This research is supported by the Swiss Federal Office of Energy under the project *Hubs2Connect — Bridging the last mile* (Project No. SI/502719).

The transfer penalty is (mostly) not about transfers:
Mode-specific discomfort in intermodal urban trips

17th Workshop on Discrete Choice Models
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Transfer penalties: what, why, and how much

The pure transfer penalty (PTP)

- Inconvenience of switching modes or vehicles during a trip, beyond walking and waiting.
- Central to the design of efficient public transport networks.

Three decades of literature

- PTPs modulated by a wide range of factors:
  - from 2.5 EIVM for uncrowded, cross-platform metro transfers in London...
  - ... to over 28 EIVM for bus-to-bus transfers in Sydney.
- Systematic pattern: transfers from/to buses carry larger penalties than rail-only ones.

  → Usually attributed to comfort, reliability, infrastructure differences, *etc.*

Previous work

First insights from Geneva (Ortelli et al., 2025)

- SP experiment, direct vs. transfer:

$$\begin{cases} V_0 = \beta_{\text{ivtt}} \text{ivtt}_0 \\ V_1 = \alpha + \beta_{\text{ivtt}} \text{ivtt}_{1A} + \beta_{\text{walk}} \text{walk} + \beta_{\text{wait}} \text{wait} + \beta_{\text{ivtt}} \text{ivtt}_{1B} \end{cases}$$

- Transfers involving shared bike carry the largest penalties.
  → Clearly, that inconvenience is associated with the mode — not with the transfer!

	EIVM	[90% CI]
PTP tram–bus	3.54	[0.22, 6.60]
PTP tram–shared bike	12.64	[10.07, 14.41]
PTP bus–bike	6.70	[2.00, 10.46]
PTP bus–shared bike	11.60	[8.44, 13.63]
PTP bike–tram	7.50	[3.80, 9.99]
PTP shared bike–tram	9.71	[6.25, 11.86]

Our claim

What conventional PTP estimates actually capture

- Most PTP studies do not include mode-specific constants.
- Any discomfort associated with the modes is therefore absorbed by the PTP.
- Because every transfer adds a leg, this absorption is systematic.

Our claim

- Differences in PTPs across mode pairs reflect mode-specific discomfort.
- Conceptual precedents:
  - Currie (2005): formalization of mode-specific factors — citing evidence dating back to 1988!
  - Douglas & Jones (2013): bus penalty of 10 EIVM on direct trips, relative to rail.
  - Arentze & Molin (2013): joint estimation of mode constants and transfer penalties.

Side-by-side comparison

The conventional approach

- Labeled alternatives, direct vs. transfer.
- PTP captured by the constant of the transfer alternative:

$$\begin{cases} V_0 = \beta_{\text{ivtt}}\text{ivtt}_0 \\ V_1 = \alpha + \beta_{\text{ivtt}}\text{ivtt}_{1\text{A}} + \beta_{\text{walk}}\text{walk} + \beta_{\text{wait}}\text{wait} + \beta_{\text{ivtt}}\text{ivtt}_{1\text{B}} \end{cases}$$

Ours

- Unlabeled alternatives, "anything vs. anything."
- Transfer as an attribute — PTP captured by a dedicated parameter:

$$V_i = \beta_{\text{mode}}\text{mode}_{i\text{A}} + \beta_{\text{ivtt}}\text{ivtt}_{i\text{A}} + \beta_{\text{trf}}\text{trf}_i + \beta_{\text{walk}}\text{walk}_i + \beta_{\text{wait}}\text{wait}_i + \beta_{\text{mode}}\text{mode}_{i\text{B}} + \beta_{\text{ivtt}}\text{ivtt}_{i\text{B}}$$

New setup

What we need from an experiment to test this

- Unlabeled alternatives: transfer as an attribute, not as a label.
  - → Allows for direct-vs-direct and transfer-vs-transfer scenarios.
- An opt-out alternative — walking, so that all mode-specific constants can be estimated.
  - → Requires access and egress segments, for realistic comparison.

Additional “nice-to-have” features

- Coverage of all mode pairs in transfer alternatives.
- Contextual variables.
- Travel cost.

Experimental design

Scenarios

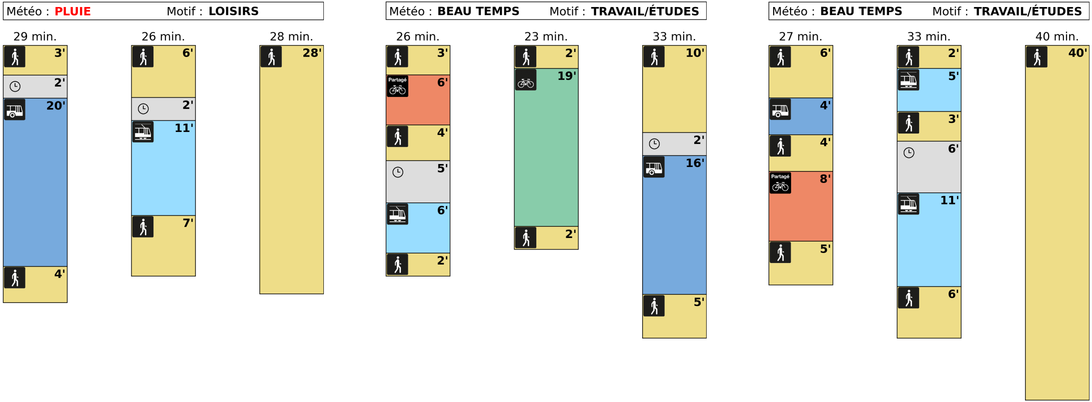
- Three unlabeled alternatives:
  - Two “public transport” options: direct or transfer, among bus, tram and shared bike;
  - One private-mode opt-out: walking or private bike, based on bike ownership.
- Contextual variables:
  - Weather: rain/no rain.
  - Trip purpose: commute/leisure, based on working status.
- Travel cost not displayed!

  → “The costs correspond to what you would pay in Geneva, given your subscriptions.”

Setup

- Fractional factorial with filtering rules, 40 scenarios in total.
- No blocking; instead, five scenarios per respondent drawn at random.

Scenarios, as presented to respondents



Data collection

Survey implementation

- Second wave of an online panel survey, October 2025, Geneva.
- 1'258 respondents (50% retention rate); 1'135 after cleaning.
  $\rightarrow$ 5'675 choice observations.

	direct		transfer			opt-out
	B/T	SHB	B/T+B/T	B/T+SHB	SHB+B/T	W/PB
(i)	63.6%					36.4%
(ii)	45.4%	20.3%				34.3%
(iii)	55.4%		19.2%			25.4%
(iv)	51.7%			11.3%		37.0%
(v)	63.3%				7.9%	28.8%
(vi)		21.1%	36.2%			42.7%
(vii)			53.4%	11.9%		34.7%
(viii)			35.3%		11.4%	53.3%

Two model variants

Common to both models

- Generic transfer dummy.
- Constants for bus, tram, private bike and shared bike, relative to walking.
  - Additional effects: shared-bike account, cyclists' age beyond 60.
- IVTT, with separate parameters for bus/tram, cycling, and walking.
  - Private bike IVTT interacted with e-bike ownership.
- Travel cost, with a distinct coefficient for undisclosed income.
- Effect of trip purpose on all travel time components.
- Effect of rain on all exposed segments.

Model A — split

- Distinct walking and waiting parameters by trip phase.

Model B — pooled

- Pooled effects, with piecewise-linear specification for walking time.

Travel times

	Model A		Model B		
	EIVM	CHF	EIVM	CHF	
IVTT bus/tram	1.00	18.2/h	1.00	18.1/h	ivtt bus/tram
IVTT shared/private bike	1.11	20.2/h	0.96	17.3/h	ivtt shared/private bike
× private e-bike	−0.42	−7.6/h	−0.41	−7.4/h	× private e-bike
walking time, opt-out	1.66	30.4/h	1.21	21.9/h	walking time, pooled
walking time, access	1.59	29.1/h	+0.20	3.7/h	above 5 min
walking time, transfer	0.77	14.1/h	+0.24	4.4/h	above 15 min
walking time, egress	1.41	25.7/h			
waiting time, access	1.27	23.1/h	0.78	14.1/h	waiting time, pooled
waiting time, transfer	0.30	5.5/h			
leisure, all travel times	−0.28	−5.1/h	−0.29	−5.2/h	leisure, all travel times
rain, all cycling times	2.77	50.6/h	2.70	48.8/h	rain, all cycling times
rain, all walking times	1.43	26.0/h	1.39	25.1/h	rain, all walking times
rain, all waiting times	0.60	10.9/h	0.54	9.7/h	rain, all waiting times

Transfer penalty, mode-specific constants, cost

	Model A		Model B		
	EIVM	CHF	EIVM	CHF	
transfer penalty	9.3	2.8	5.2	1.6	transfer penalty
tram constant	7.8	2.4	7.4	2.2	tram constant
bus constant	8.7	2.7	8.0	2.4	bus constant
private bike constant	13.3	4.0	12.9	3.9	private bike constant
shared bike constant	22.1	6.7	22.4	6.8	shared bike constant
× users	−7.9	−2.4	−7.7	−2.3	× users
age above 60, cycling	1.2	0.4	1.1	0.3	age above 60, cycling
cost, declared income	3.3	1.0	3.3	1.0	cost, declared income
cost, income unavailable	5.4	1.6	5.3	1.6	cost, income unavailable
panel effect, bus/tram	9.6	2.9	9.5	2.9	panel effect, bus/tram
panel effect, cycling	18.2	5.5	17.8	5.4	panel effect, cycling
panel effect, walking	18.8	5.7	18.4	5.6	panel effect, walking

Takeaways and implications

Takeaways

- Mode constants comparable to or larger than the transfer penalty.
  - → Constants: 7–22 EIVM. Residual transfer: 5–9 EIVM.
- Familiarity matters: shared-bike account reduces the shared-bike constant by 8 EIVM.

Implications

- Better transfer infrastructure solves only part of the problem...
  - → Reducing the barriers associated with specific modes is equally important.
  - → For shared mobility: onboarding and familiarity as direct levers.

Limitations and future work

Limitations

- Biases: stated-preference, choice-supportive, self-selection.
- Geneva context: constants reflect local conditions, infrastructure quality, cultural attitudes.
- Personal dissatisfaction with some implausible scenarios.

Future work

- Combine with RP data.
- More modes, more choice contexts.
- Propensity scores for self-selection among subscribers.

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