You cannot drive my car without me: Car ownership and mode choice within couples

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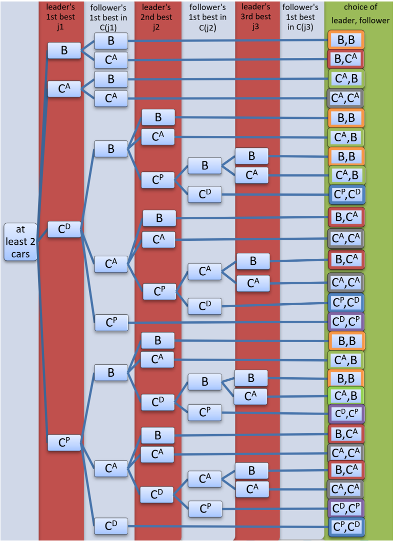
Outline

Literature review

- Historically, transport economics has mainly considered mode choice as an individual and independent decision (De Jong et al., 2004).
- Collective models have emerged to account for intra-household decisions, relying on the assumption of Pareto efficiency (Chiappori, 1988; 1992).
- Joint mode choice models explicitly capture interactions between household members (Youssef et al., 2026).
- Joint discrete family decisions have been modeled using Stackelberg leadership frameworks (Bjorn & Vuong, 1984; 1985; Kooreman, 1994).

The Stackelberg game

- The leader determines his preferred mode j_1 and the follower determines his preferred choice $i_1 \in C(j_1)$. If j_1 and i_1 are compatible, the couple chooses j_1, i_1.
- Otherwise, the leader proceeds in the same way with his 2nd-best mode j_2 and the follower determines his preferred choice $i_2 \in C(j_2)$. If j_2 and i_2 are compatible, the couple chooses j_2, i_2.
- Finally, the leader repeats the procedure for j_3 and the follower for $i_3 \in C(j_3)$, then announces j_3 and the follower chooses i_3.



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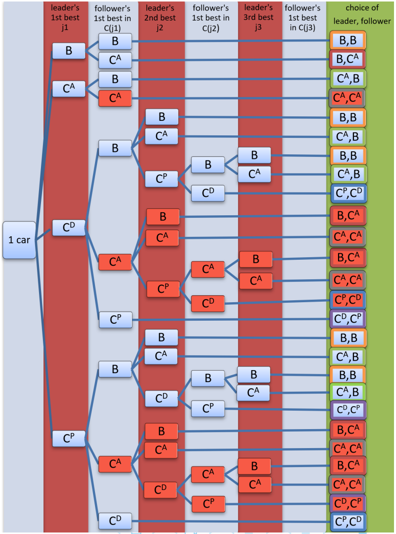


Probabilities: 2 cars

	G=F	G=M
$P_G^2(B,B)$	$P_{F,\Omega}(B)\cdot P_{M,\{B,C^A\}}(B)+P_{F,\{B,C^A\}}(B).P_{M,\Omega}(B)-P_{F,\Omega}(B)\cdot P_{M,\Omega}(B)$ $+P_{F,\Omega}(C^D,B)\cdot P_{M,\Omega}(C^D,B)+P_{F,\Omega}(C^P,B)\cdot P_{M,\Omega}(C^P,B)$	
$P_G^2(B,C^A)$	$P_{F,\Omega}(B)\cdot P_{M,\{B,C^A\}}(C^A)+P_{F,\{B,C^A\}}(B).P_{M,\Omega}(C^A)-P_{F,\Omega}(B)\cdot P_{M,\Omega}(C^A)$ $+P_{F,\Omega}(C^D,B)\cdot P_{M,\Omega}(C^D,C^A)+P_{F,\Omega}(C^P,B)\cdot P_{M,\Omega}(C^P,C^A)$	
$P_G^2(C^A,B)$	$P_{F,\Omega}(C^A)\cdot P_{M,\{B,C^A\}}(B)+P_{F,\{B,C^A\}}(C^A).P_{M,\Omega}(B)-P_{F,\Omega}(C^A)\cdot P_{M,\Omega}(B)$ $+P_{F,\Omega}(C^D,C^A)\cdot P_{M,\Omega}(C^D,B)+P_{F,\Omega}(C^P,C^A)\cdot P_{M,\Omega}(C^P,B)$	
$P_G^2(C^A,C^A)$	$P_{F,\Omega}(C^A)\cdot P_{M,\{B,C^A\}}(C^A)+P_{M,\Omega}(C^A).P_{F,\{B,C^A\}}(C^A)-P_{F,\Omega}(C^A)\cdot P_{M,\Omega}(C^A)$ $+P_{F,\Omega}(C^D,C^A)\cdot P_{M,\Omega}(C^D,C^A)+P_{F,\Omega}(C^P,C^A)\cdot P_{M,\Omega}(C^P,C^A)$	
$P_G^2(C^D,C^P)$	$P_{F,\Omega}(C^D)\cdot P_{M,\Omega}(C^P)+$ $P_{F,\Omega}(C^D)\cdot P_{M,\Omega}(C^D,C^P)+$ $P_{F,\Omega}(C^P,C^D)\cdot P_{M,\Omega}(C^P)$ $\boldsymbol{-P_{F,\Omega}(C^P,C^D)\cdot P_{M,\Omega}(C^P,C^D)}$	$P_{M,\Omega}(C^P)\cdot P_{F,\Omega}(C^D)+$ $P_{M,\Omega}(C^P)\cdot P_{F,\Omega}(C^P,C^D)+$ $P_{M,\Omega}(C^D,C^P)\cdot P_{F,\Omega}(C^D)$ $\boldsymbol{-P_{M,\Omega}(C^D,C^P)\cdot P_{F,\Omega}(C^D,C^P)}$
$P_G^2(C^P,C^D)$	$P_{F,\Omega}(C^P)\cdot P_{M,\Omega}(C^D)+$ $P_{F,\Omega}(C^P)\cdot P_{M,\Omega}(C^P,C^D)+$ $P_{F,\Omega}(C^D,C^P)\cdot P_{M,\Omega}(C^D)$ $\boldsymbol{-P_{F,\Omega}(C^D,C^P)\times P_{M,\Omega}(C^D,C^P)}$	$P_{M,\Omega}(C^D)\cdot P_{F,\Omega}(C^P)+$ $P_{M,\Omega}(C^D)\cdot P_{F,\Omega}(C^D,C^P)+$ $P_{M,\Omega}(C^P,C^D)\cdot P_{F,\Omega}(C^P)$ $\boldsymbol{-P_{M,\Omega}(C^P,C^D)\times P_{F,\Omega}(C^P,C^D)}$

Probabilities: 1 car

	G=F	G=M
$P_G^1(B,B)$	$P_G^2(B,B)$	
$P_G^1(B,C^A)$	$P_{F,\Omega}(\boldsymbol{B})+P_{F,\Omega}(C^D,\boldsymbol{B})\cdot P_{M,\{B,C^P\}}(B)$ $+P_{F,\Omega}(C^P,\boldsymbol{B}).P_{M,\{B,C^D\}}(B)$ $+P_{F,\Omega}(\{C^D,C^P\},\boldsymbol{B})\cdot P_{M,\{B,C^D,C^P\}}(B)$ $-P^1(B,B)$	$P_{M,\Omega}(\boldsymbol{C^A})+P_{F,\{B,C^P\}}(B).P_{M,\Omega}(C^D,\boldsymbol{C^A})$ $+P_{F,\{B,C^D\}}(B).P_{M,\Omega}(C^P,\boldsymbol{C^A})$ $+P_{F,\{B,C^D,C^P\}}(B).P_{M,\Omega}(\{C^D,C^P\},\boldsymbol{C^A})$
$P_G^1(C^A,B)$	$P_{F,\Omega}(\boldsymbol{C^A})+P_{F,\Omega}(C^D,\boldsymbol{C^A})\cdot P_{M,\{B,C^P\}}(B)$ $+P_{F,\Omega}(C^P,\boldsymbol{C^A}).P_{M,\{B,C^D\}}(B)$ $+P_{F,\Omega}(\{C^D,C^P\},\boldsymbol{C^A})\cdot P_{M,\{B,C^D,C^P\}}(B)$	$P_{M,\Omega}(\boldsymbol{B})+P_{F,\{B,C^P\}}(B).P_{M,\Omega}(C^D,\boldsymbol{B})$ $+P_{F,\{B,C^D\}}(B).P_{M,\Omega}(C^P,\boldsymbol{B})$ $+P_{F,\{B,C^D,C^P\}}(B).P_{M,\Omega}(\{C^D,C^P\},\boldsymbol{B})$ $-P^1(B,B)$
$P_G^1(C^D,C^P)$	$P_{F,\Omega}(C^D)\cdot P_{M,\{B,C^P\}}(C^P)$ $+P_{F,\Omega}(C^P,C^D)\cdot P_{M,\{B,C^D,C^P\}}(C^P,B)$	$P_{F,\{B,C^D\}}(C^D).P_{M,\Omega}(C^P)$ $+P_{F,\{B,C^D,C^P\}}(C^D,B).P_{M,\Omega}(C^D,C^P)$
$P_G^1(C^P,C^D)$	$P_{F,\Omega}(C^P)\cdot P_{M,\{B,C^D\}}(C^D)$ $+P_{F,\Omega}(C^D,C^P)\cdot P_{M,\{B,C^D,C^P\}}(C^D,B)$	$P_{F,\{B,C^P\}}(C^P).P_{M,\Omega}(C^D)$ $+P_{F,\{B,C^D,C^P\}}(C^P,B).P_{M,\Omega}(C^P,C^D)$

Expected utility conditional on ranking

Unconditional utility of option k: $U_k = V_k + \varepsilon_k$, $k \in \Omega$, where V_k is the deterministic part and ε_k is Gumbel-distributed.

Spouses may not obtain the 1st-best but a lower-ranked option; need to define the expected utility of:

1st-best: $$EU\big(k_1 \mid r(k_1) = 1\big) = \log\left(\sum_{k\in\Omega} e^{V^k}\right)$$

2nd-best: $$EU\big(k_2 \mid r(k_1) = 1, r(k_2) = 2\big) = \log\left(\sum_{k\in\Omega} e^{V^k}\right) - \Delta^2(k_1)$$

3rd-best: $$EU\big(k_3 \mid r(k_1) = 1, r(k_2) = 2, r(k_3) = 3\big) = \log\left(\sum_{k\in\Omega} e^{V^k}\right) - \Delta^3(k_1, k_2)$$

Expected utilities conditional on the number of vehicles n

Leader ($L_{iG} = 1$)

$$EU^n_{iG}(L_{iG} = 1) = \ln\Big(\sum_{k\in\Omega} e^{V^k}\Big) \; - \; \Delta^n_{\text{follower refusal}},$$

where $\Delta^n_{\text{follower refusal}}$ represents the utility loss due to the follower's refusals.

Follower ($L_{iG} = 0$)

$$EU^n_{iG}(L_{iG} = 0) = EU^2_{iG}(L_{iG} = 1) \; - \; \Delta^n_{\text{leader imposition}},$$

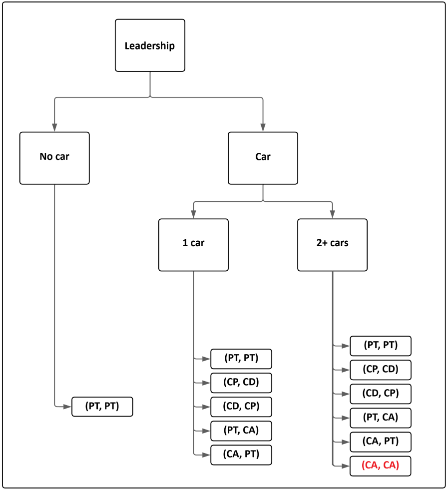
where $\Delta^n_{\text{leader imposition}}$ captures the utility loss induced by the leader's imposed choices.

Proposition

$$EU^1_{iG}(L_{iG} = 0) \leq EU^2_{iG}(L_{iG} = 0) \leq EU^2_{iG}(L_{iG} = 1) \leq EU^1_{iG}(L_{iG} = 1)$$

A 3-level Stackelberg-nested logit model

- **Level 1:** mode choice
- **Level 2:** the follower $\overline{G}$ chooses the number of cars
- **Level 3:** the leader G decides on car ownership

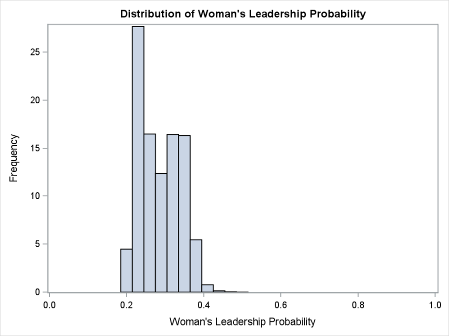


Data

- **Source:** 2021 French population census.
- **Sample:** Dual-earner couples living and working in the Île-de-France region (∼160,000 observations), restricted to households in which both spouses are employed, excluding alternative modes such as walking and cycling.
- **Key variables:**
  - Residential location and workplace location of each spouse
  - Usual commuting mode of each spouse
  - Number of cars in the household
  - Socio-demographic characteristics

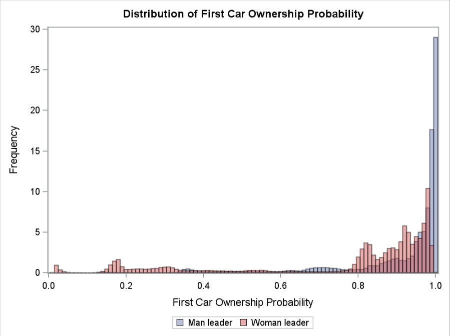
Main empirical results: Leadership probability

- The probability that the woman is the leader increases with:
  - the age difference, when the man is older than the woman,
  - the number of children,
  - being unmarried.
- However, when spouses have different education levels, the probability that the woman is the leader decreases.



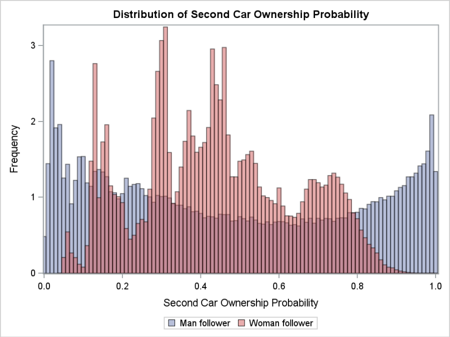
Main empirical results: 1st car (leader)

- **When the woman is the leader, first car ownership**
  - decreases strongly if she is foreign
  - decreases with the number of children
  - increases in the inner and outer rings
  - decreases with children aged 18+
- **When the man is the leader, first car ownership**
  - decreases if he is foreign, but less strongly
  - increases with the number of children
  - increases in the inner and outer rings
  - increases with children aged 18+



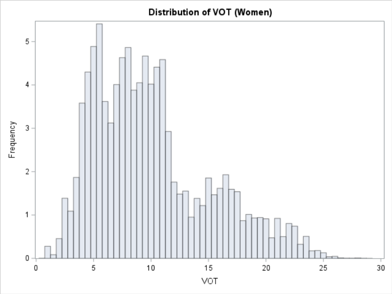
Main empirical results: 2nd car (follower)

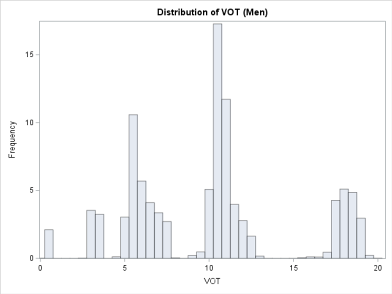
- **When the woman is the follower, second car ownership**
  - decreases if she is foreign
  - decreases with the number of children
  - increases in the inner and outer rings
  - increases with children aged 18+
- **When the man is the follower, second car ownership**
  - decreases more strongly if he is foreign
  - increases with the number of children
  - increases in the inner and outer rings
  - increases more strongly with children aged 18+



Main empirical results: VOT

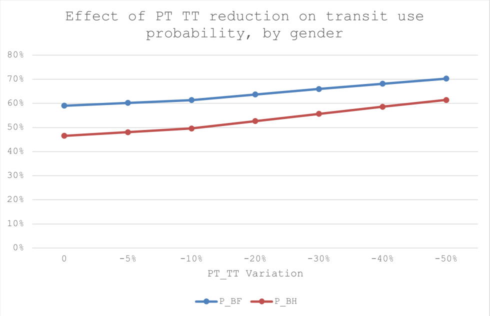
VOT increases with age for men but decreases for women; part-time work raises VOT for women while reducing it for men; executives exhibit higher VOT than other socio-professional groups; and VOT is lower for bus and car driver modes relative to solo driving, especially for women.





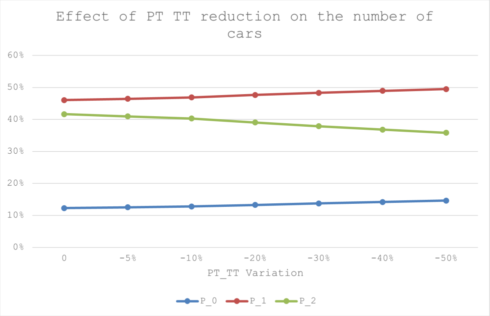
Short term effect: mode choice

Using the estimated model, we assess the impact of a reduction in public transport travel times on household decisions: **short-run effects on spouses' public transport use**, and medium-run effects on car ownership.



Long term effect: car ownership

Using the estimated model, we assess the impact of a reduction in public transport travel times on household decisions: short-run effects on spouses' public transport use, **and long-run effects on car ownership.**



Conclusion

- Modelling couple decision is required to better understand, estimate and predict spouses' mode choice and car ownership behaviour. It reveals :
  - gender differences in preferences
  - gender differences in leadership
- Leadership influences both car ownership & mode choice
  - causes endogeneity of car ownership
  - biases estimation of preferences (particularly VOT) when car ownership is not modeled
  - induces bias on public policy evaluation