consequently be modelled otherwise.

To proceed, assume an indirect utility function for each individual *i* who consumes a good or service *j* which can be written

$$U_{ij} = V_{ij} + \varepsilon_{ij} \qquad (1) \qquad or$$

$$U_{ij} = \beta X_{ij} + \gamma Y_i + \varepsilon_{ij} \qquad (2)$$

where U_{ij} is the utility of individual i from consuming commodity j (or in our context choosing alternative or option j). V_{ij} is the deterministic part of the utility function and ε_{ij} is the random part. β is a vector of parameters for the attribute set X_j of commodity j. γ is another vector of parameters and Y_i is the set of individual characteristics such as gender, income, inherent fear etc. ε_{ij} is the error term reflecting non-observable factors and measurement errors.

In order to maximize his utility an individual now choose an option out of a choice set J. An option g instead of any other option h is chosen only if $U_{ig} > U_{ih}$, i.e. the utility from g exceeds the utility from all other options h. The probability that an individual i will choose g can now be formulated as

$$P_i(g|J) = P[(U_{ig} > U_{ih}), \forall h \in J, h \neq g] = P(V_{ig} + \varepsilon_{ig} > V_{ih} + \varepsilon_{ih}) = P[(\beta X_g - \beta X_h) > (\varepsilon_{ih} - \varepsilon_{ig})] \quad (3)$$

The individual characteristics Y are not a function of the options chosen by the individuals and are therefore cancelled out from both sides of the inequalities in equation (3). For an explicit expression of the probability formulated above it is necessary to assume a distribution of the error terms. An almost standard assumption is that these random components are independently and identically distributed across all options with a type I extreme-value distribution (Gumbel distribution). The cumulative distribution function is then

$$F(\varepsilon_{ij}) = exp(-exp(-\varepsilon_{ij})) \quad (4)$$

The probability of choosing the most preferred option g can then be expressed by the logistic distribution. The specification in (5) is known as the multinomial logit model (MNL).

$$P_i(g|J) = exp\beta X_g / \sum exp\beta X_j, \quad j \in J \quad (5)$$

An assumption related to be specification of the model above is that selections from the choice set obey the Independence of Irrelevant Alternatives (IIA) property indicating that the relative probabilities of two selected options are unaffected of removal or inclusion of other alternatives. Violation of this assumption often demands other statistical models such as the nested logit or probit models.

The logit model in (5) can then be estimated by conventional maximum likelihood procedures specifying a log-likelihood function. The resulting parameter estimates are not always straightforward to interpret besides from sign and significance due to the log of odds formulation. Typically, a coefficient estimate of an attribute represents the influence of this on the log of the relative probabilities of choosing the option.

However, when the parameter estimates are obtained, a WTP compensating variation (surplus) measure can easily be derived for each attribute by treating the parameter of an included cost attribute as equal to the marginal utility of income. More formally assume that a cost attribute, X_1, can be specified in the attribute set. WTP can then be formulated for a change of another attribute X_j from one level to another by solving for the compensating variation (CV) in a standard utility equivalence formulation. Assume V^0 and V^1 representing the linear indexed utilities in the initial and alternative state respectively.

$$V^0 = \beta_1 X^0_1 + \beta_j X^0_j = \beta_1 (X^0_1 - CV) + \beta_j X^1_j = V^1 \qquad (6)$$

Solving for CV gives the willingness to pay for the change in attribute levels from initial (0) to changed ones (1), i.e. it represents the value of the utility change, ΔV.

$$CV = -\beta_j / \beta_1 [X^0_j - X^1_j] \qquad (7)$$

Assuming the usual conditions for differentiation of (7) a marginal willingness to pay expression is given by

$$MWTP = -\beta_j / \beta_1 (X^0_j) \qquad (8)$$

The ratio of coefficients given in (8) can be interpreted as implicit prices of the different attributes and is consistent with demand theory and utility maximizing behaviour specifically if a status quo option is included in the choice set. If such an option is *not* included some individuals could be "forced" to choose something which would give them no benefits and the resulting welfare estimates should be biased or in the worst completely flawed.

Following e.g. Hanley et al (2001) different stages in typical choice modelling experiments can be described by

i) Selection of attributes for the "good" to value (mostly including a monetary cost attribute).

ii) Assignment of levels, appropriate in different aspects. A baseline status quo is often included.

iii) Choice of experimental design. A complete factorial design combining all levels of attributes is seldom practical and instead some fractional factorial design to reduce the number of scenarios is often selected available through different software packages.

iv) Construction of choice sets. From the total identified options in the experimental design these option are grouped into choice sets to be presented for the respondents.

v) Measurements of preferences. Preferable by choice in favour of rating and ranking procedures.

vi) Estimation procedure. Either OLS regression or maximum likelihood estimations as logit, probit, nested logit etc can be used.

6. The pricing of fear and anxiety. An application of a choice-based stated preference method.

We now return to the discussion of fear assessment in the light of the choice experiment method presented previously. As described CE methods will give you a possibility to calculate a number of implicit prices or marginal rates of substitutions reflecting individual simultaneously (at least hopefully) made trade-offs for the included attributes typically characterising a policy. If these policies are targeted to reduce risk and fear it should be possible to define and include attributes which capture these together with other relevant characteristics of the policy such as cost and duration of effectiveness. An estimated value function derived from the model coefficients seems then to fulfil Adler's desire for a 'standardized value function' of a *combined* risk and fear reduction.

Up to now very few CE studies can be found explicit incorporating risk as an attribute. For instance, Ryan and Gerard (2003) reports in a survey of discrete choice experiments used in valuation of health care programmes only 12 such studies including a risk attribute. To our knowledge, no CE studies have been made covering an intrinsic fear or anxiety attribute. However, one economic valuation of reduction of test anxiety made with a CVM is reported from Israel (Zeidner and Shechter 1994).

We will now outline the design of some choice experiments that are aimed to estimate the value of fear and risk separately.

6.1 Vaccination against influenza

Consider the choice of having a vaccination against influenza. You may choose from a number of vaccinations. Each vaccination is described with the following attributes:

- The effect of the vaccination, i.e. the risk per year of catching influenza.
- The total number of days per year you are not worrying about catching influenza. The vaccination gives you some protection against influenza. By this protection your daily worry for catching influenza reduces. Summing up this reduction in worry the total number of days that you are not worrying about influenza is calculated. Since the time period that the vaccination gives you a protection against influenza varies as well as the effect of the vaccination, the number of days with a reduction in worry varies.
- The number of days with light fever as a side effect of the vaccination.
- Your cost, out of pocket, for the vaccination.

The number of days with fever is not correlated with the effect of the vaccination and the time period of protection. Also, the effect of the vaccination is not correlated with the time period of protection.

An example of a choice set with two different vaccination strategies and the situation of today with no vaccination can be described as follows:

Attribute	**Vaccination strategy 1**	**Vaccination strategy 2**	**Situation of today with no vaccination**
Risk of catching influenza	80 in 10.000	2 in 10.000	100 in 10.000
Total number of days per year without worry for influenza	200 days	280 days	180 days
Number of days with light fever	2 days	10 days	non
Payment	120 SEK	30 SEK	non

6.2 Transportation configurations of hazardous materials using risk as an attribute.

Consider the case of choosing between different transport configurations of hazardous materials (hazmats) transporting the same amount of hazmat. The configurations are assumed to differ with respect to how many days per week these transports are carried out. A reduction in the number of days with hazmat transports is also assumed to reduce the risk of an accident involving hazmat since fewer train movements are used to transport the same amount of hazmat. The reduction in the number of days with hazmat transports may, however, also result in an increased accident risk due to increased pressure on the railway system. Due to changes in the accident risk and in the number of days that hazmat is transported, the total time per month that you worry about hazmat is assumed to alter.

Different transport configurations may, furthermore, use different types of wagons resulting in different levels of noise and, finally, changes in the configuration of the transports may be argued to influence the value of estates nearby the transport route resulting in an altered housing cost for households due to an altered real estate tax.

The transport configurations will be described by the following attributes:

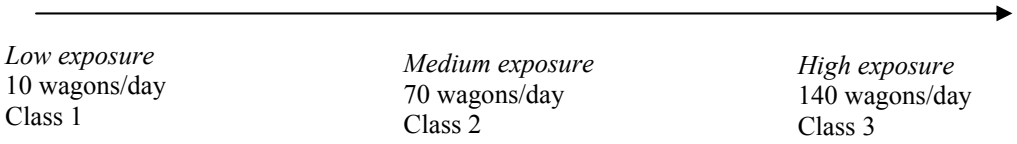
- The risk of a hazmat accident.
- Total number of days per month that you do not worry about transports of hazmat.
- Noise level.
- Altered household cost per month.

An example of a choice set with two different transport configurations and the situation today can be as follows:

Attribute	**Transport configuration 1**	**Transport configuration 2**	**Situation of today**
Accident risk	3 in 1.000.000	50 in 1.000.000	20 in 1.000.000
Total number of days per month without worry for hazmat transports	30 days/month	25 days/month	15 days/month
Noise level	73 dBa	80 dBa	68 dBa
Altered housing cost per month	Increase with 120 SEK/month	Increase with 30 SEK/month	Unaltered

6.3 Transportation configurations of hazardous materials using exposure as an attribute.

Consider the case of choosing between different transport configurations of hazardous materials (hazmats). Suggested transport configurations are assumed to differ with respect to the amount of exposure to hazmat that people living nearby experience. The various degrees of exposure are assumed to be described by the combination of the amount of hazmat transported, i.e. the number of wagons with hazmat per day, and the degree of dangerousness of the transported good. The dangerousness of the good transported today is assumed to have a dangerousness of class 2, class 1 is assumed to be less dangerous and class 3 more dangerous.



The configurations are also assumed to differ with respect to how many days per month these transports are carried out. The level of exposure and the number of days with hazmat is assumed to affect you worry for these transports. The total time that you are worrying about hazmat transports are assumed to be measured as number of days per month. Furthermore, different transport configurations may use different types of wagons resulting in different levels of noise. Finally, changes in the configuration of the transports may be argued to influence the value of estates nearby the transport route resulting in an altered housing cost for households due to an altered real estate tax.

The transport configurations will be described by the following attributes:

- The exposure to hazardous materials.
- Total number of days per month that you do not worry about transports of hazmat.
- Altered household cost per month.
- Noise level.

An example of a choice set with two different transport configurations and the situation today can be as follows:

Attribute	**Transport configuration 1**	**Transport configuration 2**	**Situation of today**
Exposure to hazmat	High	Low	Medium
Total number of days per month without worry for hazmat transports	30 days/month	25 days/month	15 days/month
Noise level	73 dBa	80 dBa	68 dBa
Altered housing cost per month	Increase with 120 SEK/month	Increase with 30 SEK/month	Unaltered

6.4 A new safety device for cars

Now consider the following situation of choosing between two different configurations of a new safety device for cars. This example is assumed to be constructed, in contrast to the preceding ones, as generic i.e. there is no "brand effect" connected to the options to choose between. Each car safety description is (only) defined by the following attributes.

- The risk of dying in a car accident during the coming year with unchanged driving miles
- The number of fear days experienced when driving
- The additional probability for burglary in your car due to the new valuable (and transferable) device
- Cost for the device per year

An example of a choice set with two descriptions A and B and the possibility of non-buying

Attribute	**Car safety device A**	**Car safety device B**	**No new safety device**
Risk of dying in a car accident the following year	1 in 100 000	3 in 100 000	5 in 100 000
Total number of driving days per year with fear	10 days	190 days	250 days
Additional probability of burglary	high	high	none
Cost per year, SEK	5 000	1 000	none

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