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

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Abstract

Transfers are a well-documented source of discomfort in public transport, yet estimated transfer penalties systematically differ by mode pair, suggesting that mode-specific discomfort may be conflated with the penalty itself. We test this hypothesis using an unlabeled discrete-choice experiment conducted in Geneva, Switzerland, with 1'135 respondents choosing among direct and transfer alternatives involving bus, tram, private and shared bike, and walking. Two logit specifications with random panel effects decompose the transfer penalty into mode-specific constants and a residual transfer component. We find that the residual penalty — 5 to 9 equivalent in-vehicle minute — is comparable to or smaller than the mode-specific constants, which range from about 7 to 22 EIVM.

Keywords

intermodality; transfer penalty; mode-specific factors; stated preferences; shared mobility

Preferred citation

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1 Introduction

Transfers are a well-documented source of discomfort in urban transport systems. The inconvenience of switching between vehicles or modes during a trip — beyond any incurred additional walking or waiting time — is commonly referred to as the *pure transfer penalty* (PTP), and is usually expressed in *equivalent in-vehicle minutes* (EIVM). Understanding the magnitude and determinants of this penalty is central to the design of efficient public transport networks.

Over the past three decades, a substantial body of work has sought to quantify this penalty, producing estimates that range from approximately 2.5 EIVM for uncrowded, cross-platform metro transfers in London (Raveau *et al.*, 2014) to over 28 EIVM for bus-to-bus transfers in Sydney (Douglas and Jones, 2013). Drawing on both stated-preference (SP) and revealed-preference (RP) data, this literature has progressively identified a range of factors that modulate the penalty, such as infrastructure quality at transfer stations, including wayfinding, shelter, and the presence of escalators or shops (Guo and Wilson, 2004, 2011; Navarrete and Ortúzar, 2013; Schakenbos *et al.*, 2016; Nielsen *et al.*, 2021), physical configuration of the interchange — *e.g.*, cross-platform, up or down, out-of-station, *etc.* (Douglas and Jones, 2013; Yap *et al.*, 2024) — availability of real-time passenger information (Chowdhury *et al.*, 2014; Cascajo *et al.*, 2017), station crowding (Raveau *et al.*, 2011, 2014; Yap *et al.*, 2020; Yap and Cats, 2021), weather conditions (Jara-Diaz *et al.*, 2022), and individual characteristics such as gender, age (Navarrete and Ortúzar, 2013; Garcia-Martinez *et al.*, 2018), income (Douglas and Jones, 2013), or familiarity with the transport system (Espino and Román, 2020; Meskell *et al.*, 2024).

One of the most consistent findings in these studies is that PTPs differ systematically by mode pair, with transfers that involve buses carrying greater penalties than those relying solely on rail-based modes (Douglas and Jones, 2013; Navarrete and Ortúzar, 2013; Schakenbos *et al.*, 2016; Ye *et al.*, 2021; Yap *et al.*, 2024). This pattern, which echoes the so-called "rail bonus" — whereby rail-based modes tend to be preferred over bus even when measurable attributes are equal (Axhausen *et al.*, 2001; Ben-Akiva and Morikawa, 2002; Scherer and Dziekan, 2012; Preto *et al.*, 2025) — is commonly attributed to differences in service reliability, comfort and facilities. For instance, Meskell *et al.* (2024) point to the larger perceived uncertainty of buses due to traffic delays, the relative lack of facilities at bus stops, the frequent need to cross roads to catch a connection, and the greater exposure to the elements compared to rail stations. But if those are characteristics of the bus mode and its operating environment rather than of the transfer itself, how much of the estimated PTPs is actually about transferring?

We argue that the transfer penalty, whenever estimated without accounting for what Currie (2005) calls "mode-specific factors", actually conflates two distinct sources of disutility: a genuine inconvenience associated with the disruption of transferring, and a mode-specific discomfort that would exist even on a direct trip. In mode choice models, the latter appears as alternative-specific constants that capture residual attractiveness differences not explained by observable attributes; most PTP studies, however, do not include such constants, and since any transfer adds a trip leg, its associated mode-specific discomfort is inevitably absorbed into the transfer penalty estimate. When different modes are involved, varying levels of discomfort then produce the systematic mode-pair differences observed in the literature. Nevertheless, a few studies have come closer to addressing this issue: Arentze and Molin (2013) consider mode-specific constants alongside transfer penalties in a comprehensive travel choice model that relies on four distinct SP experiments, and Douglas and Jones (2013) estimate a perceived "bus penalty" — relative to rail — of approximately 10 EIVM for direct trips, providing evidence that mode-specific effects are substantial. Neither of them, however, frames these findings as a challenge to the interpretation of the PTP, and in the broader transfer-penalty literature, the discomfort associated with the modes themselves remains largely unaccounted for.

In this paper, we propose decomposing the conventionally defined PTP into mode-specific discomfort terms — reflecting the intrinsic attractiveness of each mode, independent of any transfer — and a residual transfer component. We test this decomposition on data from an unlabeled discrete-choice experiment set in an urban context in Geneva, Switzerland, in 2025. Its key design feature is the inclusion, in every choice scenario, of a private-mode opt-out alongside two public transport alternatives that may be direct or involve a transfer among bus, tram, and shared bike, enabling the identification of mode-specific constants separately from transfer penalty. Following the suggestion of Currie (2005) that mode-specific factors should be further decomposed into mode-specific variables that vary with travel distance and mode-specific constants, we also estimate mode-specific time-related parameters, yielding mode-specific values of in-vehicle travel time. We present two logit formulations with random panel effects and find that under both specifications the residual transfer component remains comparable to or smaller than the mode-specific constants, suggesting that what the literature calls the transfer penalty is, for the most part, not about transfers.

Beyond this conceptual contribution, this study — together with our previous work (Ortelli *et al.*, 2025) — is also the first to extend the analysis of intermodal transfer disutility to trips involving shared bikes, and provides new evidence on the effect of adverse weather conditions, nuancing the findings of Jara-Diaz *et al.* (2022).

2 Survey design and data collection

2.1 Experimental design

To test our proposed decomposition, we design a discrete-choice experiment on urban intermodal route choice, in which each scenario presents the respondent with three alternatives: two "public transport" options, either direct or involving a transfer, among bus (B), tram (T) and shared bike (SHB); and a "private-mode" opt-out alternative, namely walking (W) or private bike (PB). We opt for an unlabeled design, with modes and transfer shown as attributes rather than used as labels of the alternatives; this prevents the labeling itself from influencing respondents toward or against transfers, and naturally accommodates scenarios with two direct or two transfer alternatives alongside the opt-out.

Alternatives are varied along several attributes, whose possible levels are summarized in Table 1. Direct alternatives are described by access walking and waiting times, in-vehicle travel time (IVTT) on a single mode, and egress walking time. Transfer alternatives add a second leg on a possibly different mode, with transfer walking and waiting times between the two in-vehicle segments. Waiting times are set to zero for shared bike legs, reflecting the simplifying assumption that there is always at least one bike available at stations, whereas access and egress walking times of the cycling opt-out are fixed to two minutes. Travel cost is not varied within scenarios, but depends on the actual fares in effect in Geneva, with possible reductions depending on existing subscriptions. The scenarios also contain two context variables: (i) rain conditions, modeled as a binary variable that reflects the frequency of rainy days in Geneva; and (ii) trip purpose, *i.e.*, either commuting or leisure.

In total, the experiment includes 40 distinct scenarios, based on a fractional factorial design with filtering rules applied to exclude implausible scenarios and dominating alternatives. The scenarios are structured along two dimensions: (i) five distance categories, ranging from 28 to 45 minutes of equivalent door-to-door walking time;[1] and (ii) eight different combinations of alternatives for the public transport options, presented in Table 2. As shown, bus and tram are not distinguished in the combinations of alternatives; instead, the assignment is performed randomly in each scenario. Conversely, the opt-out mode is assigned afterwards, based on bike ownership.

[1]The distance categories were chosen such that the corresponding walking times are short enough to remain a plausible alternative in an urban context, yet long enough for transfer routes with realistic attribute values to be competitive.

Table 1: Trip attributes and values by alternative type. All times are in minutes and cost is in Swiss francs (CHF). Direct alternatives, by definition, do not contain a transfer, nor a second mode. Waiting times are set to zero for shared bike legs, and access and egress walking times of the cycling opt-out are fixed to two minutes each. Cost depends on the respondent's existing subscriptions. Weather and trip purpose are scenario-level contextual variables. B/T: bus or tram; SHB: shared bike; W: walking; PB: private bike; ivtt: in-vehicle travel time.

	Direct alternatives		Transfer alternatives			Opt-out	
	B/T	SHB	B/T + B/T	B/T + SHB	SHB + B/T	W	PB
$\text{walk}_{\text{access}}$	{3, 5, 6, 8, 10}	{2, 3, 4, 5, 6}	{2, 4, 5, 6, 7}	{2, 3, 4, 5, 6}	{2, 3, 4, 5}	—	{2}
$\text{wait}_{\text{access}}$	{2, 3, 4, 5, 6}	{0}	{0, 1, 2, 3, 4}	{0, 1, 2, 3, 4}	{0}	—	—
$\text{mode}_{\text{first}}$	{B, T}	{SHB}	{B, T}	{B, T}	{SHB}	{W}	{PB}
$\text{ivtt}_{\text{first}}$	{11, 13, 16, 18, 20}	{11, 12, 16, 17, 20}	{4, 5, 6, 7, 8}	{4, 5, 6, 7, 8}	{3, 4, 5, 6, 7}	{28, 34, 36, 40, 45}	{15, 18, 19, 21, 24}
$\text{walk}_{\text{transfer}}$	—	—	{0, 2, 3, 4, 6}	{0, 1, 2, 3, 4}	{0, 1, 2, 3, 4}	—	—
$\text{wait}_{\text{transfer}}$	—	—	{2, 4, 5, 6, 7}	{0}	{2, 4, 5, 6, 7}	—	—
$\text{mode}_{\text{last}}$	—	—	{B, T}	{SHB}	{B, T}	—	—
$\text{ivtt}_{\text{last}}$	—	—	{5, 6, 8, 9, 11}	{4, 5, 6, 7, 8}	{5, 6, 8, 9, 11}	—	—
$\text{walk}_{\text{egress}}$	{4, 5, 7, 9, 11}	{2, 3, 4, 5, 6}	{2, 3, 4, 5, 6}	{2, 3, 4, 5}	{2, 3, 4, 5, 6}	—	{2}
cost	{0, 2, 3}	{0, 2}	{0, 2, 3}	{0, 2, 3, 4, 5}	{0, 2, 3, 4, 5}	—	—
weather				{rain, no rain}			
purpose				{commute, leisure}			

Table 2: Possible combinations of alternatives in the scenarios. Alongside the opt-out, combinations (i) and (ii) present two direct alternatives, (iii) to (vi) one direct and one transfer, and (vii) and (viii) two transfers. B/T: bus or tram, assigned randomly with equal probability in each scenario; SHB: shared bike; W/PB: walking or private bike, assigned depending on bike ownership.

	Direct alternatives		Transfer alternatives			Opt-out
	B/T	SHB	B/T + B/T	B/T + SHB	SHB + B/T	W/PB
(i)	× ×					×
(ii)	×	×				×
(iii)	×		×			×
(iv)	×			×		×
(v)	×				×	×
(vi)		×	×			×
(vii)			×	×		×
(viii)			×		×	×

2.2 Survey implementation and sample

Respondents were recruited through the second wave of an online panel survey conducted in Geneva, Switzerland, in October 2025 (Masse *et al.*, 2026). Alongside the discrete-choice experiment described above, the questionnaire gathered detailed information on the respondents' socioeconomic characteristics, their use of shared mobility services, and their experience with urban intermodal travel and its dedicated infrastructure, with a focus on changes since the previous year.

To prevent blocking-related issues (Meskell *et al.*, 2024), each respondent was presented with five scenarios drawn at random from the full set, with the assignment managed by the survey platform to ensure approximately equal coverage across all 40 scenarios. Each scenario could be presented in either a commuting or a leisure context, and with either a walking or a cycling opt-out, depending on the respondent's profile. Specifically, retired and non-working respondents were always assigned the leisure context, whereas workers and students received a mix of both, with the proportion calibrated based on the composition of the first-wave sample to ensure a sufficient number of observations in commuting scenarios. Similarly, bike-owners received three scenarios with the cycling opt-out and two with walking based on ownership rates observed in the first wave, whereas non-owners were always assigned the walking option.

Scenarios were presented graphically as stacked bars, with each segment representing a trip component — walking, waiting, or in-vehicle time — identified by an icon and its duration in minutes. Travel cost was not displayed within the scenario graphics themselves; instead, a preliminary instruction screen informed respondents of the applicable fares for each mode given their existing subscriptions. The left-to-right ordering of the three alternatives was randomized across scenarios, both to mitigate position effects and to identify respondents who repeatedly select the same position without engaging with the scenario content. The total door-to-door travel time of each alternative was displayed above the corresponding bar, and adverse weather conditions were highlighted in red to ensure that respondents would not overlook them. Figure 1 illustrates four scenarios as presented to respondents, with different combinations of alternatives, modes, weather conditions and trip purposes.

In total, 1'258 respondents completed the survey, corresponding to a retention rate of approximately 50% from the first wave of the panel survey. Of these, 101 were excluded from the analysis due to incomplete responses, and a further 22 for systematically selecting the same position in all five scenarios, suggesting a lack of engagement with the choice tasks. The final sample therefore includes 1'135 individuals, corresponding to 5'675 choice observations. As shown in Table 3, the sample skews older than the general population, with the 45–74 age range notably overrepresented, and women accounting for a larger share than in the cantonal average. Moreover, full-time and part-time workers are overrepresented at the expense of non-employed individuals, possibly reflecting the composition of the first-wave recruitment channels, which drew heavily from public transport subscribers.

3 Modeling approach

We specify a logit model with random agent effects in which, given the unlabeled design of our experiment, all alternatives are associated with the same utility function. This function includes all constituent trip components: access, in-vehicle travel, transfer — where applicable — and egress, alongside a travel cost term, contextual interactions for trip purpose and weather, and mode-specific constants that capture attractiveness differences across modes.

Figure 1: Graphical representation of four scenarios, as presented to respondents: (a) two direct alternatives and a walking opt-out, in adverse weather and for leisure; (b) one direct and one transfer alternative with a private bike opt-out, in fair weather and for commuting; (c) one transfer and one direct alternative with a walking opt-out, in adverse weather and for commuting; and (d) two transfer alternatives with a walking opt-out, in fair weather and for commuting.

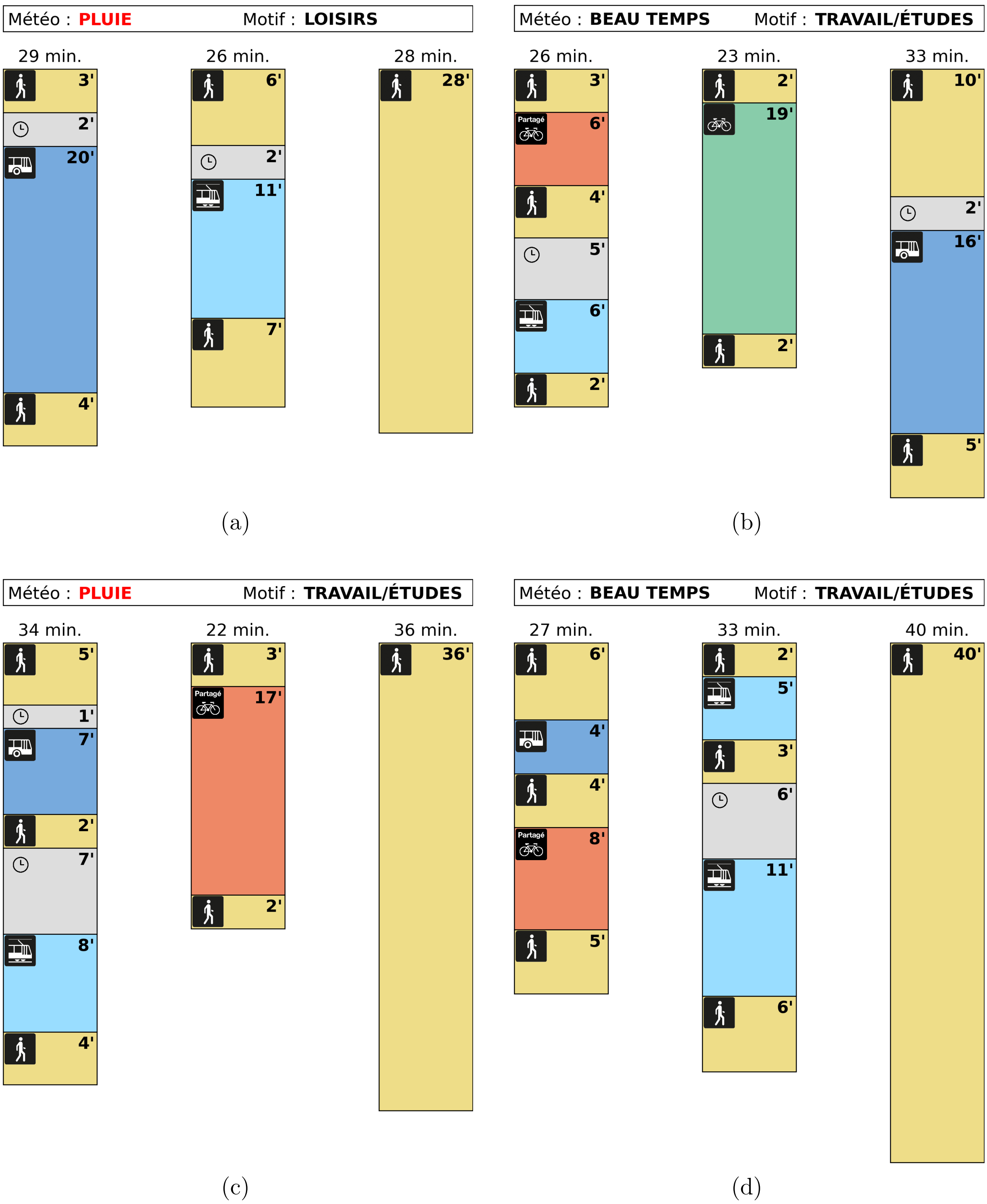

Table 3: Characteristics of the sample compared with official statistics: age and gender figures are from the Cantonal Statistical Office and refer to 2025, employment status is drawn from the 2023 Structural Survey (Federal Statistical Office), and bike ownership from the 2021 Mobility and Transport Microcensus (Federal Statistical Office and Federal Office for Spatial Development).

	This sample		Censuses
Age:			
0–14	0	0.0%	15.1%
15–24	64	5.6%	11.5%
25–34	163	14.4%	14.3%
35–44	204	18.0%	15.0%
45–54	293	25.8%	14.5%
55–64	201	17.7%	12.7%
65–74	148	13.0%	7.9%
75–84	61	5.4%	6.1%
85+	1	0.1%	2.9%
Gender:			
male	469	41.3%	48.4%
female	666	58.7%	51.6%
Employment status:			
student	77	6.8%	9.4%
full time	468	41.2%	37.5%
part time	277	24.4%	16.4%
not employed	88	7.8%	16.9%
retired/pensioner	225	19.8%	19.8%
Bike ownership:			
yes	659	56.1%	53.5%
no	476	43.9%	46.5%
Shared bike account:			
yes	207	18.2%	
no	928	81.8%	
Total	1’135	100.0%	

We estimate two specifications that differ in the way they include walking and waiting times. Model A estimates separate parameters for each trip phase, distinguishing opt-out, access, transfer, and egress for walking, and access and transfer for waiting, for a total of 25 parameters. However, given the structure of intermodal trips, transfer-related walking and waiting only occur in alternatives that *precisely* involve a transfer, making these parameters prone to collinearity with the transfer dummy and complicating the identification of their individual effects. Model B addresses this by pooling walking and waiting times across trip phases, with a piecewise-linear specification for walking time, for a total of 23 parameters. Unless stated otherwise, the description that follows refers to elements common to both specifications.

In-vehicle travel time IVTTs enter the utility function with mode-type-specific parameters, distinguishing three groups: (i) bus and tram; (ii) cycling, both shared and private bike; and (iii) walking. This grouping reflects the expectation that the perceived burden of a minute spent in a vehicle differs across travel conditions: sheltered and passive for bus and tram, physically active and exposed for cycling, and slow but requiring no vehicle for walking. The marginal disutility of travel time is therefore assumed to be homogeneous within each group. For private bike, an additional interaction with e-bike ownership is included, to allow capturing the effect of reduced physical effort associated with pedal assistance.

Walking time As explained above, Model A estimates separate walking time parameters for each trip phase, that is, opt-out, access, transfer, and egress. Conversely, to avoid any collinearity issues involving transfer walking time and the transfer constant, Model B pools walking time across all trip phases into a single piecewise-linear formulation, with terms that activate beyond 5 and 15 minutes, respectively, to account for increasing marginal disutility on longer walking segments.

Waiting time Similarly, Model A estimates separate parameters for access and transfer waiting times, whereas Model B pools them under a single parameter, this time without a piecewise-linear extension, as waiting does not exceed seven minutes in the experiment.

Mode-specific constants In addition to IVTT, the utility of each alternative includes up to two mode-specific constants that capture the discomfort of accessing each involved mode — bus, tram, shared bike, or private bike — net of any time spent on board. These constants are estimated relative to walking, which serves as the reference. For shared bike, an additional dummy variable captures the effect of holding a shared bike account, regardless of subscription type, as a proxy for greater familiarity with the service. Moreover, to account for the declining attractiveness of cycling among older respondents, the utility function includes an additional linear effect starting at the threshold age of 60 for alternatives that include a shared or private bike segment. This allows cycling discomfort to increase with each year beyond 60 without imposing any effect on younger respondents.

Transfer penalty A single, generic transfer penalty parameter is added to the utility of alternatives that involve a transfer, capturing any residual disutility of interrupting a trip after accounting for any discomfort associated with the involved modes.

Travel cost Travel cost enters the utility of all alternatives involving a mode for which a fare applies, with reductions determined by the respondent's existing subscriptions. A separate cost parameter is estimated for respondents who did not report their household income, as preliminary analyses indicated a significantly higher sensitivity in this group.

Trip purpose Trip purpose is modeled through a leisure dummy variable that interacts with all travel time components — in-vehicle, walking, and waiting — allowing the overall time sensitivity to differ between commuting and leisure trips.

Weather effects Adverse weather conditions are modeled through rain interactions with the travel time of all trip segments exposed to rain, that is, cycling, walking across all trip phases, and waiting. These interactions capture the additional discomfort of being outdoors in the rain, which we assume increases with every minute of travel time.

Random panel effects Unobserved preference heterogeneity across respondents is captured through normally distributed random effects on the mode-specific constants, grouped by mode type: one for bus and tram, one for private and shared bike, and one for walking. These effects are held constant across the five scenarios answered by each respondent.

4 Results and discussion

Both models are estimated in two stages: first, to verify that they do not overfit, a random 80% of the respondents is used for estimation, with the remaining 20% held out for validation; then, given the relatively limited number of observations, we re-estimate each model on the full sample of 1'135 individuals to improve the quality of the parameter estimates. All estimations are carried out by maximum simulated likelihood using Biogeme 3.3.2 (Bierlaire, 2023) with 1'000 Halton draws per individual.

Table 4 reports goodness-of-fit statistics for both models and both stages; the relatively low rho-square values are attributable to the experimental design, which deliberately avoids dominating alternatives and therefore produces choice scenarios that are intrinsically difficult to predict. Model A achieves a slightly better fit over Model B, though the practical difference is negligible. The parameter estimates obtained on the full sample are presented in Tables 5 and 6; the confidence intervals (CIs) presented in Table 6 are obtained via bootstrapping, with 100 resamples.

Overall, the estimates are broadly consistent across specifications, except for the transfer penalty, which is nearly halved when moving from Model A to Model B. This difference is an expected consequence of pooling the phase-specific walking and waiting parameters, respectively, which effectively sidesteps the collinearity issue that probably inflates the transfer penalty parameter of Model A. Less expected is the 14% decrease in the estimated value of cycling IVTT, from 20.2 to 17.3 CHF/h, which also results from the change in walking and waiting specification despite not being directly involved in the pooling, hinting at more complex substitution effects occurring.

Table 4: Goodness-of-fit statistics. Both models are first estimated on a random 80% of respondents and validated on the remaining 20%, then re-estimated on the full sample. Log-likelihood values are normalized by the number of observations in each sample.

	Model A (split)			Model B (pooled)		
	Est.	Val.	Full	Est.	Val.	Full
Sample size	908	227	1'135	908	227	1'135
Observations	4'540	1'135	5'675	4'540	1'135	5'675
Null log likelihood, normalized	−1.026	−1.000	−1.021	−1.026	−1.000	−1.021
Final log likelihood, normalized	−0.795	−0.794	−0.794	−0.796	−0.793	−0.795
Rho-square	0.225	0.206	0.222	0.224	0.207	0.221

Table 5: Parameter estimates on the full sample — 1’135 individuals, 5’675 observations. Model A separates walking and waiting time parameters by trip phase; Model B pools them into single parameters, with a piecewise-linear specification for walking. Both models are estimated by maximum simulated likelihood with 1’000 Halton draws.

	Model A (split)		Model B (pooled)	
	Value	Rob. t-stat	Value	Rob. t-stat
ivtt bus/tram	−0.101	−5.69	−0.103	−5.90
ivtt shared/private bike	−0.112	−4.51	−0.0987	−4.14
× private e-bike	0.0421	3.73	0.0421	3.72
walking time, opt-out	−0.168	−9.05		
walking time, access	−0.161	−7.47		
walking time, transfer	−0.0780	−2.53		
walking time, egress	−0.142	−6.21		
walking time, pooled			−0.125	−6.21
above 5 min			−0.0208	−2.62
above 15 min			−0.0248	−1.84
waiting time, access	−0.128	−4.38		
waiting time, transfer	−0.0304	−0.94		
waiting time, pooled			−0.0801	−3.12
leisure, all travel times	0.0280	2.72	0.0297	2.88
rain, all cycling times	−0.280	−15.6	−0.278	−15.7
rain, all walking times	−0.144	−12.2	−0.143	−12.2
rain, all waiting times	−0.0603	−1.87	−0.0554	−1.84
tram constant	−0.786	−1.84	−0.757	−2.77
bus constant	−0.881	−2.05	−0.820	−2.99
private bike constant	−1.34	−2.75	−1.33	−3.54
shared bike constant	−2.23	−4.56	−2.31	−6.36
× users	0.801	4.18	0.794	4.12
age above 60, cycling	−0.122	−5.37	−0.112	−5.04
transfer penalty	−0.935	−1.91	−0.531	−1.88
cost, declared income	−0.332	−5.51	−0.342	−5.69
cost, income not reported	−0.544	−4.15	−0.550	−4.18
panel effect bus/tram	0.969	11.2	0.974	11.2
panel effect cycling	1.84	15.5	1.83	15.6
panel effect walking	1.90	12.8	1.89	12.8

4.1 Travel times

As shown in Table 6, the IVTT parameters yield a value of in-vehicle time on bus and tram of approximately 18 CHF/h for commuting trips — *i.e.*, trips to work or school. In comparison, cycling IVTT with fair weather is valued at 20.2 CHF/h in Model A, and 17.3 CHF/h in Model B; neither estimate is very different from the bus/tram reference, but both are broadly in line with values reported in the Swiss literature (Schmid *et al.*, 2021; Weis *et al.*, 2021). E-bike ownership reduces the cycling disutility by approximately 40%, bringing the associated value of time down to 12.6 CHF/h in Model A, and to 9.9 CHF/h in Model B, effectively capturing the effect of reduced physical effort associated with pedal assistance.

In Model A, walking time parameters differ markedly across trip phases: opt-out walking carries the highest disutility, followed by access, egress, and transfer walking. The last of these is notably lower than the others, which is a clear manifestation of the collinearity anticipated in Section 3: because transfer walking only occurs in alternatives that involve a transfer, the model cannot cleanly separate its effect from that of the transfer penalty, and the low estimate suggests that part of the transfer walking disutility is absorbed by the transfer penalty. Model B sidesteps this by pooling walking time across all phases, yielding an EIVM ratio of 1.21 at baseline, increasing beyond 5 and 15 minutes through the piecewise-linear terms, with every minute after the second threshold valued at 1.65 EIVM. The same pattern appears for waiting time: in Model A, access waiting has an EIVM ratio of 1.27, while transfer waiting is valued at 0.30 EIVM and is not statistically significant.

Adverse weather substantially increases the disutility of all exposed trip components: the effect is largest for cycling, where rain adds 2.7 to 2.8 EIVM per minute, or 48.8–50.6 CHF/h; walking in rain adds approximately 1.4 EIVM per minute, more than doubling the baseline disutility, irrespective of the model; the effect on waiting time is significantly smaller, adding roughly 0.54–0.60 EIVM per minute of waiting, which may reflect the fact that part of the respondents interpret waiting as taking place in a sheltered location, thereby attenuating the perceived exposure to adverse weather conditions.

Relative to commuting, the leisure interaction reduces the effective disutility of all travel time components by approximately 0.3 EIVM, or 5 CHF/h. A single parameter is applied uniformly across in-vehicle, walking, and waiting times; separate interactions by time component could not be reliably identified given the sample size.

Table 6: Equivalent in-vehicle minutes (EIVM) and willingness-to-pay (WTP) values for Models A and B. EIVM express travel time parameters as a ratio to bus/tram IVTT and constants in equivalent minutes of bus/tram travel. Confidence intervals (CIs) are obtained via bootstrapping with 100 resamples; WTP values are computed for individuals who reported their income; they are expressed in CHF/h for time-related parameters and in CHF for constants.

	Model A (split)			Model B (pooled)		
	EIVM	[90% CI]	WTP	EIVM	[90% CI]	WTP
ivtt bus/tram	1.00	[1.00, 1.00]	18.2/h	1.00	[1.00, 1.00]	18.1/h
ivtt shared/private bike	1.11	[0.91, 1.37]	20.2/h	0.96	[0.71, 1.19]	17.3/h
× private e-bike	−0.42	[−0.70, −0.25]	−7.6/h	−0.41	[−0.66, −0.25]	−7.4/h
walking time, opt-out	1.66	[1.39, 1.97]	30.4/h			
walking time, access	1.59	[1.34, 1.97]	29.1/h			
walking time, transfer	0.77	[0.33, 1.26]	14.1/h			
walking time, egress	1.41	[1.18, 1.72]	25.7/h			
walking time, pooled				1.21	[1.00, 1.52]	21.9/h
above 5 min				+0.20	[0.09, 0.37]	3.7/h
above 15 min				+0.24	[0.02, 0.48]	4.4/h
waiting time, access	1.27	[0.93, 1.87]	23.1/h			
waiting time, transfer	0.30	[−0.05, 0.70]	5.5/h			
waiting time, pooled				0.78	[0.32, 1.18]	14.1/h
leisure, all travel times	−0.28	[−0.49, −0.10]	−5.1/h	−0.29	[−0.44, −0.11]	−5.2/h
rain, all cycling times	2.77	[2.13, 3.68]	50.6/h	2.70	[2.15, 3.74]	48.8/h
rain, all walking times	1.43	[1.12, 1.89]	26.0/h	1.39	[1.09, 1.82]	25.1/h
rain, all waiting times	0.60	[0.13, 1.09]	10.9/h	0.54	[0.10, 1.01]	9.7/h
tram constant	7.8	[0.87, 16.2]	2.4	7.4	[1.6, 12.2]	2.2
bus constant	8.7	[1.65, 17.1]	2.7	8.0	[1.8, 13.0]	2.4
private bike constant	13.3	[5.2, 22.2]	4.0	12.9	[6.6, 20.2]	3.9
shared bike constant	22.1	[13.0, 33.4]	6.7	22.4	[15.7, 32.4]	6.8
× users	−7.9	[−12.7, −4.5]	−2.4	−7.7	[−12.0, −4.9]	−2.3
age above 60, cycling	1.2	[0.8, 1.8]	0.4	1.1	[0.7, 1.7]	0.3
transfer penalty	9.3	[1.1, 16.2]	2.8	5.2	[0.28, 10.0]	1.6
cost, declared income	3.3	[2.1, 4.8]	1.0	3.3	[2.4, 4.6]	1.0
cost, income unavailable	5.4	[3.1, 8.8]	1.6	5.3	[3.3, 8.1]	1.6

4.2 Mode-specific discomfort and the transfer penalty

All mode-specific constants are estimated relative to the walking opt-out. The tram and bus constants are similar in magnitude, with a difference of only 0.6–0.9 EIVM, suggesting that in Geneva, the intrinsic discomfort of using bus and tram is comparable. In contrast, the disutility associated with private bikes is valued around 13 EIVM, more than 50% higher than bus and tram. The shared bike constant is even greater, at over 22 EIVM, reflecting substantial intrinsic barriers to using a shared cycling service; however, holding a shared bike account reduces this value by about 8 EIVM, bringing it very close to its private counterpart, suggesting that familiarity with the service largely eliminates the additional friction of sharing. For both bike types, the age effect adds roughly 1.2 EIVM per year beyond the age of 60, compared to the walking opt-out.

The residual transfer penalty is estimated at 9.3 EIVM in Model A and 5.2 EIVM in Model B; the difference is a direct consequence of the above-mentioned collinearity issue and the pooling strategy to avoid it. In Model A, the implausibly low transfer walking and transfer waiting coefficients indicate that part of their disutility has been absorbed into the transfer penalty, inflating it; in Model B, the pooling removes the collinear parameters, yielding a lower estimate. If, however, transfer-phase walking and waiting are genuinely perceived differently from their access and egress counterparts — as some studies suggest, though the evidence is mixed — then the pooled coefficients in Model B impose a uniform valuation that may not hold. Should transfer-phase times be perceived as more burdensome than their access and egress counterparts, the pooled parameters would underestimate them, and the transfer penalty would compensate upward; conversely, should they be perceived as less burdensome, the transfer penalty would be pushed further down. The two estimates therefore bracket the transfer penalty from different angles, rather than providing a single definitive value.

Regardless of specification, the transfer penalty is comparable to or smaller than the mode-specific constants: in Model A, it is close to the tram and bus constants and well below the cycling ones; in Model B, it is smaller than all of them. To illustrate, consider a bus-to-shared-bike transfer compared with a direct bus trip. A conventional model without mode-specific constants would attribute the entire utility difference to the transfer penalty: in our decomposition, the shared bike constant accounts for approximately 22 EIVM, and the residual transfer penalty for 5 to 9 EIVM, totaling 27 to 31 EIVM; for a bus-to-tram transfer, the decomposition yields the tram constant plus the residual, totaling 13 to 17 EIVM. These values well within the range typically reported in the literature; in this sense, the transfer penalty is, for the most part, not about transfers.

5 Conclusion

This paper proposes decomposing the conventionally defined pure transfer penalty into mode-specific discomfort terms and a residual transfer component, and tests this decomposition using data from a stated-preference experiment conducted in Geneva in 2025. Our results show that, across our model specifications, the residual transfer penalty — estimated at 5 to 9 equivalent in-vehicle minutes (EIVM) — is comparable to or smaller than the mode-specific constants, which range from 7.4 EIVM for bus and tram to over 22 EIVM for shared bike. This suggests that part of what the literature attributes to the act of transferring is, in fact, discomfort associated with the modes themselves.

This finding has direct implications for transport planning and policy: if the perceived cost of intermodal trips is driven more by mode-specific discomfort than by the transfer itself, then interventions aimed solely at improving the transfer experience — *e.g.*, better wayfinding, shorter connection times, real-time information — while valuable, address only part of the problem. Equally important is reducing the intrinsic barriers associated with specific modes, particularly shared bikes, for which we estimate a substantial discomfort that is largely decreased among users of the service. This points to familiarity and onboarding as levers for promoting intermodal travel habits that involve shared mobility.

Several limitations of our approach should be acknowledged. First, the experiment is set in a single urban context, and the mode-specific constants may reflect local conditions, infrastructure quality, and cultural attitudes that do not generalize directly to other cities. Second, the collinearity between transfer walking and waiting time parameters and the transfer dummy, while addressed through the pooling strategy in Model B, means that the two specifications bound the transfer penalty from complementary perspectives, and that a precise point estimate is out of reach. Finally, the stated-preference design, while necessary to observe choices over intermodal alternatives that respondents may not encounter in practice, is subject to the usual caveats regarding hypothetical bias; notably, respondents who hold public transport or shared mobility subscriptions may exhibit choice-supportive bias, overstating their preference for the subscribed mode in hypothetical scenarios. While this primarily affects the measurement of stated preferences rather than the identification of the decomposition itself, it could lead to an underestimation of mode-specific discomfort constants among subscribers. Future work could address these limitations by replicating the decomposition in other urban settings and with revealed-preference data. Extending the framework to include additional public and shared mobility modes, such as e-scooters or car-sharing, and to capture heterogeneity in mode-specific discomfort beyond the effects of age and subscriptions, would further refine our understanding of intermodal travel.

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