The Contingent Valuation Method:

a tool to assess « non-market goods' » values

M2R Applied Economics – December 2015

Objectives of the class:

- To understand the issues linked to the valuation of « non-market goods »
- To present some methodologies allowing to undertake operational research (Master thesis)
- To discuss two articles using the contingent valuation method

Selected bibliography:

- Haab et McConnel (2002). *Valuing Environmental and Natural Resources*, Edward Elgar.
- Mitchell et Carson (1989). *Using Surveys to Value Public Goods*, Resources for the Future, Washington DC.
- Arrow et al (1993). « Report of the NOOA Panel on Contingent Valuation », *Federal Register*.

- See also:

http://www.ecologie.gouv.fr

Outline of the talk:

1) Theoretical foundations

2)The Contingent Valuation Method (CVM)

3) Transport Costs and Hedonic Prices Methods

4) Discussion on two papers valuing:

- **The damages of the Erika's sinking**
- **The crowding costs in Paris subways**

Theoretical foundations:

- Since A.C. Pigou (1920), it is well recognized that the free market allocation can produce **sub-optimal equilibriums**:

Public goods

Goods generating externalities

- These cases justify « pareto improving » actions and **public interventions** (« *to internalize the externalities* », to produce the sufficient quantity of public goods) : **maximizing the social welfare**

However:

- One needs first to:
  - **Assess the benefits** of the public intervention
  - Insure that these **benefits do overpass the costs** of the intervention

- Imperative needs of **measurement tools**

- **Legal obligations** (Clean Air Act, Oil Pollution Act, LOTI) and old practices (US Army)

Two main options:

- **Behavioral methods** (*revealed preferences*):
  - Transport Costs
  - Hedonic Prices
- **Direct methods** (*stated preferences*):
  - The CVM
- Nb: Which method is the most relevant?
  Can we trust stated preferences?

Analytical support:

- (Micro) **consumers' theory,** we focus on the « non-market good » q (=environment, transport quality...)

- We can use either the **undirect utility function**:

$$V(p, q, y) = max_{(x)} \{u(x, q)/ p^*x \leq y\}$$

$$x(p, q, y) = - V_p(p, q, y)/ V_y(p, q, y) \quad (Roy' lemma)$$

- Or the minimal **expenditures function**:

$$m(p,q, u) = min_{(x)} \{p^*x/ u(x, q) \leq u\}$$

$$x_u(p, q, u) = m_p(p, q, u)$$

« Non-market goods » valuation:

- Either you calculate the **change in the undirect utility function** (when q*>q):

$$V(p, q^*, y - WTP) = V(p, q, y)$$

Or $$V(p, q, y + WTA) = V(p, q^*, y)$$

- You can also calculate the **change in the expenditures function** (when *u*>u)*:

$$WTP = m(p, q, u) - m(p, q^*, u)$$

Or $$WTA = m(p, q, u^*) - m(p, q^*, u^*)$$

- In both cases, **the income should vary to make the individuals undifferent between the states of nature**

Which income variation?

- It depends on the comparison of the utility level *ex ante/ ex post* :

	Equivalent variation	Compensatory variation
Utility increase	WTA	WTP
Utility decrease	WTP	WTA

WTP and WTA generally differ with the same method (but also between the methods !)

Most of the time, **we rely on the WTP**

The Contingent Valuation Method

The CVM:

- **The most recent practice (70') and the most used by applied economists**
- Numerous applications in Environmental Economics (Exxon Valdez in 1989, air/water quality), in Transportation Economics (time values), but also in Marketing
- Conversely to behavioral methods, **the CVM allows to study the « non-use » values** (altruist, inheritage, option): the ice floe, amazonian forest, animal species…

General framework:

- You ask directly the individuals how much they value the « non-market good »?
- You present some **hypothetical scenarios** with an **improved furniture** of the « non-market good » (if $q^* > q$) that individuals could benefit in exchange of paying a **bid** (T)
- **If people accept the bid**, you deduce:

$$V(p, q^*, y - T) > V(p, q, y)$$

Two main dimensions:

- **Draft and collection of the survey:**
  - Which population is relevant?
  - How to collect the answers?
    (F2F, internet, phone…)
  - How to describe the hypothetical scenarios?
    (words, visual supports)

- **Modelling of individual choices and empirical analysis of the answers :**
  - Utility/WTP specifications
  - Econometrics (discrete choice)
  - Extension of results to the whole population
  - Policy implications

Draft and collection:

- The most important thing is **to describe accurately the hypothetical scenarios**:
  - What is the « non-market good » studied?
  - How will it be furnished?
  - What are the payment conditions?

- The modelizator should obtain some individual characteristics (or at the households level) to control for specific tastes

- Because we study intentions, we have to **check if individuals' statements do inform us on their true preferences** (not always the case)

- We have also to limit **the biases** (and to identify the « true zeros »)

Main biases:

- **Hypothetical**: individuals do not understand the hypothetical scenarios

- **Inclusion**: individuals do not fully understand what is the « non-market good » studied

- **Strategic**: individuals manipulate their answers in order to avoid supporting the cost of their choices (« free-riding »)

The valuation question:

- **Open question**: how much are you willing to pay in order to…. ?
- **Bounded question (or double bounded)**: initial (random if possible) bid (+ second bid depending on the first answer, i.e. higher if agreement)
- **Bids system**: same principle untill the first negative answer
- **Payment cards**: you show several values and the individuals chose the one they prefer

- NB: Most of the time, the bounded question is preferred because it « looks like » everyday decisions

Payment conditions:

- Many possibilities concerning the « **payment vehicle** »: annual/monthly taxes, access fees, gift, increased transport costs

- How will be taken the decision of delivering the hypothetical scenario? Frequent use of **referendums** (if 50% of the people agree, then…)

- The final choice largely depends on the **trade-off between realism and refusal's risk**, but also on the « payment vehicle » used

Structural specification:

- **Random Utility** (MacFadden, 1974) : $\boldsymbol{V_{ij}=u_j(Y_i, Z_i, e_{ij})}$

  (Zi represents the individual characteristics,

  as those of the « no- market good », with j=state of nature)

- Several structural forms are possible:
  - linear : $u_j(Y_i, Z_i, e_{ij}) = a_i Z_i + b_i Y_i + e_{ij}$
  - log-linear : $u_j(Y_i, Z_i, e_{ij}) = a_i Z_i + b_i ln Y_i + e_{ij}$
  - Box-cox : $u_j(Y_i, Z_i, e_{ij}) = a_i Z_i + b_i Y_i(\lambda) + e_{ij}$

  with : $Y_i(\lambda) = (Y_i^{\lambda} - 1)/ \lambda$

- It is also possible to estimate directly the **WTP**:

$$WTP = f(Y_i, Z_i, e_{ij})$$

Simple linear specification (1):

(with a bounded question)

- Utility with the hypothetical scenario :

$$u_1(Y_i - T, Z_i) = a_1 Z_i + b_1(Y_i - T)$$

- Utility with the « *statu quo* » :

$$u_0(Y_i, Z_i) = a_0 Z_i + b_0 Y_i$$

- **Change in the deterministic utility** :

$$u_1 - u_0 = (a_1 - a_0) Z_i + b_1(Y_i - T) - b_0 Y_i$$

- If U_{jy}=k in the two states of nature, then $b_1 = b_0$:

$$\mathbf{Pr(yes_j) = Pr(aZ_i - bT + e_j > 0)}$$

Simple linear specification (2):

$$\boldsymbol{Pr(yes_j)} = Pr(aZ_i - bT + e_j > 0) = Pr(-(aZ_i - bT) < e_j)$$

$$= 1 - Pr(-(aZ_i - bT) > e_j) = \boldsymbol{Pr(e_j < aZ_i - bT)}$$

- After transformation of the residual e:
  - **Probit model** (e follows a Standard Norma distribution function)
  - **Logit model** (Logistic)
- Easy to implement with softwares (Stata)
- We compute the **average and median WTP** (and look at the distribution + extrapolate to the population, accounting for the individual characteristics)

To go further (1):

- If you reject the assumption U_{jy}=k, you can use the log-linear model:

$$(\delta u_j / \delta Y_i) = (b / Y_i)$$

$$\mathbf{Pr(yes_j) = Pr(b\ln((Y_i - T)/ Y_i) + aZ_i > - e_i)}$$

- The Box-cox transformation is even more flexible:

$$(\delta u_j / \delta Y_i) = bY_i^{\lambda-1}$$

$$\mathbf{Pr(yes_j) = Pr(b((Y_i - T) / Y_i)^{\lambda} - Y_i^{\lambda})/ \lambda) + aZ_i > - e_i)}$$

- NB: Stata provides packages to estimate the Box-cox

To go further (2):

- **Double bounded models should produce more precise WTP estimates** (thanks to the second question, the intervals of values are reduced)
- **Inconsistencies are observed**: the average WTP estimated with the second answers is always lower and/or does not belong to the confindence interval of first answers' estimates
- Recent models allow to test (and control for) the **presence of « first bid biases »**
- **NB: Is the CVM still relevant for policy purposes if answers are not rational?**

« First bid biases »:

- **Anchoring effect:** the second answer is influenced by the first bid

$$WTP_2=(1-\gamma)WTP_1 + \gamma T_1$$

- **Shift effect:** WTP_1 and WTP_2 structurally differ (individuals feel that interviewers steal them)

$$WTP_2= WTP_1 + \alpha \qquad (\alpha <0)$$

- **Framing effect**: individuals who accept the first bid are more prone to reject the second one because of risk adversion (w.r.t. the « reference point », the losses are over-valued): work only with the individuals rejecting the first offer

Transport Costs Method

Valuing the Environmental Damages of the Erika's Sinking

(2006)

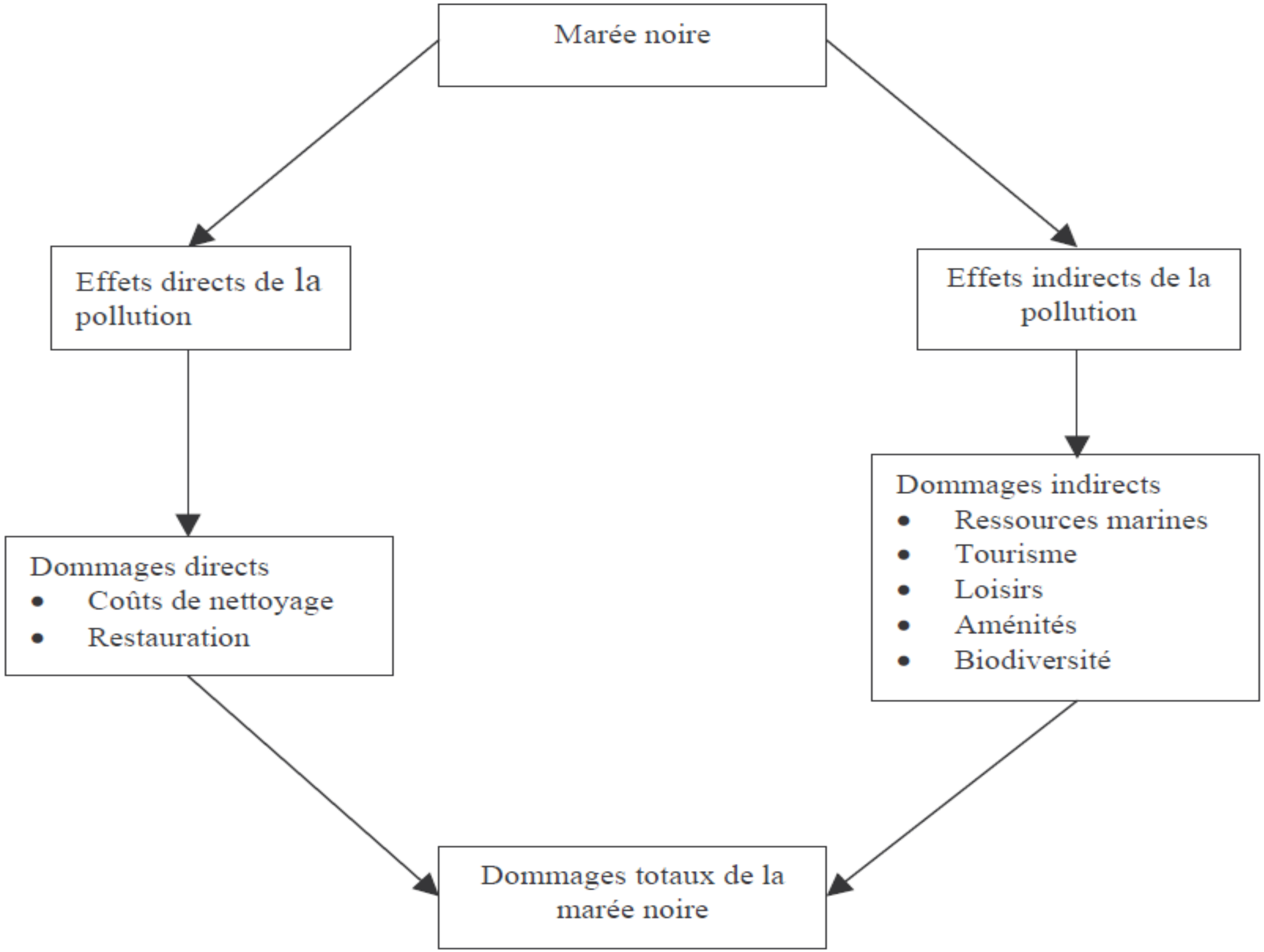
François Bonnieux (INRA)

Context:

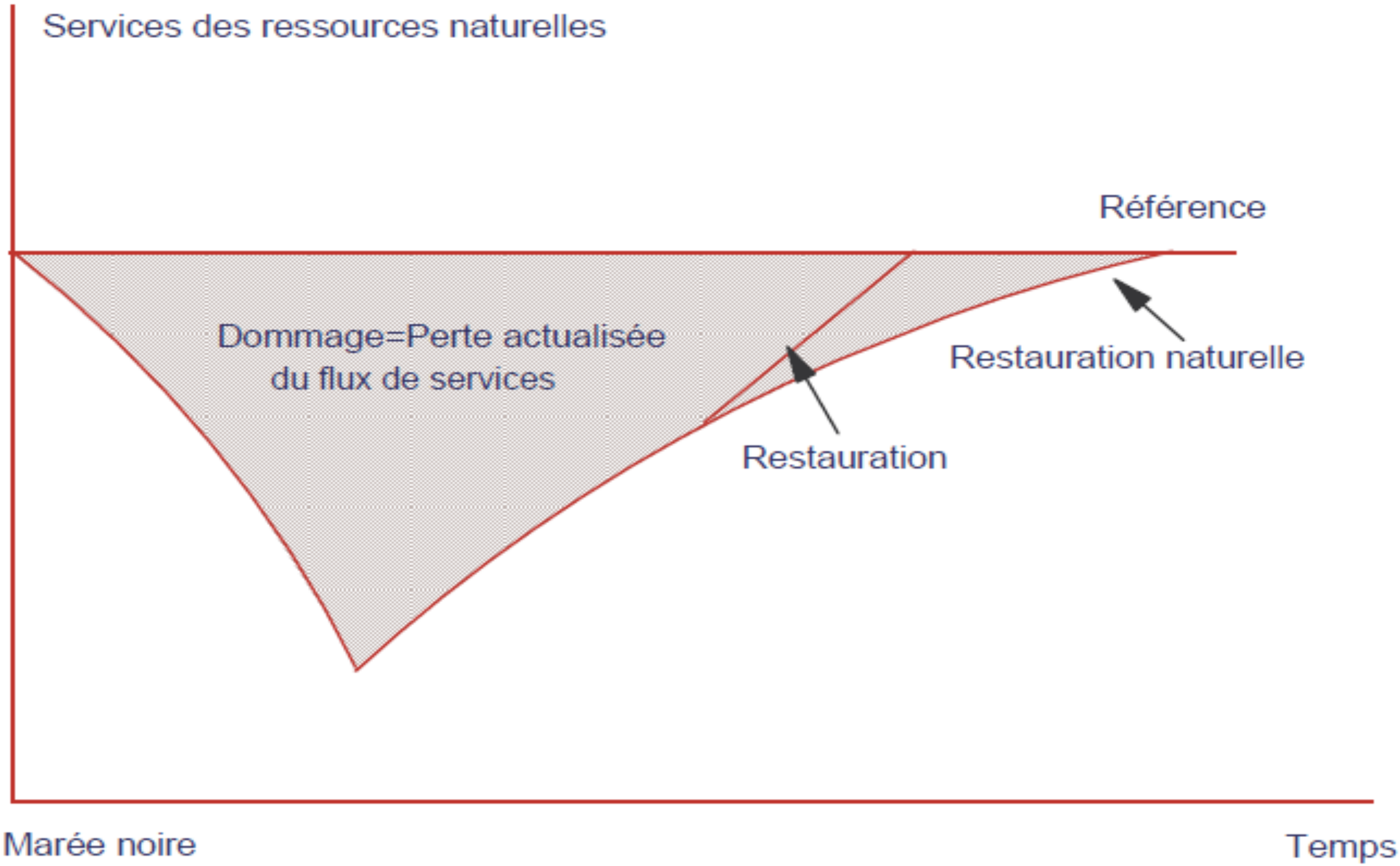
- December 16th 1999: **Sinking of the Erika** tanker in the Atlantic ocean
- **Oil spill** on the British and Atlantic coasts
- **Environmental damages** (and real shock for the public opinion)
- In this article: **valuation of the different costs arisen from the Erika's sinking**

- NB: Similar accidents in the past (Amoco Cadiz, 1979 and Exxon Valdez, 1989)

What are the damages?



The dynamic of the damages:



The three kinds of damages:

- Those directly **valued by the market**: sea products (fishes, shellfishes) and tourism
- Those not valued by the market but **revealed by inhabitants' behaviors**: leisure activities (coast and sea fishing notably)
  - Travel costs method + CVM
- Those non valued by the market, nor the inhabitants' behaviors (**non-use values**): **animal species, natural amenities**
  - Contingent valuation method
  - « Trophic channels », costs of restoration

Usage damages (1):

- Basic idea: **because of the oil spill, some individuals stop fishing on the coasts** (or they change of fishing sites)
- 4 geographical areas are considered: 3 directly on the coasts + Nantes agglomeration
- Face-to-face survey + phone survey: 692 individuals
- 1/3 of the concerned population fish on the coasts
- **The frequency of fishing decreases with the distance to the coasts**:

Fréquentation	Au moins une fois par semaine	Plusieurs fois par mois	Une fois par mois	Marées d'équinoxe	Total
Littoral	8,8	22,6	27,1	41,6	100,0
Nantes	1,6	9,2	26,2	63,0	100,0

Usage damages (2):

- Without the Erika's sinking, 2.8 M visits of the coasts would have been realized for fishing

	Population totale	Fréquentation de référence	Abandon de la pêche à pied		Poursuite de la pêche à pied	
			Sans remplacement	Avec remplacement	Même site	Autre site
Zone 1 (Bretagne)	411	719,3	79,3	237,9	382,0	20,1
Zone 2 (Pays de la Loire)	206	533,5	124,8	374,5	32,5	1,7
Zone 3 (Pays de la Loire)	239	560,5	130,3	391,0	37,2	2,0
Zone 3 (Poitou Charentes)	118	276,7	64,3	192,9	18,5	1,0
Total littoral	974	2090,0	398,7	1196,3	470,2	24,8
Agglomération de Nantes	545	774,3	87,9	263,6	380,5	42,3
Total général	1519	2864,3	486,6	1459,9	850,7	67,1

Note. Population au recensement général de la population de 1999.

- **50% of people stopped fishing on the coasts and substitute that activity** (with walking essentially), **3% have changed of fishing sites**

Usage damages (3):

- Survey collected directly on the coast, once the people had finished to fish:

Littoral	Nord	Ouest	Sud	Total
Nombre annuel de visites	18,9	14,5	13,3	15,5
Distance du domicile au site (km)	15,3	9,9	37,5	22,6
Age (années)	49,1	46,9	54,8	50,8
Revenu mensuel (€ 2000)	1690	1440	1550	1570

- **Negative correlation distance/frequency of fishing**
- 40% of the people do not fish on their usual sites, with longer distances (28 km vs. 19 km)
- Econometrics: a **visit = 55 euros** (- effect of the distance, non linear effect of the income, fishing=inferior good)
- NB: the author does not use time values

Usage damages (4):

- **Risks of infection** (because of polluted shellfishes): each visit generates a reduced individual surplus
- **CVM and hypothetical scenarios** to assess the changes of distances travelled/fishing frequency w.r.t. high/low sanitary risks

- Results: **The WTP is lower for the « less risky » scenario (58 euros/year) than for the other one (81 euros/year)**
- The individual surplus is reduced by 7-10% respectively
- Results (semi) consistent with previous CVM applied to the water quality in France

Usage damages (5):

- For people who now walk instead of fishing, **compare the WTP of alternative activities**: 6 euros
- Finally:

	Abandon de la pêche à pied		Poursuite de la pêche à pied		Total
	Sans remplacement	Avec remplacement	Même site	Autre site	
Zone 1 (Bretagne)	4758,0	10467,6	?	120,6	15346,2
Zone 2 (Pays de la Loire)	7488,0	16478,0	?	10,2	23976,2
Zone 3 (Pays de la Loire)	7818,0	17204,0	?	12,0	25034,0
Zone 3 (Poitou Charentes)	3858,0	8487,6	?	6,0	12351,6
Total littoral	23922,0	52637,2	?	148,8	76708,0
Agglomération de Nantes	5274,0	11598,4	?	253,8	17126,2
Total général	29196,0	64235,6	?	402,6	93834,2

- **Total usage damages estimated at 93.8 M euros** (under-estimate probably), most of the losses are for the individuals who walk instead of fishing

Non-usage damages (1):

- No specific data available for the Erika' s case
- **Review of the related literature**, with a special attention given to the Exxon Valdez (in Alaska)
- The NOAA Panel had to value the damages in order to apply the **« polluter-payer » principle**
- CVM on American households, **hypothetical scenarios: two boats escorting the tankers** in order to 1) avoid any risk of sinking, 2) avoid too many oil to go into the sea
- **Project funded jointly by the Oil companies and by the US citizens** (annual taxes)

Non-usage damages (2):

- Use of double bounded questions:

Version	Valeur 1	Valeur 2	Valeur 3
A	10	30	5
B	30	60	10
C	60	120	30
D	120	250	60

- Answers:

Version	Non	Non peut-être	Oui
A	29,9	2,7	67,4
B	33,3	9,0	51,7
C	43,5	5,9	50,6
D	59,1	6,6	34,3

Paramètre	Intervalle
Médiane	26,2 – 35,1
Moyenne	85,8 – 108,5
Moyenne révisée	67,9 – 90,1

- **With the median WTP: 2.8 billions dollars**
- NB: A second survey arrived at same values

Non-usage damages (3):

- French study on the « eutrophication » of the water in the harbour of Brest: 24 euros
- The other studies on coastal waters includes recreative, option and existence values: 30-33 eu
- Finally, studies on the quality of continental waters (lakes, rivers…): lower valuations

Etude	Valeur originale	Année	Coefficient*	Valeur (€ 2005)
Composante de non-usage				
Exxon Valdez	31 $	1990	130,1	33,5
Rade de Brest	24 €	1993	120,6	28,9
Rives de la Garonne	9,6 €	1996	114,3	11,0
Lignon du Velay	9,6-16,3 €	2001	107,7	10,3-17,6
Composante de non-usage et autres composantes				
Lac de la forêt d'Orient	10-12 €	1991	126,1	12,6-15,1
Etang de Thau	30-33 €	1992	123,1	36,9
Rives de la Garonne	10-22 €	1996	114,3	11,4-25,1
Estuaire de l'Orne	30-33 €	2003	103,8	31,1-34,3
Loir	15,4-25,9 €	2004	101,8	15,7-23,4

Non-usage damages (4):

- The Exxon Valdez' case is the most similar experience, as the one of Brest: **WTP = 28.9 euros/indiv**
- We find a total loss of **91 M euros**

	Population totale (1000)	Ménages (1000)	Dommages (1000 € 2005)	Dommages (%)
Bretagne	2906	1181	34131	37,4
• Zone 1	411	167	4826	5,3
• Reste Région	2495	1014	29305	32,1
Pays de la Loire	3222	1310	37859	41,5
• Zone 2	206	84	2428	2,7
• Zone 3	239	97	2803	3,1
• Agglomération de Nantes	545	222	6416	7,0
• Reste région	2232	907	26212	28,7
Poitou Charentes	1640	667	19276	21,1
• Zone 3	118	48	1387	1,5
• Reste région	1522	619	17889	19,6
Total général	7768	3158	91266	100,0
• Total littoral pollué	974	396	11444	12,6
• Agglomération de Nantes	545	222	6416	7,0
• Total reste régions	6249	2540	73406	80,4

Dynamic of the damages:

- **The environmental consequences of the oil spill do not vanish instantaneously**
- Tourism indicators: return to the « business as usual » conditions in 2002
- Seafoods consumption (+ analysis of previous agricultural crises): at least two years
- Results: As a « conservative » assumption, the author assumes that **it will take two years before the environmental damages fully disappear**

Conclusion:

10^6 € 2005	2000	2001	Total
Pertes d'usage (pêche à pied)			
Littoral pollué	134,2	57,5	191,7
Nantes	30,0	12,9	42,9
Reste	?	?	?
Total	164,2	70,4	234,6
Pertes de non-usage			
Littoral pollué	11,5	5,7	17,2
Nantes	6,4	3,2	9,6
Reste	73,4	36,7	110,1
Total	91,3	45,6	136,9
Préjudice écologique			
Littoral pollué	145,7	63,2	208,9
Nantes	36,4	16,1	52,5
Reste	73,4	36,7	110,1
Total	255,5	116,0	371,5

- **Total damages of 371 M euros (lowest estimates):**
  - 60% for the people living close to the coasts
  - 69% for the initial year (2000)
  - 37% for the non-usage damages

Estimating Crowding Costs in Public Transport

(Work in very progress)

Martin Koning (IFSTTAR, SPLOTT)
Luke Haywood (PSE, DIW)

Urban transport policies:

- The use of **private cars** (PC) in dense areas induces major **social costs**
- To minimize these costs, economists advise to:
  - **Enhance the modal report from PC** towards other modes, notably the **public transport** (PT) system
  - **Modify the generalized cost** (GC=time+money) of PC/PT (congestion charges/subsidies for example)
  - **Value the qualitative attributes of PT** trips and promote them (= decrease in PT GC = PT attractivity)

In this article:

- We present the **contingent valuation method** (CVM) as a tool to value **subway crowding costs** (declared preferences of Paris PT users)
- We propose a **relationship between the GC of subway usage and the in vehicle passanger density** (proxy for the subway crowding)
- We highlight some **policy implications of PT congestion** (undercovered topic, especially with respect to road congestion)

The Paris case:

- Since 2001, municipal **« road diet strategy »** (-30% of the road space available for PC, see PK08):
  - 10% decrease of PC speed over 2000/07 = -24% of kms driven with PC in Paris
  - Modal report towards rail-based PT (+22/15% of kms perfomed in the Paris subway/regional trains over 2000/09)

- **The GC of PC has increased, but also the one in the rail-based PT system:**
  - The Paris subway supply grew by 15% over 2000/09 = **10% increase in passanger density**, the regularity indicator being constant (time losses on the regional network, bottleneck?)
  - Major concerns for commuters (past elections)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Consumer theory:

- Utility function of a PT user i:

$$U_{i,j} = \alpha + \theta\, p_i + \sum_{j=0}^{J} \beta_j\, c_j\, t_i + \delta\, X_i + \varepsilon_i$$

- **The crowding effect (dummies c_j) is working through the travel time marginal disutility ($\beta_j<0$):**

$$U_{i,1} - U_{i,0} = (\beta_1 - \beta_0)\, t_i > 0 \Rightarrow 0 > \beta_1 > \beta_0$$

- Assuming **t_i=k**, an important passanger density in trains implies that **individuals cannot seat**, a non polychronic use of the travel time, personal stress:

The subway GC is higher


COLLÉ
SERRÉ
J'ASSURE
DE L'ASSURANCE EN TOUTES CIRCONSTANCES
HOLLYWOOD
FRESH
CLEAN
OLLYWOOD

The CVM:

- Propose **hypothetical trips (more comfortable, but longer) to find the equivalent variation (EV) in subway GC** which makes PT users indifferent between c_1 and c_0
  - EV in quantities (**willingness to pay**, WTP):

$$U_{i,1} = U_{i,0} \Rightarrow \beta_0 \; t_i = \beta_1 \; (t_i + WTP) \qquad WTP = t_i \frac{(\beta_0 - \beta_1)}{\beta_1}$$

  - EV in marginal disutility (**«time multiplier»**, Tm):

$$U_{i,1} = U_{i,0} \Rightarrow \beta_0 \; t_i = \beta_1 \; t_i \; Tm \qquad Tm = \frac{\beta_0}{\beta_1} > 1$$

- Advantages linked to the time payment vehicle (reduced hypothetic and strategic biases)

Crowding costs in the literature:

- Numerous studies provided by UK and AUS consulting agencies (**WW11, LH11**):
  - **Tm is prefered : 1.34-2.0** (for load factors of 100-200%)
  - WTP : 0.43-2.43 $AUS /trip
- Few studies in France: **the Boiteux report (2001, 2005) advises a Tm=1.5 for standing trips**
- Stif (2006) on regional trains reliability: WTP=5-20 min/trip, Tm=1.3-1.9 (seat, stand, stand crowded)
- Our past works on Paris subway L1 (HK12, PK12): **WTP=6-8 min/trip=1.0-1.4 eu/trip, i.e. Tm=1.3-1.4**

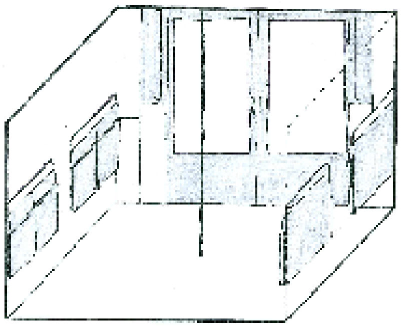
(policy implications, but also limits in the survey)

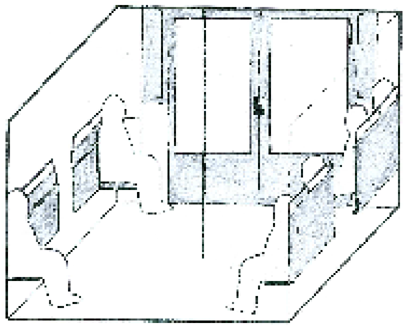
The new survey on Lines 1 and 4 :

- Late 2010, **1,000 users interviewed on the platforms of L1&4, during the morning (7:30-10:00) and the evening (5:00-7:30) peaks** (more individual heterogeneity + scheduling costs)
- 20% of the sample deals with WTA valuation (less comfortable, but faster trips)
- Users can answer longer surveys (verso + on line)
- **Data on objective trip conditions** (Ratp + count)
- Procedures for **random time bids** (2 rounds) and **random comfort improvements**

Showcards (reference/hypothetical trips):

Le confort dans le métro parisien


Carte 1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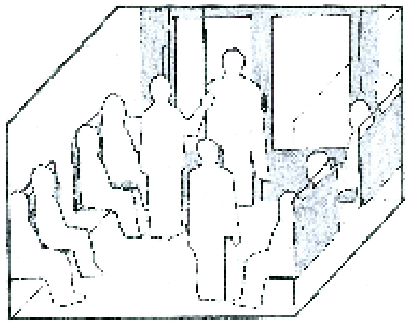
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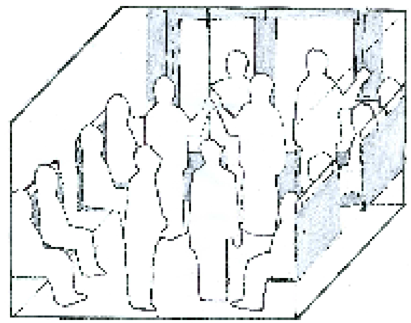
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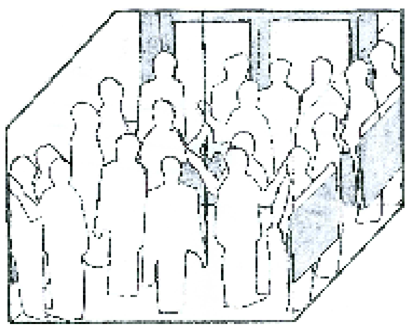
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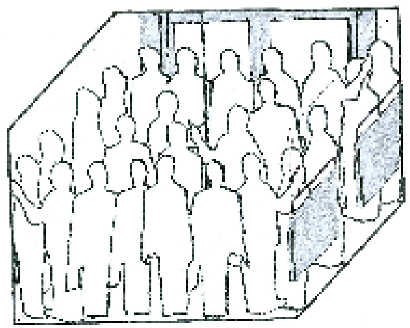
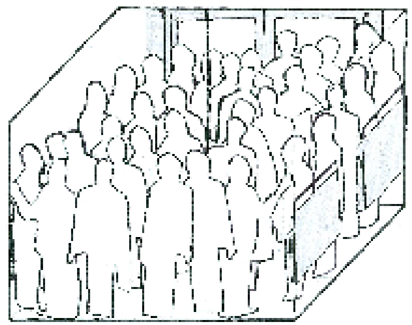

Carte 6


Carte 7

Descriptive statistics:

- High participation rate (60%), 30% of verso, 10% on internet
- WTP sample = 688 individuals (the sample used here)

Table 2: Individual characteristics

	Total	Line 1	Line 4	Morning	Evening
Age (years)	35	36	34	36	35
Male (%)	50%	49%	51%	50%	50%
Parisian (%)	57%	53%	62%	56%	58%
Francilian (%)	94%	94%	95%	92%	96%
Car's ownership (%)	38%	42%	33%	38%	37%
Income (euros/month)	2,245	2,790	2,100	2,570	2,320
Time opportunity cost (euro/min)	0.20	0.23	0.17	0.21	0.19

Table 3: Trips' characteristics

	Total	Line 1	Line 4	Morning	Evening
Home-Work (%)	69%	78%	62%	76%	64%
Line daily usage (%)	64%	66%	62%	63%	64%
"Door-to-door" travel time (minutes)	46	47	45	51	41
Number of inter-stations	6.8	7.2	6.4	6.7	6.9
In-vehicle travel time (minutes)	9.7	11.5	7.9	9.4	10

Comfort «reference point»:

Table 4: Expected density

Expected density (pass/m^2)	0	1	2	2.5	3	4	6
Total	0.0%	2.3%	16.7%	27.8%	24.3%	20.2%	8.7%
Line 1	0.0%	1.2%	8.7%	20.8%	26.6%	28.0%	14.7%
Line 4	0.0%	3.5%	24.8%	34.8%	21.9%	12.3%	2.6%
Morning	0.0%	3.2%	22.0%	29.2%	22.0%	17.3%	6.4%
Evening	0.0%	1.5%	11.4%	26.3%	26.6%	23.1%	11.1%

Table 5: Density indicators

	Total	Line 1	Line 4	Morning	Evening
Expected density (pass/m^2)	3.1	3.5	2.7	2.9	3.3
Count density (pass/m^2)	2.4	3.2	1.5	2.4	2.3
Ratp density (pass/m^2)	1.7	2.2	1.3	1.6	1.9
Count density at departure (pass/m^2)	2.2	2.7	1.7	2	2.5
Ratp density at departure (pass/m^2)	1.8	2.1	1.4	1.5	2
Count density at arrival (pass/m^2)	2.1	2.9	1.5	2.2	2.2
Ratp density at arrival (pass/m^2)	1.4	1.9	1	1.3	1.6

- Exploratory estimates: **the comfort perception depends on the objective density**, DtD travel time and income

Hypothetical scenarios:

Table 6: Descriptive statistics on hypothetical scenarios

	Total	Line 1	Line 4	Morning	Evening
Expected density (pass/m^2)	3.1	3.5	2.7	2.9	3.3
Hypothetical density (pass/m^2)	1.3	1.5	1.1	1.1	1.4
Bid 1 (minutes)	8.7	8.5	8.9	8.9	8.5
Bid 1 (euros)	1.8	2	1.5	1.9	1.6
Answer 1 positive (%)	42%	49%	35%	37%	47%
Bid 2 (minutes)	8	8.1	7.9	7.9	8.1
Bid 2 (euros)	1.6	1.9	1.4	1.7	1.5
Answer 2 positive (%)	42%	44%	40%	40%	44%

- **A1 and A2 more positive for L1 and evening peak**
- A2>A1 for L4 and morning peak (inverse on L1 and during evening peak)

Econometric strategy (1):

- With k=(P,A) the hypothetical/real situations:

$$U_{i,j}^{k} = \alpha^{k} + \theta^{k}\, p_i + \sum_{j=0}^{J} \beta_j^{k}\, c_j^{k}\, (t_i + b_i^{k}) + \delta^{k}\, X_i + \varepsilon_i^{k}$$

- Variables c_j and t_i (via b_i) differ in k:

$$\begin{aligned} Prob(Accept) &= Prob(U_{i,j}^{P} > U_{i,j}^{A}) \\ &= \Phi\left[\alpha^{*} + \sum_{j=0}^{J} \beta_{j,k}^{*}\, (T_{i,j}^{P} - T_{i,j}^{A})\right] \end{aligned}$$

- **Probit models (simple, bivariate**, **random effects**)
- **We estimate the different β_j (and calculate the Tm)**

Econometric strategy (2):

- If an **interdependency between answers** is found, future study of « first bid biases »:
  - **Anchoring:** the first offer substitutes the true comfort valuation
  - **Framing:** Individuals who accept the first bid consider the follow up offer as a loss
- The **individual heterogeneity** may play through a **premium (ϒj) to the marginal disutility**:

$$Prob(Accept) = Prob(U^P_{i,j} > U^A_{i,j}) \quad (11)$$

$$= \Phi\left[\alpha^* + \sum_{j=0}^{J} \beta^*_{j,k} \ (T^P_{i,j} - T^A_{i,j}) + \lambda^* Z_i + \sum_{j=0}^{J} \gamma^*_{j,k} \ (T^P_{i,j} - T^A_{i,j}) \ Z_i\right] \quad (12)$$

Probit results:

	Probit	Probit	Probit	Probit
	Answer 1	Answer 2	Answer 1	Answer 2
Time marginal disutility at:				
0 pass/m^2	-0.117	-0.096	-0.115	-0.098
	(0.013)	(0.015)	(0.013)	(0.015)
1 pass/m^2	-0.111	-0.105	-0.11	-0.107
	(0.013)	(0.015)	(0.014)	(0.015)
2 pass/m^2	-0.124	-0.111	-0.125	-0.114
	(0.013)	(0.015)	(0.014)	(0.015)
2.5 pass/m^2	-0.138	-0.124	-0.136	-0.127
	(0.014)	(0.017)	(0.015)	(0.017)
3 pass/m^2	-0.153	-0.13	-0.151	-0.133
	(0.017)	(0.018)	(0.017)	(0.018)
4 pass/m^2	-0.171	-0.147	-0.164	-0.15
	(0.018)	(0.02)	(0.019)	(0.02)
6 pass/m^2	-0.188	-0.174	-0.18	-0.179
	(0.021)	(0.022)	(0.022)	(0.024)
Constant	0.537	0.394	0.798	0.693
	(0.114)	(0.118)	(0.201)	(0.196)
Controls	No	No	Yes	Yes
Pseudo-R2	14.5	9.5	17.1	10.3
Observations	688	688	688	688

- **The β_j parameters decrease with the density**
- Estimates from A2 are less precise (larger S.E.)

Bivariate probit results:

	Biprobit	Biprobit	Biprobit	Biprobit
	Answer 1	Answer 2	Answer 1	Answer 2
Time marginal disutility at:				
0 pass/m^2	-0.118	-0.14	-0.116	-0.139
	(0.013)	(0.014)	(0.014)	(0.014)
1 pass/m^2	-0.112	-0.15	-0.111	-0.15
	(0.013)	(0.015)	(0.014)	(0.015)
2 pass/m^2	-0.125	-0.154	-0.126	-0.155
	(0.013)	(0.015)	(0.014)	(0.015)
2.5 pass/m^2	-0.139	-0.171	-0.138	-0.17
	(0.014)	(0.016)	(0.015)	(0.016)
3 pass/m^2	-0.155	-0.18	-0.151	-0.179
	(0.017)	(0.017)	(0.017)	(0.017)
4 pass/m^2	-0.173	-0.2	-0.165	-0.199
	(0.019)	(0.02)	(0.02)	(0.02)
6 pass/m^2	-0.191	-0.226	-0.179	-0.224
	(0.022)	(0.022)	(0.022)	(0.023)
Constant	0.541	0.728	0.724	0.808
	(0.115)	(0.115)	(0.205)	(0.192)
Controls	No	No	Yes	Yes
Rhô	0.613		0.622	
	(0.062)		(0.062)	
Log pseudo	-787.8		-770.1	
Observations	688	688	688	688

- The main result holds but **A1 and A2 appear to be correlated (potential mis-estimates)**

Graphics (1):

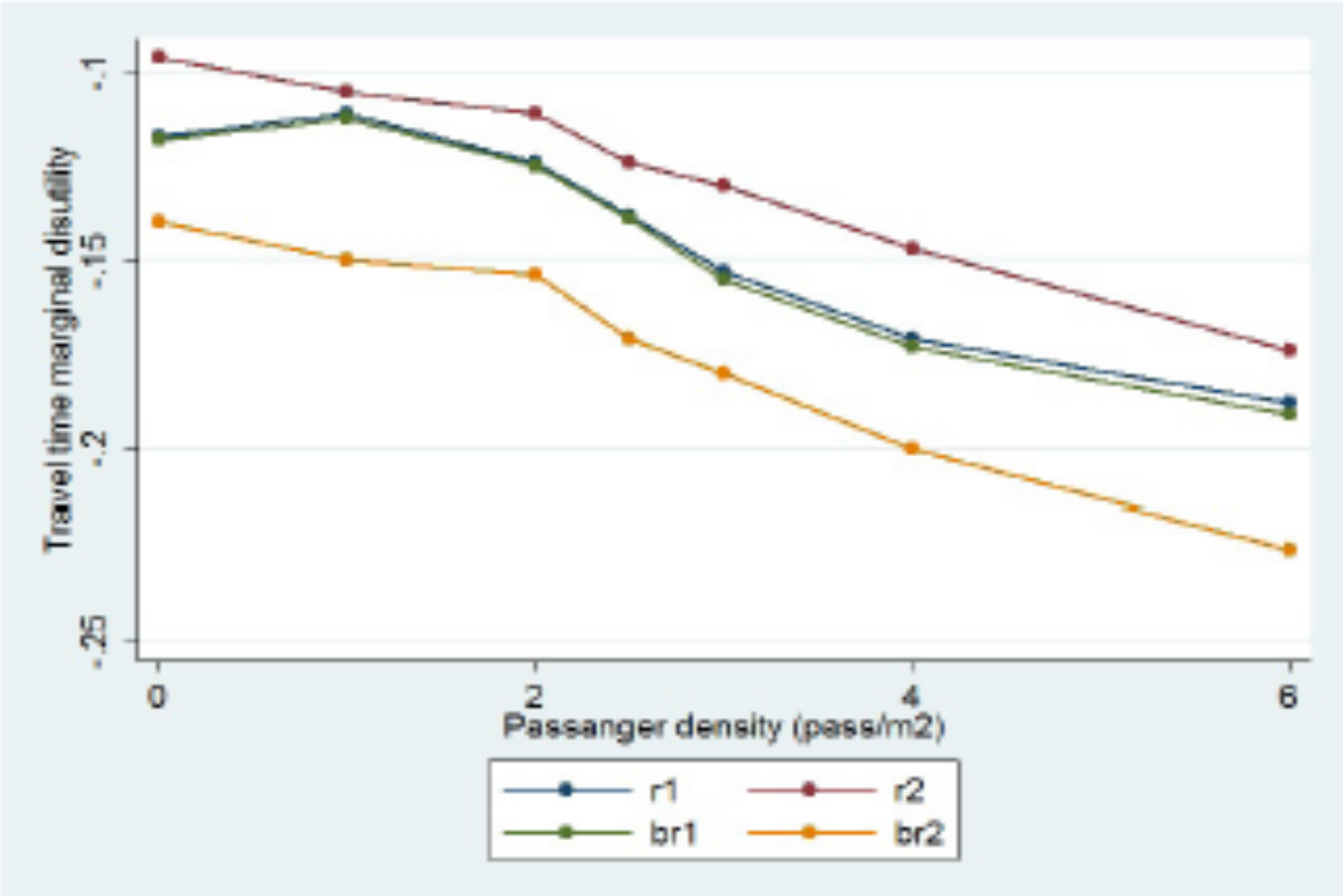


Figure 1: Travel time marginal disutilities

Graphics (2):

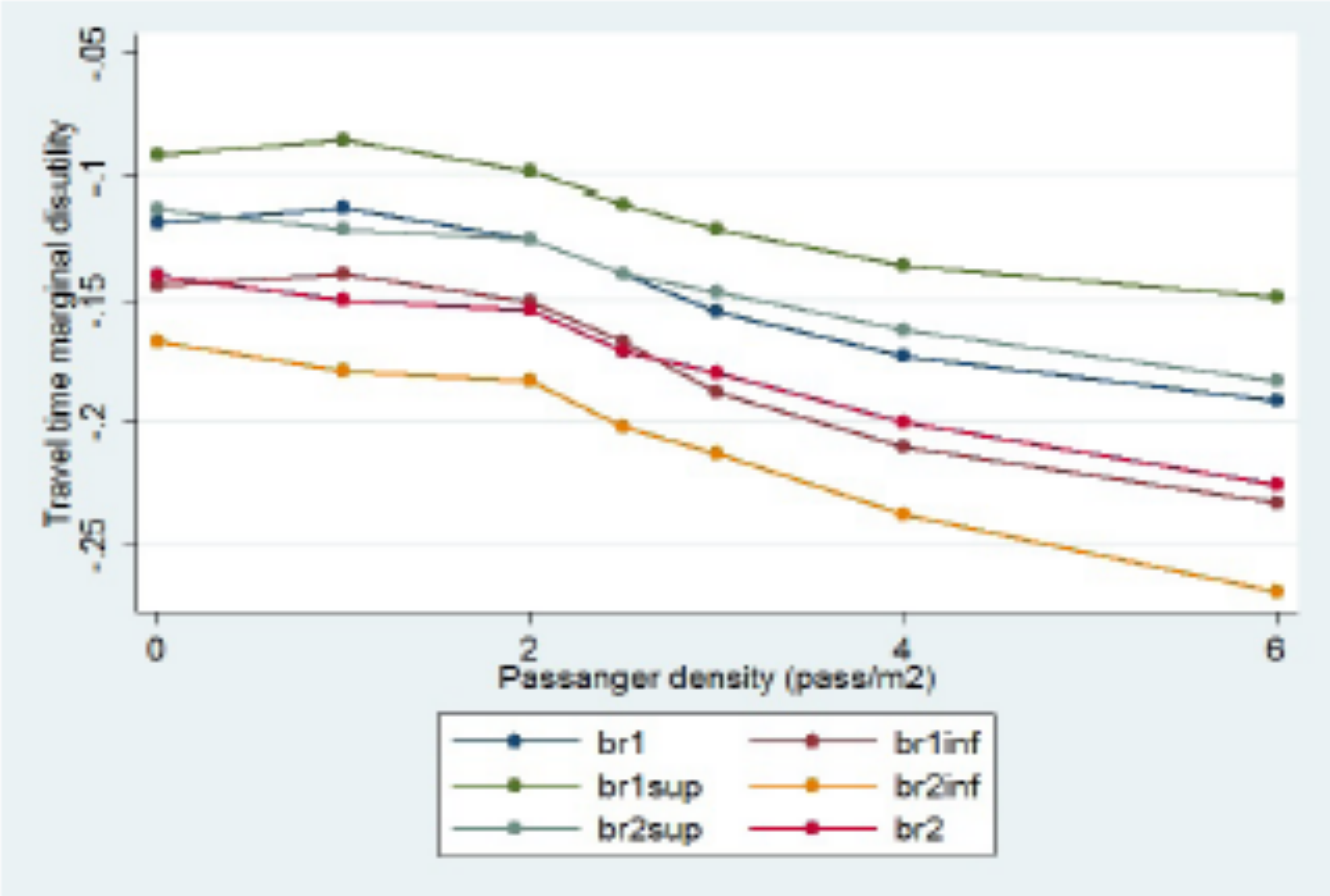


Figure 4: Confidence intervals of marginal disutilities

Graphics (3):

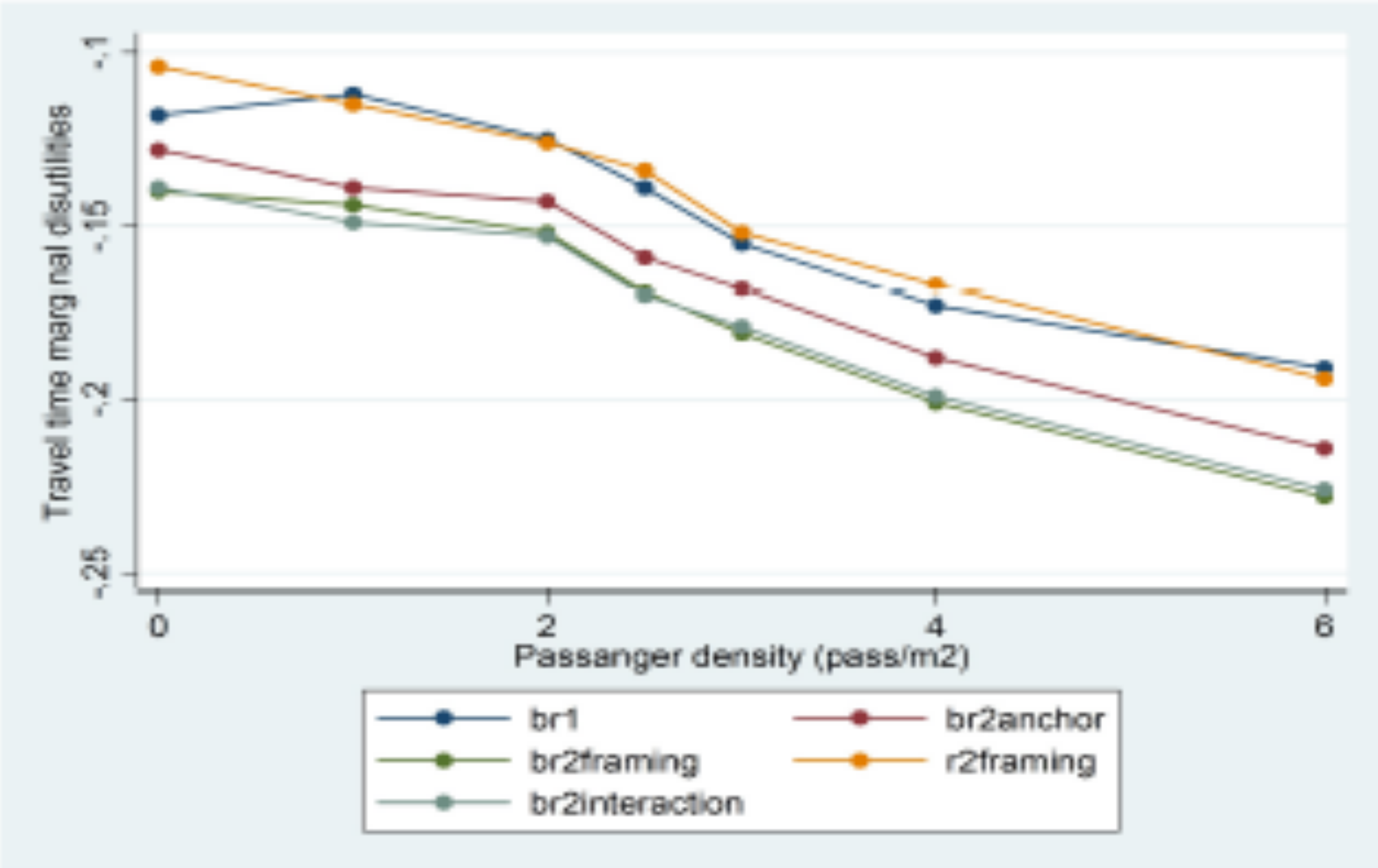


Figure 3: Exploratory estimates of "first bid biases"

Graphics (4):

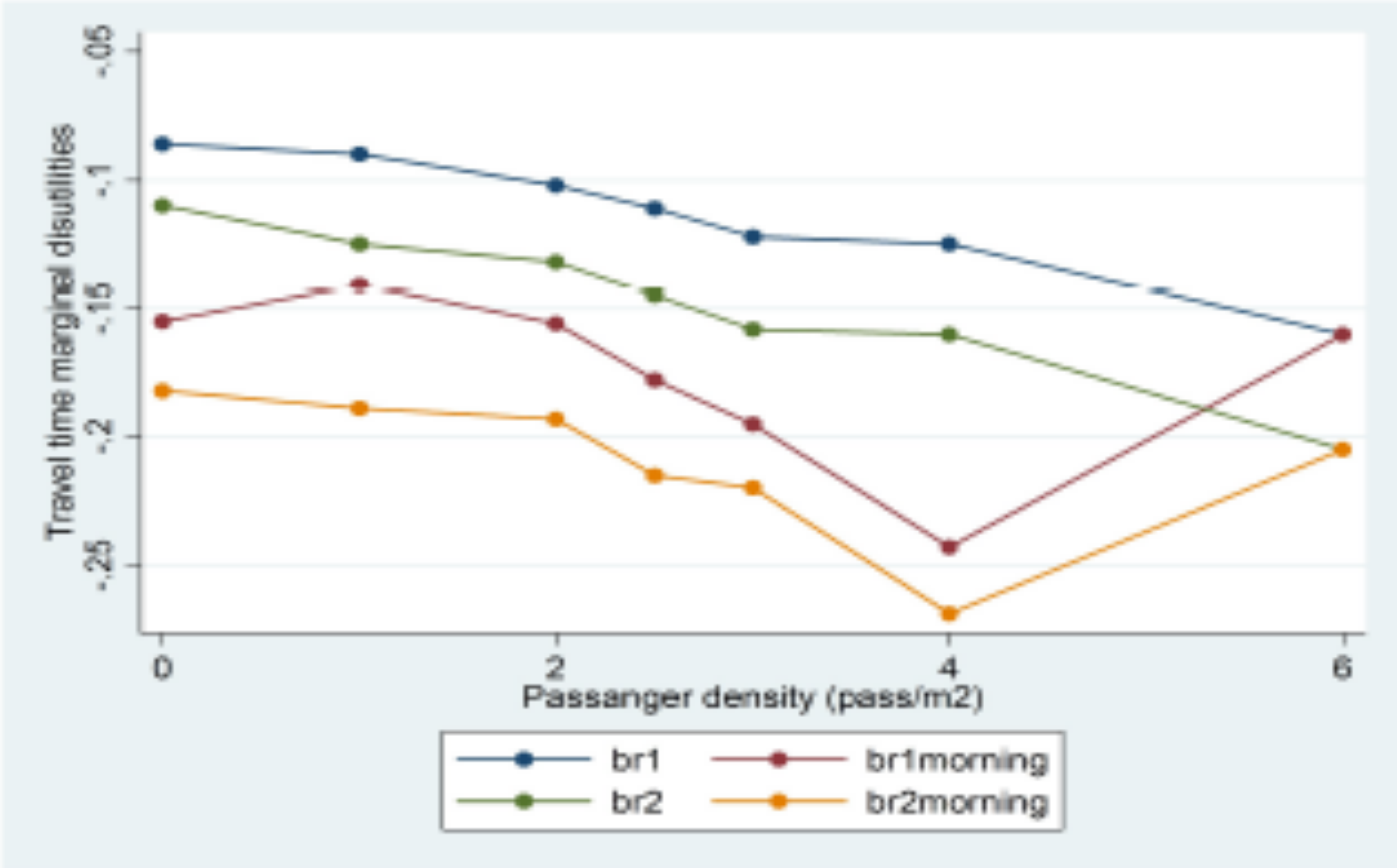


Figure 4: Time marginal disutilities during the peak of the morning

The «time multipliers»:

- We choose **cj=1 pass/m2 as referential**, with 2 seats still available on showcards (better than the «empty subway» situation):

Table 9: Time multipliers

	Probit	Probit	Biprobit	Biprobit
Density	Tm1	Tm2	Tm1	Tm2
0 pass/m^2	1.05	0.91	1.05	0.93
1 pass/m^2	1.00	1.00	1.00	1.00
2 pass/m^2	1.12	1.06	1.12	1.03
2.5 pass/m^2	1.24	1.18	1.24	1.14
3 pass/m^2	1.38	1.24	1.38	1.20
4 pass/m^2	1.54	1.40	1.54	1.33
6 pass/m^2	1.69	1.66	1.71	1.51

- **The Tm ranges from 1.51-1.71 for 6 pass/m2**

Graphics (5):

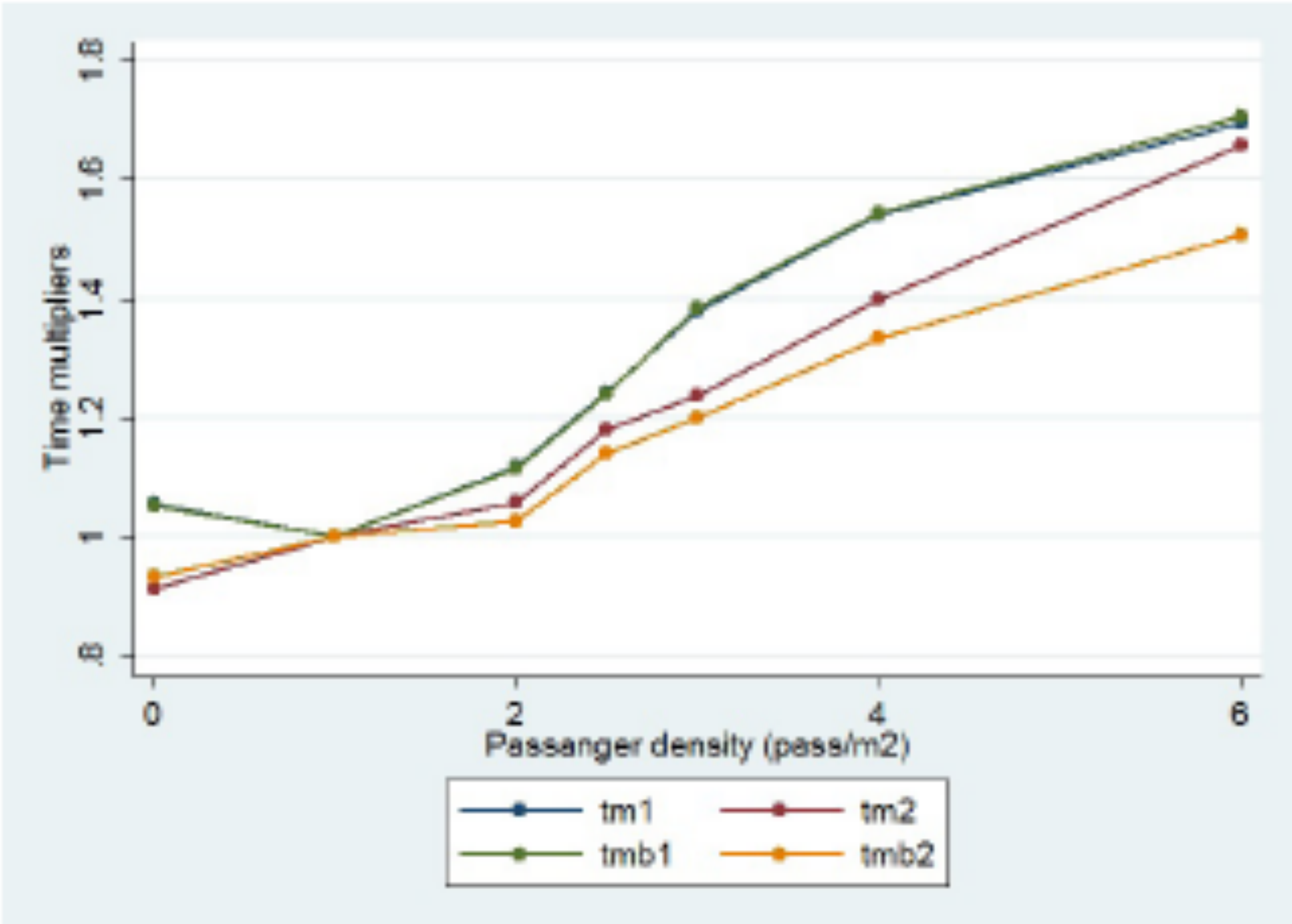


Figure 2: Time multipliers

Relationship between GC and density:

- Defining w as the time opportunity cost:

$$GC(c_j) = p_i + w\ t_i\ Tm(c_j)$$

- Normalizing A1 estimates w.r.t. (c_j=1, Tm=1):

$$\mathrm{Tm}(c_j) = 1 + 0.14\ c_j\ if\ c_j > 1\ pass/m^2 (R2=92.1)$$

Table 10: Generalized costs, time multipliers and willingness to pay

	Total	Line 1	Line 4	Morning	Evening
GC(peaks) (eu/pass)	3.28	4.44	2.35	3.28	3.28
GC(seat) (eu/pass)	2.44	3.14	1.84	2.47	2.40
Tm	1.43	1.49	1.38	1.40	1.46
WTP (min/pass)	4.2	5.6	3.0	3.8	4.6
WTP (eu/pass)	0.84	1.28	0.51	0.80	0.87

- **Neglecting the crowding costs would lead to a 35% under-estimation of the subway GC**

The externality of PT congestion:

- Pigou: $SC(c_j) = GC(c_j) + MC(c_j) = GC(c_j) + \frac{\partial GC(c_j)}{\partial c_j} c_j$

Table 11: Generalized, external and social costs of Paris subway usage

Density	$GC(c_j)$ (eu/pass)	$MC(c_j)$ (eu/pass)	$SC(c_j)$ (eu/pass)	MC/SC (%)
0 pass/m^2	2.44	0	2.44	0
1 pass/m^2	2.44	0	2.44	0
2 pass/m^2	2.98	0.54	3.52	15
2.5 pass/m^2	3.12	0.68	3.80	18
3 pass/m^2	3.25	0.81	4.06	20
4 pass/m^2	3.53	1.09	4.62	24
6 pass/m^2	4.07	1.63	5.70	29

- **PT crowding is a major transport externality**:

Table 12: Urban transport marginal costs

	Subway congestion	Road congestion	Cars accidents	Local pollutants	Cars noise	GHG emissions
MC (eu/km)	0.21	0.43	0.07	0.02	0.01	0.01

Capacities investments' appraisals: (*in progress*)

- For I_0=100 M euros, **the L1 capacity may be increased by 15-20%**, i.e. via higher frequency:

Table 16: Net Present value of Line 1's automation

	Constant demand in Line 1	Report from RER A
Line 1, before:		
Peak passangers (1,000/day)	375	375
Peak density (pass/m^2)	3.5	3.5
GC(peak) (eu/pass)	4.44	4.44
Line 1, after:		
Peak passangers (1,000/day)	375	405
Peak density (pass/m^2)	2.8	3.3
GC(peak) (eu/pass)	4.18	4.37
GC(L1) difference (M eu/y)	-29.3	-7.9
GC(RER) difference (M eu/y)	0.0	-12.0
GC(report) difference (M eu/y)	0.0	-2.1
Net Present Value (M eu) (r=4%, 20 years)	268.2	169.0

Future researches:

- Compare these Tm results with WTPs
- Compare WTP and WTA valuations
- Use of the rich empirial material (PC users, scheduling costs, comfort and money trade-off, revealed preferences)

Thank you
for the comments!