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Recent Valuation Research on Environmental and Human Health Impacts linked to Harmful Chemicals

OECD Workshop on Socioeconomic Impact Assessment of Chemicals Management: July 6 – 8, 2016

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CHEMICALS MANAGEMENT PLAN

PLAN DE GESTION DES PRODUITS CHIMIQUES

Canada

Outline

- Challenges for CBA and the role of valuation
- Recent health valuation projects
- ECCC-HC Valuation Project
- Water Quality Valuation

Typical Health & Environmental Benefits Analysis

- Goal usually to:
  - Identify impacts of regulation.
  - Measure impacts of regulation in physical terms.
  - Quantify the economic impact of physical changes using WTP.
- Well established process, highly defensible, used extensively for many scenario (i.e., air pollution).
- Not always possible for chemical management.

A Key Challenge for Chemical CBAs

- We often know that chemical X is bad for people.
- But we don't know just how bad it is.
- We expect regulation to reduce risks.
- But we can't measure or predict how much the regulation will reduce risks.
- Makes it very hard to quantify the physical impacts of the regulation.
- Without a measurable physical impact, what good does valuation do?

Comparing Air and Chemicals

Analytical element	Dimethyl Sulfate	PM2.5 from cars & trucks
Quantification of health risk	Could be a potential health risk, based on tox studies of rodents.	DRFs derived from extensive epidemiological work
Baseline exposure	Very limited	Extensive national monitoring & satellite surveillance
Predicting response to regulation	Unknown	Extensive stakeholder consultation plus a detailed macro economic model
Predicting changes in exposure	Unknown	National emissions monitoring and detailed atmospheric dispersion modelling
Quantification of physical impacts	Not possible	1,400 deaths prevented
Economic valuation	No physical impacts on which to base values	$7.2 billion in benefits

So what to do?

- CBA requires benefits be valued.
- But how to derive values when physical impacts of regulation unclear?
- Or why bother?
- Economic values generally based on WTP. Which requires a good or service that people care about.
- Scientific evidence may exist, but not always a clear link to things that people value.

One Approach: Do valuation where the science is strong

- Scientists measure what they can.
- Then economists try to value it.
- Valuation will be difficult if there is no clear link to something the general public understands and cares about.
- Try to use it in CBA, with various assumptions and caveats.

An Alternative: Valuation now, fill in the science later

- Estimate WTP for some meaningful good or service people value.
- Then do the CBA but with some of the science missing.
- Discuss whether it is likely benefits exceed costs.
- Example:
  - Chemical X is known to cause birth defects.
  - Estimate WTP to avoid birth defects ($130,000).
  - Estimate cost of regulation ($13 million).
  - As long as the regulation can prevent at least 100 birth defects, the benefits of the regulation will exceed costs.
  - Talk to scientists and ask them how likely they think it is that the regulation could prevent 100 birth defects.

Some recent WTP valuation studies

- WTP to avoid a reduction in children's IQ, caused by exposure to lead.
- WTP to increase fertility and lower the risk of birth defects and low birthweight
- WTP of parents to reduce children's mortality risks.
- WTP to avoid assorted negative effects associated with chemicals.
- In some cases, we have tried to value things where the scientific link is clear, even though the good may be hard for an average person to value / associate with.
- In other cases, we've estimated WTP for easily understood outcomes, even though the science is not yet 100% there.

Selected WTP estimates from recent work

- VERHI Children's health valuation (Alberini & Scasny):
  - Parental WTP to reduce risks to children is 25% to 40% higher than WTP to reduce risks to adults.
  - Child "premium" depends on cause of death.
- Fertility and birth outcomes (Scasny):
  - Increased fertility WTP of $75,000 per pregnancy.
  - $130,000 to avoid minor/cosmetic birth defects
  - $1 to $2 million to avoid major birth defects
  - $250,000 - $400,000 to avoid very low birthweight
- Lead & IQ valuation (Industrial Economics):
  - $3,800 to avoid a 1 point drop in IQ
  - $7,200 to avoid a hyper active child

ECCC-HC Valuation Project

- An Environment and Climate Change Canada (ECCC) – Health Canada (HC) collaborative research and analysis project to:
  - enhance internal capacity to conduct high quality cost benefit analysis,
  - enhance evidence-based decision making and
  - address an existing quantitative analysis gap.
- Objective: develop and implement a stated preference survey to elicit primary data on Canadians' willingness to pay to reduce risks of harm to the environmental and human health from toxic chemicals.
- Study findings to be used in benefits transfer when conducting cost benefit analysis, and to inform risk management actions on toxic chemicals.
- Regulatory and program context
  - Canadian Environmental Protection Act (1999); Other enabling legislation
  - Chemicals Management Plan
- Research team – Industrial Economics Inc. - Henry Roman, Robert Paterson, Michael Welsh, Nora Scherer, Jonathan Bressler, Spencer Shonio; Expert Advisors: James Hammitt and Barbara Kanninen; Survey implementation - Ipsos Reid

The Conceptual Framework

- Choice modeling identified for estimating the value Canadians place on reducing risks of harm to the environment and human health from toxic chemicals, given
  - Chemicals Management Plan (CMP) complexity with many substances and planned actions pre- and post 2020
  - Many attributes and potential impacts. CMP provides a comprehensive approach to assess and manage chemical risks
  - Canadian Environmental Protection Act provisions for chemical risk management

- Incorporates :
  - A consumer (user) choice approach to allow estimation of the marginal willingness to pay to reduce adverse environmental and human health risks linked to harmful chemicals at any stage along the life cycle.
  - Framing a consumer product containing harmful chemicals that may cause damage to the environment, human health or both.
  - Not identifying specific chemicals to allow greater transferability of marginal willingness to pay estimates in benefits transfer analysis.
  - Attributes frame alternative options of commonly purchased products available to survey respondents. Options presented at increasing monthly cost to households.

Survey Design Elements

- A national representative stated preference survey incorporating the following:
  - Questionnaire development using 13 focus groups, with Aboriginal population participants.
  - Online English and French web-based delivery of the pilot and final surveys
  - Environmental and human health endpoints/attributes
    - Persistence
    - Bioaccumulation
    - Environmental impacts (air, water, soil)
    - Toxic to non-human organisms
    - Carcinogenic to humans
    - Other potential health effects to humans (reproductive, developmental, respiratory/cardiovascular effects)
  - Differences in exposure by area of residence – six geographical regions; rural verses urban
  - Nine different willingness-to-pay estimates

Attributes and levels included

ATTRIBUTES	LEVELS
Persistence	Persistent Not persistent
Bioaccumulation	Bioaccumulates Does Not Bioaccumulate
Environmental Impacts	No Impacts Impacts Water Quality Impacts Air Quality Impacts Soil Quality
Toxic to Non-Humans	No Effects Toxic to Non-Human Organisms
Carcinogenic to Humans	Not Carcinogenic Carcinogenic
Other Potential Health Effects on Humans	No Effects Respiratory/Cardiovascular Effects Reproductive Effects Developmental Effects
Additional Cost per Month	$0, $5, $30, $60, $90, $120, $150

Choice questions

Please consider the current and alternative products option and indicate which option you would purchase. Please keep in mind that the options are identical in all other aspects except potential environmental and health risks and monthly cost to your household.

	Current Products with Chemical A ▼	Alternative Products Option ▼
Persistence		
Bioaccumulation		
Environmental Impacts		
Toxic to Non-Human Organisms		
Carcinogenic to Humans		
Other Potential Health Effects on Humans		
Additional Cost Each Month		

	Current Products with Chemical A ▼	Alternative Products Option ▼
Persistence	*Persistent*	*Not Persistent*
Bioaccumulation	*Bioaccumulates*	*Does Not Bioaccumulate*
Environmental Impacts	*No Impacts*	*No Impacts*
Toxic to Non-Human Organisms	*No effects*	*No Effects*
Carcinogenic to Humans	*Carcinogenic*	*Not Carcinogenic*
Other Potential Health Effects on Humans	*No Effects*	*No Effects*
Additional Cost Each Month	*$0*	*$90*

Which option would you purchase? (CIRCLE ONE NUMBER)

1. I would continue to purchase currently available products
2. I would purchase alternative products

Final Questionnaire Elements

- Pre-tested with 300 completed questionnaires; test model highly significant with expected outcomes. No changes to final questionnaire.

Section	Purpose
1. Introductory questions	Acclimatised respondent to survey topic and question formats
2. Attribute definitions	Presented definitions of each attribute in clear, non-technical language
3. Choice scenario	Described choice scenario and presented a series of choice questions (choice cards)
4. Follow-up questions	Debriefing questions – basic demographic information and respondent's views (potential bias)

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Survey Implementation

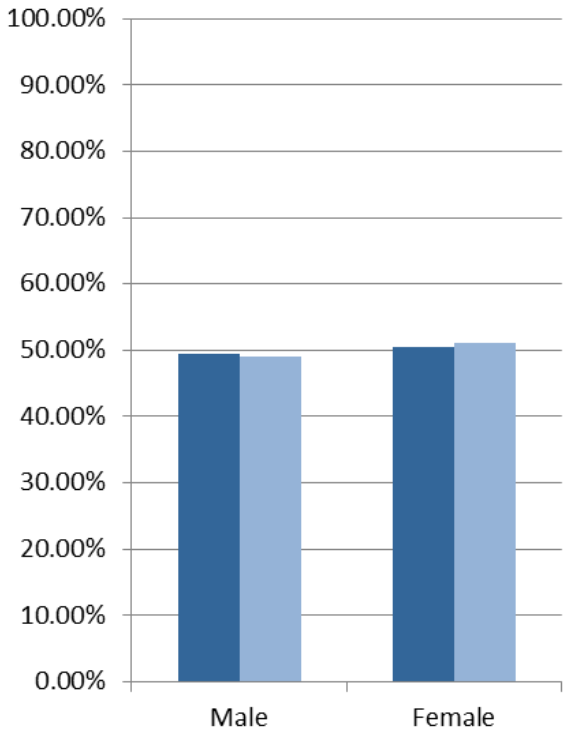
- Questionnaire administered by Ipsos Reid July 7, 2015 through July 17, 2015
- Survey implementation parameters
  - 3,000 completed questionnaires, representative of Canadian population
  - Minimum 500 per geographic area (urban/rural; provincial; Prairies; Atlantic)
  - Two-option card, 40 unique choice cards, seven attributes per choice card
  - Vary cost across choice options, and vary three of remaining six attributes
  - Five choice questions per respondent (randomly assigned without replacement from 40 options)
- Final dataset: 3,174 completed questionnaires used in analysis

FINAL DISPOSITION	NUMBER (%)
Invited, no action	51,452 (84.0%)
Screened out of survey	5,824 (9.5%)
Got to consent screen, did not go further than consent screen	333 (0.5%)
Initiated survey (got past consent screen), did not complete	529 (0.9%)
Completed	3,303[1] (5.0%)
Total	61,441 (100%)

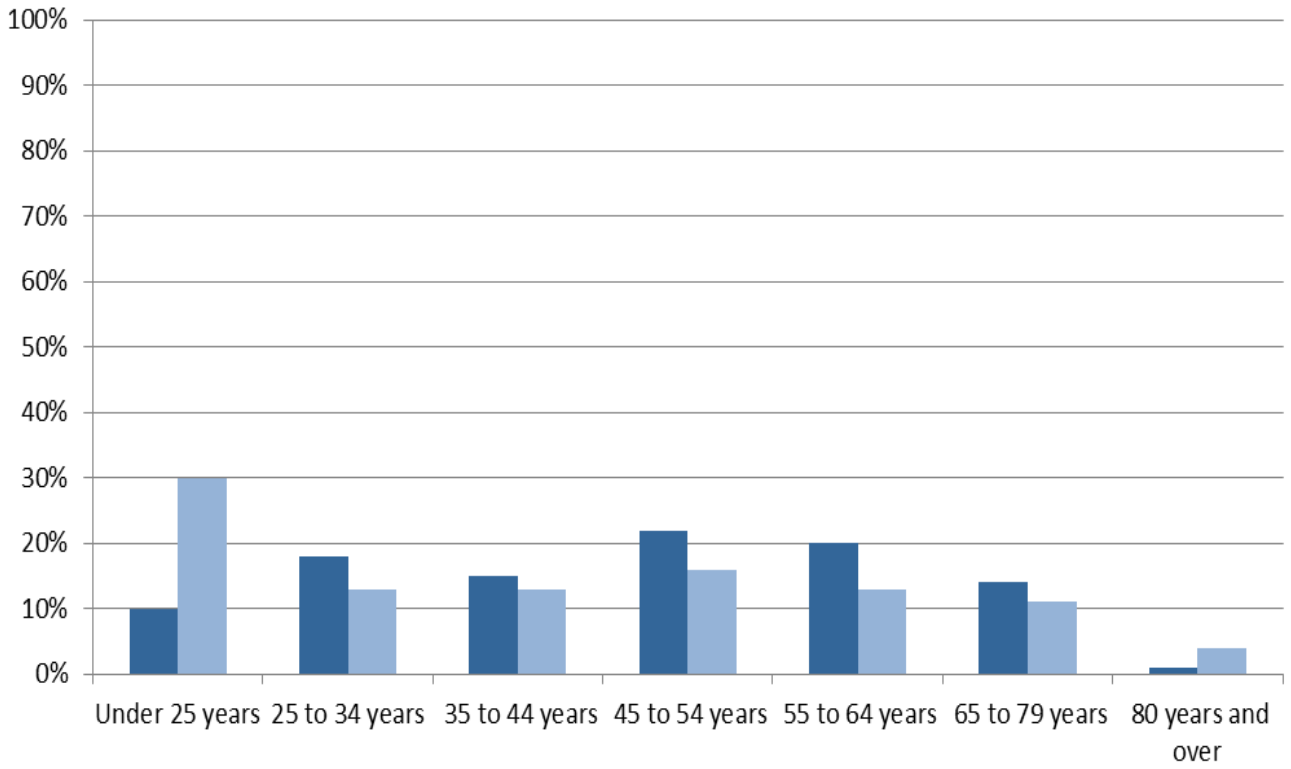
Notes: 1) 129 responses were flagged as "fraudulent" by Ipsos, or were removed because of filled quotas. 3,174 responses were used in the analysis (see Chapter 3 for full discussion).

Characteristics of the panel

Gender

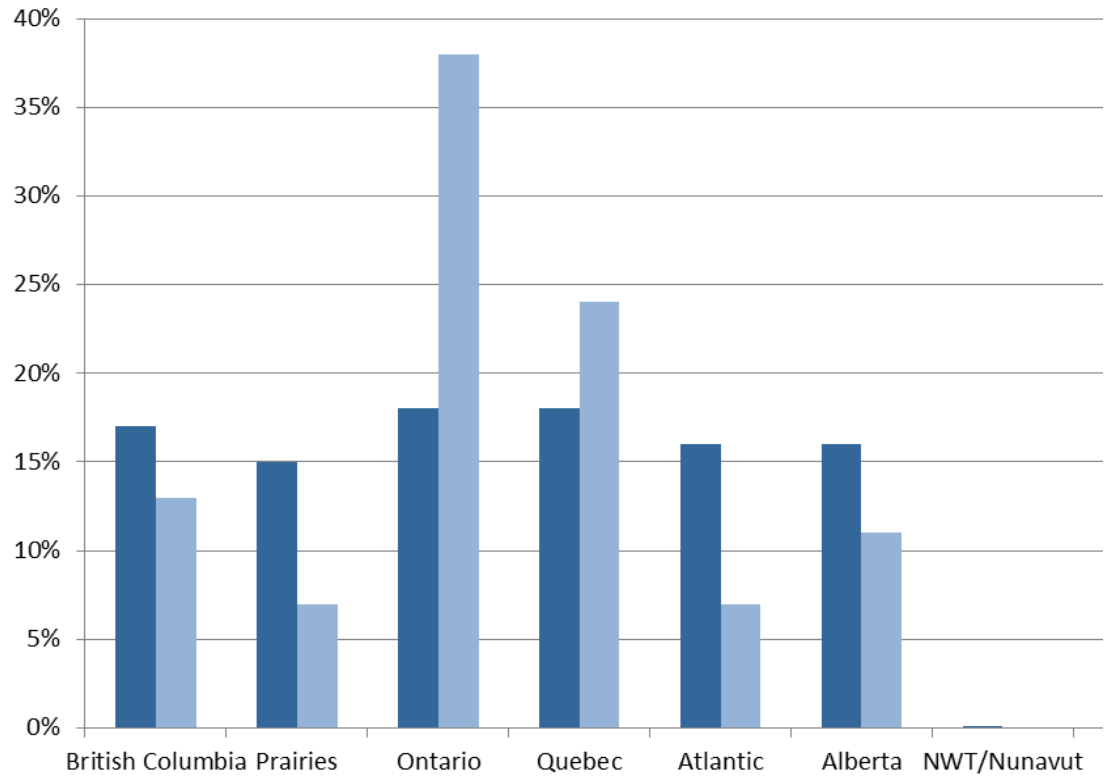


Age

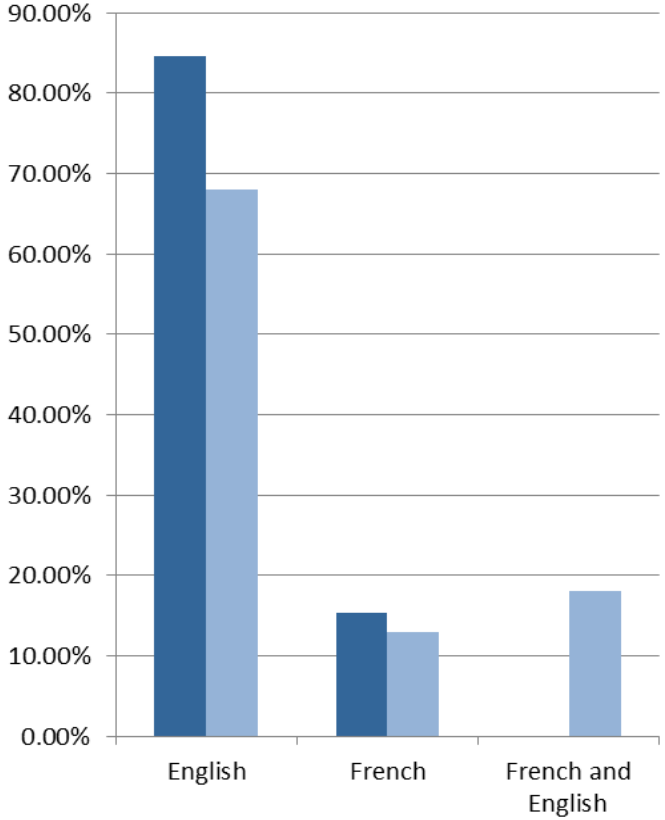


Characteristics cont.

Geographic Region



Language



Respondents

Canadian Population

Summary of Survey Responses

- **Section 1 – Introductory Questions:**- Gathered information on respondents' familiarity with chemicals
  - 86% reported information provided in survey about chemicals was similar to what they previously knew about chemicals
  - 47% had taken measures to avoid use of, or exposure to chemicals they believe are harmful
  - 33% had heard of, or experienced instances where chemicals were released to the environment in their vicinity, they believed were harmful

- **Section 2 – Attribute questions:**- Asked about respondent's level of concern about each attribute
  - Majority reported being very concerned about attributes in the questionnaire
  - <3% reported "not concerned" about any of the attributes
  - 70% were aware of attributes before taking the survey

Summary of Survey Responses

- **Section 3 – Choice Scenario Questions:-** Asked how potential risks from chemicals would affect purchasing decisions (including choice scenarios)
  - Five choice scenarios. Attribute and levels for each scenario (randomly assigned)
  - 62% would purchase alternative products
  - 71% reported no other factors (besides the seven listed) influenced choice

QUESTION	FREQUENCY (%)	
	I WOULD CONTINUE TO PURCHASE CURRENTLY AVAILABLE PRODUCTS	I WOULD PURCHASE ALTERNATIVE PRODUCTS
Please consider the current and alternative product options and indicate which option you would purchase. Please keep in mind that the options are identical in all other aspects except potential environmental and health risks and monthly cost to your household. Which option would you purchase?		
Scenario 1	1,205 (36.5)	2,098 (63.5)
Scenario 2	1,269 (38.4)	2,034 (61.6)
Scenario 3	1,256 (38.0)	2,047 (62.0)
Scenario 4	1,275 (38.6)	2 028 (61.4)
Scenario 5	1,259 (38.1)	2,044 (61.9)
Average	1,253 (37.9)	2,050 (62.1)

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Results of Analysis

- The relative magnitude of the coefficient shows the relative importance of the attribute in the probability of choosing an alternative
- The model is highly significant
- All coefficients are significant and of the expected signs

Number of obs = 31740						
LR chi2(11) = 2804.36						
Log likelihood = -9598.68						
Prob > chi2 = 0.0000						
	Coef.	Std. Err.	Z	P>|Z|	[95% Conf. Interval]	
CostPerMonth	-0.01516	0.00045	-33.7	0	-0.01604	-0.01428
Persistence	-0.437	0.035795	-12.21	0	-0.50716	-0.36684
Bioaccumulation	-0.38895	0.033183	-11.72	0	-0.45398	-0.32391
WaterQuality	-0.5642	0.051223	-11.01	0	-0.6646	-0.4638
AirQuality	-0.54195	0.044437	-12.2	0	-0.62904	-0.45485
SoilQuality	-0.56713	0.065653	-8.64	0	-0.69581	-0.43846
Toxic_NonHumans	-0.62232	0.031361	-19.84	0	-0.68378	-0.56085
Carcinogenic	-0.7462	0.032509	-22.95	0	-0.80992	-0.68249
RespCardio	-0.40372	0.050566	-7.98	0	-0.50282	-0.30461
Reproductive	-0.35972	0.044033	-8.17	0	-0.44602	-0.27342
Developmental	-0.26581	0.052699	-5.04	0	-0.3691	-0.16253

Estimated Willingness to Pay – Main Effects Model

	COEFFICIENT	IMPLIED WTP
Carcinogenic	-0.7462	$49.23
Toxic_NonHumans	-0.62232	$41.06
SoilQuality	-0.56713	$37.42
WaterQuality	-0.5642	$37.22
AirQuality	-0.54195	$35.76
Persistence	-0.437	$28.83
RespCardio	-0.40372	$26.64
Bioaccumulation	-0.38895	$25.66
Reproductive	-0.35972	$23.73
Developmental	-0.26581	$17.54
CostPerMonth	-0.01516	N/A

Estimated Willingness to Pay by Residence

	URBAN WTP	RANK	RURAL WTP	RANK	RURAL/ URBAN RATIO
Carcinogenic	$51.13	1	$38.53	3	0.75
Toxic_NonHumans	$44.12	2	$24.12	10	0.55
WaterQuality	$37.72	3	$34.24	5	0.91
SoilQuality	$36.84	4	$39.70	2	1.08
AirQuality	$34.80	5	$41.37	1	1.19
Persistence	$28.08	6	$33.10	6	1.18
RespCardio*	$26.77	7	$25.57	8	0.96
Bioaccumulation	$23.96	8	$35.10	4	1.46
Reproductive	$23.14	9	$26.60	7	1.15
Developmental*	$16.13	10	$25.08	9	1.55

Urban: Population >10,000; Number of Observations = 27,590
Rural: Population < 10,000; Number of Observations = 4,150; *insignificant estimates

Study Observations

- This study tells us that:
  - Canadians have significant WTP for elimination of harmful attributes in chemicals linked to consumer products
  - WTP is positive for all attributes included – both environmental and human health endpoints
  - WTP is highest for reducing carcinogenic effects from chemicals, followed by toxic-to-nonhuman organisms; lowest for reducing developmental effects
  - WTP differs among rural and urban areas. Rural dwellers' are WTP more to eliminate air and soil quality than carcinogenic effects, and are least WTP to eliminate chemicals toxic to non-human organisms.
  - There are no differences across geographic regions. Some differences based on income.
- What this could be used for:
  - Prioritizing the regulatory actions for different types of chemicals
  - Communicating the benefits of Canada's Chemicals Management Program
- How the results should not be used:
  - The WTP for elimination of all negative attributes of chemicals is not the sum of the individual WTPs
- Next Steps – further analysis in order for results to be useable in CBAs

Water Quality Valuation

(1) Proposed Regulation/Policy/Project
e.g. mining related, limiting effluent of "X"

"Change": difference between policy scenario and business-as-usual scenario. In CBA we monetize benefits resulting from projected incremental water quality improvements.

Changes in water quality parameter values are unknown

Otherwise

(2) Scientific Water Quality Modelling

(3) Changes in water quality parameter values

Water Quality Valuation Model (WQVM)

(4) Change in water quality ladder value

(5) Benefits in terms of WTP (Benefit Transfer)

(6) Economic Analysis for regulations, environmental assessment, enforcement, etc.

Discussion and Questions

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Additional Information

Product Examples

Final list of examples of consumer products that contain chemicals, or for which chemicals are used in their production or are released during disposal:

- Personal care products (e.g., shampoo and cosmetics)
- Cleaners (e.g., detergents, bleach, and dry cleaning chemicals)
- Paper products (e.g., paper, toilet paper and napkins)
- Plastic products (e.g., bottles)
- Batteries
- Lights (e.g., bulbs, fluorescent tubes)
- Electronics (e.g., radios, computers and music players)
- Fertilizers and pesticides
- Automotive products (e.g., gasoline, motor oil, antifreeze and tires)
- Construction materials (e.g., paint and insulation)

Analysis of Choices

Choices Modeled Using A Conditional Logit Model

$$U_{ij} = \beta_y(y_i - C_j) + \sum_{k=1}^{K} \beta_k X_{jk} + \varepsilon_{ij}$$

The probability of choosing bundle j over bundle k is the probability that $U_{ij} > U_{ik}$.

Where C_j = \$0 for current products

X_{jk} = 0 for all alternative products

$$U_{ij} - U_{ik} = \beta_y(y_i - C_j - (y_i - Ck)) + \sum_{k=1}^{K} \beta_k X_{jk} + \varepsilon_{ij}$$

$$U_{ij} - U_{ik} = \beta_y(C_k) + \sum_{k=1}^{K} \beta_k X_{jk} + \varepsilon_{ij}$$

This implies that what matters is the difference in attributes and the difference in cost of the two alternatives.

Interpretation of coefficients

- The sign of the coefficient shows how the probability of selection changes with that variable

  - All non-cost attributes are defined as the presence (1) or absence (0) of that attribute
    - The presence of a possibly adverse environmental/health outcome should decrease the probability of choosing a product with that attribute
    - We would expect the coefficients on non-cost attributes to be negative

  - All else equal, a respondent should be less likely to choose a product with a higher cost
    - We would expect the coefficient on additional cost to be negative

Estimating Willingness to Pay

- The coefficient on an attribute shows how “utility” changes with respect to a unit change in that attribute
  - Think of this as MU/Attribute (marginal utility for that attribute)

- The coefficient on cost tells us how “utility” changes with a $1 change in price
  - Think of this as MU/$ (marginal utility of income)

- Dividing the coefficient for an attribute by the coefficient for the cost
  - [MU/Attribute]/[MU/$] = $/Attribute
  - In this study this is the Willingness to Pay to avoid the presence of that attribute in consumer products

Estimated Willingness to Pay by Income

	BELOW $75,000	ABOVE $75,000	RATIO
Carcinogenic	$43.62	$55.58	1.27
Toxic_NonHumans	$39.97	$45.97	1.15
SoilQuality	$33.25	$40.71	1.22
WaterQuality	$35.68	$38.25	1.07
AirQuality	$38.02	$34.47	0.91
Persistence	$28.38	$27.90	0.98
RespCardio	$28.12	$24.41	0.87
Bioaccumulation	$27.16	$23.40	0.86
Reproductive	$21.18	$25.71	1.21
Developmental	$16.64	$23.16	1.39

Number of Observations for Household Income Less than CDN$ 75,000 = 15,880
Number of Observations for Household Income Greater than CDN$ 75,000 = 12,000