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Sustainable Mobility Transitions in Academic Hubs: A PLS-SEM Analysis of Student Intentions in Baia Mare

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ABSTRACT:
The global environmental crisis and the United Nations 2030 Agenda place Higher Education Institutions (HEIs) at the forefront of sustainability transitions. This study examines the key factors influencing sustainable mobility adoption among students at the North University Centre of Baia Mare, Technical University of Cluj-Napoca, Romania, (CUNBM) a medium-sized academic hub underrepresented in the empirical literature on sustainable transport behaviour. The research adopts a quantitative design grounded in an adapted Technology Acceptance Model (TAM), investigating how environmental awareness, sustainability beliefs, perceived ease of use, and infrastructure quality — framed within the '15-minute city' paradigm — shape students' intention to use sustainable transport modes. The model further incorporates adverse weather as a contextual moderator of ease-of-use perceptions. Data were collected between March and May 2026 via a structured digital questionnaire across three university campuses (Engineering, Arts and Sciences), with latent constructs measured through 5-point Likert scales. The model was estimated using Partial Least Squares Structural Equation Modelling (PLS-SEM), selected for its predictive robustness in complex behavioural frameworks. Findings reveal that perceived infrastructure quality ($\beta = 0.417$) and 15-minute city accessibility ($\beta = 0.281$) are significant antecedents of ease of use, while adverse weather exerts no significant moderating effect on behavioural intention. Because the weather construct did not meet conventional reliability standards and data were collected outside the winter season, this null result is interpreted as inconclusive rather than as evidence that weather is irrelevant; the pattern of results is nonetheless consistent with mobility barriers in this context being structural rather than meteorological.

Keywords: sustainable mobility, technology acceptance model (TAM), partial least squares structural equation modelling, 15-minute city, higher education, student behavioural intentions, Eastern Europe

1. Introduction

The global transition toward sustainable urban mobility sits at the intersection of environmental policy, urban planning, and behavioural science. Universities represent high-leverage sites for this transition: they concentrate large volumes of short-distance daily trips, host a demographic with above-average environmental awareness, and are frequently embedded within urban fabrics where active and public transport alternatives are most viable. Yet our understanding of what drives sustainable transport adoption among university students in Central-Eastern European (CEE) medium-sized cities (SMCs) remains limited. Existing literature skews heavily toward Western European and North American metropolitan contexts, leaving a significant empirical gap for transitional

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urban settings characterised by legacy infrastructure and continental climates (Hudde, 2023; Nastacă & Simion, 2025).

Baia Mare, a post-industrial city of approximately 130,000 inhabitants in north-western Romania, exemplifies this gap. The city features a transitional public transport system, growing micro-mobility provision through app-based platforms, and a student population concentrated within notional walking and cycling range of multiple campus buildings. Its continental climate — with temperatures ranging from −15°C to +35°C and significant seasonal precipitation — introduces a meteorological dimension that, as Hudde (2023) demonstrates in the German-Dutch context, may interact with mobility culture and infrastructure quality to shape transport intentions in ways not fully captured by standard behavioural models.

This study applies an Extended Technology Acceptance Model (TAM; Davis, 1989) to sustainable mobility adoption at CUNBM. The TAM posits that Perceived Ease of Use (PEOU) and Perceived Usefulness (PU) are the primary cognitive antecedents of Behavioural Intention (BI). We extend the model by introducing three contextual constructs: perceived 15-minute city accessibility (CTX.15min) and perceived public transport infrastructure quality (CTX.Infra) as antecedents of PEOU, and perceived adverse weather (CTX.Weather) as a situational moderator of the PEOU-to-BI path. This structure follows the TAM specification in which external variables act through PEOU (Davis, 1989; Venkatesh & Davis, 2000). The TAM framework has recently been validated in Romanian contexts by Calotă et al. (2025) for electric truck adoption and by Văduva et al. (2023) for digital technology acceptance among university students, supporting its applicability in this setting.

The study makes three theoretical contributions. First, it provides one of the first PLS-SEM applications of an Extended TAM to sustainable mobility in a Romanian SMC. TAM is preferred over the Theory of Planned Behaviour and UTAUT because the object of interest is the perceived accessibility of a transport system rather than the actor's normative or volitional judgement, and because UTAUT specifies facilitating conditions as a direct antecedent of use behaviour, which would render unobservable the mediation of infrastructure quality through PEOU that this study is designed to test; the omission of a normative pathway is acknowledged as a limitation. Second, it operationalises the 15-minute city concept (Moreno et al., 2021; Profiroiu et al., 2025) as a measurable composite within a behavioural adoption framework. Third, it reports a non-significant test of the weather moderation hypothesis and examines its interpretation with care, treating the result as inconclusive given the measurement and seasonal limitations discussed below rather than as confirmation that weather operates as a structural rather than a cognitive barrier.

2. Literature Review and Hypothesis Development

2.1 The Technology Acceptance Model in Urban Mobility

Davis (1989) proposed the TAM as a parsimonious framework for predicting technology adoption, with PEOU and PU as the core cognitive antecedents of BI. Extended versions — TAM2 (Venkatesh & Davis, 2000) and TAM3 (Venkatesh & Bala, 2008) — progressively incorporated external variables as antecedents entering through PEOU. In mobility research, PEOU maps onto the perceived cognitive and physical accessibility of

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a transport mode, while PU captures anticipated efficiency gains. The TAM has been validated for public transport adoption (Nastacă & Simion, 2025), e-scooter multimodal integration (Harpalete, 2023), and fleet electrification (Calotă et al., 2025). Notably, the TAM framework has been applied in Romanian institutional contexts, including food delivery platform adoption during COVID-19 (Profiroiu et al., 2021), supporting its methodological transferability to behavioural adoption studies in Romania. In CEE SMCs, the model's emphasis on perceived barriers and facilitating conditions is particularly relevant given the structural mobility challenges documented by Bezerra et al. (2020) and Andrei and Luca (2022) for cities in transitional urban settings.

2.2 The 15-Minute City Framework and PEOU

The 15-minute city concept (Moreno et al., 2021) proposes that essential daily services should be accessible within 15 minutes by non-motorised or public transport. The framework has gained traction as an analytical benchmark: Zhang et al. (2023) developed a network-based evaluation framework demonstrating how polycentric urban structures influence active mobility patterns, while Profiroiu et al. (2025) applied the Sony CSL tool to map accessibility gaps across Bucharest districts, finding significant spatial heterogeneity even within a major capital. Figure 1 replicates this approach for Baia Mare, revealing that campus areas exceed the 15-minute pedestrian threshold in several peripheral zones, motivating the inclusion of CTX.15min as a perceptual construct. We argue that students who perceive their environment as 15-minute-city-compliant will find sustainable modes cognitively easier to use, positioning CTX.15min as a TAM-external variable acting on PEOU (De Lotto et al., 2022).

Figure 1. Average pedestrian accessibility in Baia Mare (minutes), visualised with the Sony CSL 15-minute City tool. Red dots indicate approximate locations of CUNBM campus buildings. Warm colours (18–28 min) indicate areas where the 15-minute threshold is not met on foot. Source: Sony CSL / 15min-City platform; accessed May 2026. The three red dots correspond, from left to right, to the Dr. V. Babeş 62A (Engineering), Victoriei 76, and Crişan 10 campus sites; their objective walking and cycling accessibility values are reported in Table 1 below.

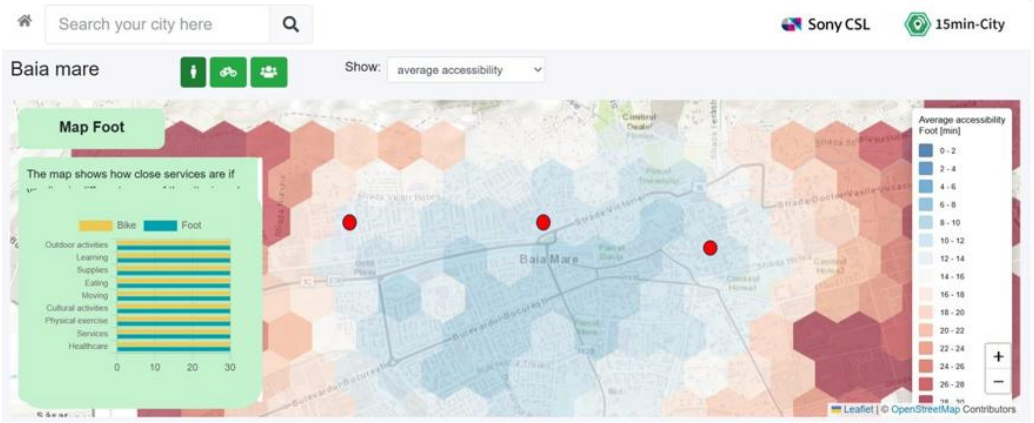

Table 1. Objective pedestrian and cycling accessibility of the three CUNBM campus sites (Sony CSL 15-minute City platform), matching the red dots in Figure 1 from left to right. All three sites meet the 15-minute walking threshold.

Campus site (red dot)	Walking (min)	Cycling (min)	Meets 15-min on foot
Babeş 62A — Engineering (left)	13.16	4.98	Yes
Victoriei 76 (centre)	11.56	5.70	Yes
Crişan 10 (right)	10.49	5.12	Yes

H1: Perceived 15-minute city accessibility (CTX.15min) is positively associated with Perceived Ease of Use of sustainable transport modes.

2.3 Public Transport Infrastructure Quality and PEOU

Infrastructure quality — service frequency, stop accessibility, and network coverage — is a primary driver of public transport use intention (Nastacă & Simion, 2025; Bezerra et al., 2020). Andrei and Luca (2022) demonstrate that Romanian SUMPs (Sustainable Urban Mobility Plan) consistently underperform on infrastructure indicators relative to Western European benchmarks, while Tormo-Lancero et al. (2022) highlight that university campus mobility plans in Mediterranean cities share similar structural gaps between stated sustainability goals and actual infrastructure provision. In TAM terms, reliable and accessible infrastructure reduces the cognitive burden of adoption, mapping directly onto PEOU. CTX.Infra is operationalised with three items targeting bus schedule adequacy, stop proximity, and network sufficiency.

H2: Perceived public transport infrastructure quality (CTX.Infra) is positively associated with Perceived Ease of Use of sustainable transport modes.

2.4 Adverse Weather as a Situational Moderator

Weather is a well-documented contextual barrier to sustainable mobility. Hudde (2023) provides the most directly relevant evidence: analysing 335,000 trips from German and Dutch national travel surveys, he demonstrates that winter conditions reduce cycling rates in Germany significantly more than in the Netherlands, attributing the difference not to climate per se but to mobility culture and infrastructure design. This finding is critical for the present study: in a CEE context where cycling culture is nascent and winter infrastructure is limited; adverse weather perception may suppress intention to use sustainable modes even when those modes are perceived as easy to use. Willberg et al. (2023) corroborate this mechanism, showing that seasonal accessibility reductions disproportionately affect mobility choices in northern cities with harsh winters. CTX.Weather is operationalised with three items measuring perceived compatibility of weather with active mobility choices and willingness to maintain mode choice under adverse conditions.

H3: Perceived adverse weather (CTX.Weather) negatively moderates the relationship between Perceived Ease of Use and Behavioural Intention to use sustainable transport.

2.5 Core TAM Paths and Attitudinal Antecedent

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Beyond the three hypotheses, the model retains the standard TAM structure. Attitude toward sustainable mobility is included as an upstream antecedent of both PEOU and PU, consistent with TAM extensions that incorporate attitudinal precursors (Davis et al., 1989; Sopjani et al., 2020). The PEOU → PU path captures the mechanism by which ease augments usefulness. PU → BI constitutes the primary TAM prediction. A direct PEOU → BI path is retained as a control path. University campus mobility is treated as a microcosm of sustainable urban transition, consistent with the campus-as-laboratory framework proposed by Tormo-Lancero et al. (2022).

3. Methodology

3.1 Research Context and Data Collection

The study was conducted at CUNBM, Technical University of Cluj-Napoca, Romania. Baia Mare is a medium-sized post-industrial city of approximately 130,000 inhabitants in the Maramureş region of north-western Romania. The city's public transport infrastructure comprises a municipal bus network connecting the three main CUNBM campus buildings, supplemented by private micro-mobility services (principally Bolt and e-scooters) and high levels of private vehicle use — a pattern consistent with the wider challenges of Romanian urban mobility documented by Andrei and Luca (2022) and Andrei et al. (2022). A structured digital questionnaire was administered across the three campuses — Engineering, Arts, and Sciences — between March and May 2026, targeting undergraduate and postgraduate students. The instrument comprised 50 items covering socio-demographic characteristics and seven multi-item constructs, each measured on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). Items were translated from English and back-translated for conceptual equivalence. After data cleaning and verification of zero missing values on all model items, the final usable sample comprised n = 212 valid responses.

The realised sample was 70.3% female and 29.7% male; 92.0% were enrolled at bachelor level and 8.0% at master level, and 58.5% were aged 18–21. Just over half (54.2%) lived off campus within Baia Mare, 38.7% commuted from outside the city, and 86.8% held a driving licence. Respondents were distributed unevenly across the three sites (Victoriei 76: 193; Dr. V. Babeş 62A: 10; Crişan 10: 9), so the analysis is effectively driven by the Victoriei sub-sample and site-level comparisons are treated as descriptive only. Administration was not improvised: in the two months preceding fieldwork the instrument and its rollout were planned in detail, specific classes were designated so that the questionnaire reached students across different courses and years, and the instrument was verified through a small pilot of approximately twenty responses before full administration. Participation was voluntary and unremunerated. The questionnaire opened with an introductory message identifying the host institution and stating that the survey formed part of an academic study on student mobility, that the responses would be used solely for that purpose and would not be communicated or disseminated, and giving the responsible researcher's contact details; respondents provided consent by choosing to proceed past this message before any item was displayed, and were free not to continue. Most items, including the optional provision of an e-mail address, were not compulsory, so respondents could complete the questionnaire without supplying any personal contact

detail, and the constructs used in the model contain no personal identifiers. No formal institutional ethics committee governs this category of research at the host institution, so no formal ethics approval was required for an anonymous academic survey of this kind; the study was nonetheless conducted in accordance with the ethical principles of the Declaration of Helsinki, and the data were analysed and reported only in aggregate, without disclosing individual respondents.

3.2 Constructs and Operationalisation

Seven constructs were operationalised as reflective composites using Mode A (correlation-based) weighting, consistent with the reflective measurement specification in PLS-SEM (Hair et al., 2019). Table 2 summarises each construct, the number of indicators, and key reliability statistics.

Table 2. Constructs, indicator items, and reliability statistics. α = Cronbach's alpha; rhoA = Dijkstra-Henseler's rho; rhoC = composite reliability. CTX.15min and CTX.Weather fall below conventional reliability thresholds; these two constructs, and the associated hypothesis test for H3, are therefore treated as exploratory (see Sections 4.1 and 5.4).

Construct	Indicator items (examples)	Items	α	rhoA	rhoC
Attitude (ATT)	Active mobility attitude; bike/walk sport; e-bike charge; bus attitude	4	0.715	0.718	0.824
CTX.15min	University within 15 min; campus connectivity; bike/e-scooter suitability	3	0.332	0.336	0.686
CTX.Weather	Weather-mode compatibility; bad-weather mode persistence	3	0.128	0.431	0.568
CTX.Infra	Bus schedule adequacy; stop proximity; network sufficiency	3	0.834	0.836	0.901
PEOU (PEOU)	Walk ease; Bolt e-scooter ease; city navigability; bus time/ticket ease	5	0.741	0.751	0.828
Perceived Usefulness (PU)	Bike/walk time saving; parking benefit; e-scooter utility; bus safety	7	0.723	0.760	0.804
Behavioural Intention (BI)	Walk; bike; e-scooter; bus; Bolt intention	5	0.721	0.714	0.817

3.3 Analytical Strategy: PLS-SEM

PLS-SEM was selected for three methodological reasons: (1) appropriateness for exploratory research with moderate sample sizes (n = 212); (2) technical tractability for the product-indicator interaction term required for H3; and (3) absence of distributional assumptions (Hair et al., 2019). The approach is consistent with recent TAM applications in Romanian contexts (Calotă et al., 2025; Văduva et al., 2023; Profiroiu et al., 2021). All analyses were performed in R using the seminr package (Ray et al., 2022) with path weighting and 5,000 bootstrap iterations (seed = 2026). Discriminant validity was assessed via the HTMT criterion and the Fornell-Larcker criterion. All VIF values fell below 3.3. Out-of-sample predictive relevance via the PLSpredict/Q^2 procedure is not reported: the product-indicator moderated model is incompatible with that routine, which requires two-

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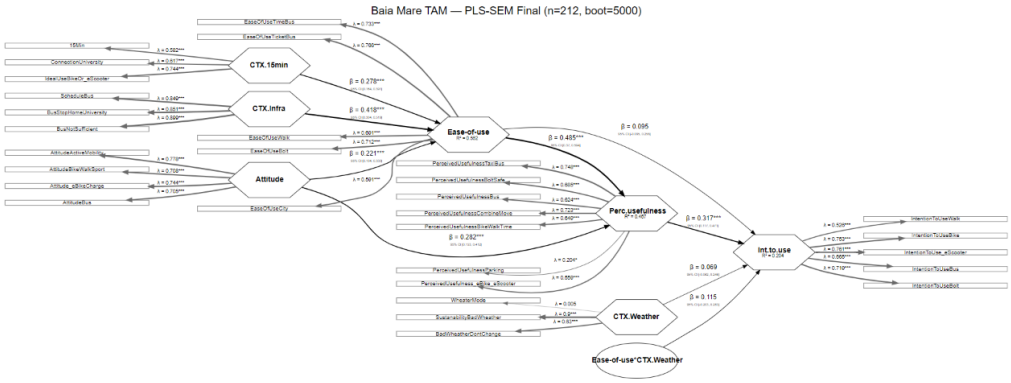
stage estimation of the interaction (Danks & Ray, 2023); effect sizes (f^2) are therefore used as the measure of predictive contribution in their place.

3.4 Model Specification

Figure 2 presents the final estimated model (SM). CTX.15min and CTX.Infra enter the structural model as antecedents of Ease of Use, consistent with the TAM specification in which external variables act through PEOU (Davis, 1989). CTX.Weather is introduced as a moderator of the EoU → BI path via the product indicator method, with a direct control path retained. Attitude functions as an upstream antecedent of both EoU and PU. This specification is deliberate: routing external variables through PEOU, rather than directly to intention as UTAUT would with facilitating conditions, is what makes the mediation of infrastructure quality observable and is the analytical core of the study.

Figure 2. Extended TAM model PLS-SEM, Baia Mare sustainable mobility study (n = 212, bootstrap = 5,000). Standardised path coefficients with 95% bootstrapped CI. $p < 0.001$; $p < 0.05$; ns = not significant. Path coefficients shown in the diagram are the bootstrap means produced by the plotting routine and may differ marginally (third decimal) from the point estimates reported in Table 5 and the text.



4. Results

4.1 Measurement Model Assessment

Composite reliability (rhoC) ranges from 0.568 (CTX.Weather) to 0.901 (CTX.Infra), meeting or approaching the conventional 0.70 threshold for most constructs. AVE exceeds 0.50 for Attitude (0.539) and CTX.Infra (0.751) only. CTX.15min and CTX.Weather show low internal consistency ($\alpha = 0.332$ and 0.128; rhoA = 0.336 and 0.431) and AVE below 0.50 (0.424 and 0.402). We do not claim these values are adequate: both constructs are treated as exploratory, and the CTX.Weather items in particular combine a perceptual judgement of weather-mode compatibility with a conative judgement of persistence under adverse conditions, which is not a unidimensional reflective set. The H3 test built on CTX.Weather is accordingly reported as provisional. The remaining AVE values below 0.50 — PEOU (0.492), Perc.usefulness (0.388) and Int.to.use (0.476) — reflect the multi-faceted item content of those constructs and are

noted as a limitation in Section 5.4. HTMT ratios are below the 0.85 threshold for the core TAM construct pairs (for example Attitude–CTX.Infra = 0.596, PEOU–Perc.usefulness = 0.820, Perc.usefulness–CTX.Infra = 0.608). Several ratios involving CTX.15min and CTX.Weather exceed this threshold, however, which we do not conceal: these are the two constructs already identified above as weak and treated as exploratory, and their elevated HTMT values are consistent with that low-reliability status rather than being reported as sound. The interaction term likewise shows the inflated ratios expected under the product-indicator method (Hair et al., 2019). Discriminant validity is therefore adequate for the core structural constructs and acknowledged as unresolved for the two exploratory contextual measures.

To make the source of the reliability shortfall transparent, Table 3 reports the standardised outer loading of every indicator, and Table 4 reports item-removal diagnostics for the two weakest constructs. The WeatherMode indicator loads at 0.005, effectively zero, confirming that CTX.Weather is not a coherent reflective set; within Perceived Usefulness the parking indicator (0.204) is likewise weak. Removing the offending indicator raises reliability for each construct but does not lift average variance extracted above 0.50 for CTX.15min, so both contextual constructs are retained but treated as exploratory, and the structural paths that involve them are interpreted with corresponding caution.

Table 3. Standardised outer loadings (SM2, n = 212).

Construct	Indicator	Loading
Attitude	AttitudeActiveMobility	0.778
	AttitudeBikeWalkSport	0.708
	Attitude_eBikeCharge	0.744
	AttitudeBus	0.705
CTX.15min	15Min	0.582
	ConnectionUniversity	0.617
	IdealUseBikeOr_eScooter	0.744
CTX.Weather	WeatherMode	0.005
	SustainabilityBadWeather	0.900
	BadWeatherDontChange	0.630
CTX.Infra	ScheduleBus	0.849
	BusStopHomeUniversity	0.851
	BusNotSufficient	0.899
PEOU	EaseOfUseWalk	0.691
	EaseOfUseBolt	0.712
	EaseOfUseCity	0.591
	EaseOfUseTimeBus	0.733
	EaseOfUseTicketBus	0.766
Perceived Usefulness	PerceivedUsefulnessBikeWalkTime	0.649

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Construct	Indicator	Loading
	PerceivedUsefulnessParking	0.204
	PerceivedUsefulness_eBike_eScooter	0.559
	PerceivedUsefulnessTaxiBus	0.748
	PerceivedUsefulnessBoltSafe	0.685
	PerceivedUsefulnessBus	0.624
	PerceivedUsefulnessCombineMove	0.723
Behavioural Intention	IntentionToUseWalk	0.526
	IntentionToUseBike	0.753
	IntentionToUse_eScooter	0.761
	IntentionToUseBus	0.665
	IntentionToUseBolt	0.719

Table 4. Item-removal diagnostics for the two weakest constructs.

Construct	Indicator removed	α	rhoC	AVE	Note
CTX.15min	(none — baseline)	0.332	0.686	0.424	below threshold
CTX.15min	15Min (λ=0.582)	0.351	0.699	0.451	still < 0.50 AVE
CTX.Weather	(none — baseline)	0.128	0.568	0.402	below threshold
CTX.Weather	WeatherMode (λ=0.005)	0.481	0.742	0.593	two persistence items only

Note. Removing WeatherMode raises CTX.Weather reliability but leaves only two persistence items that no longer capture weather perception; the construct is therefore retained in full and treated as exploratory rather than trimmed. λ = standardised loading.

4.2 Structural Model Results

Table 5 reports the full bootstrapped path coefficients for the structural model. The model explains 56.2% of variance in Ease of Use ($R^2 = 0.562$), 46.7% in Perceived Usefulness ($R^2 = 0.467$), and 20.4% in Behavioural Intention ($R^2 = 0.204$). The total indirect effect of Attitude on BI through the TAM pathways is $\beta = 0.144$, consistent with indirect-only mediation through PEOU and PU. The non-significant direct PEOU → BI path ($\beta = 0.086$, $p = 0.342$) is consistent with indirect-only mediation of PEOU's effect on BI through PU — the canonical pattern of Davis (1989). Effect sizes confirm this pattern: CTX.Infra shows a medium-to-large effect on ease of use ($f^2 = 0.269$), CTX.15min a small-to-medium effect ($f^2 = 0.118$), and ease of use a large effect on perceived usefulness ($f^2 = 0.284$), whereas the weather interaction is negligible ($f^2 = 0.019$). Adjusted R^2 values (0.556 for ease of use, 0.462 for perceived usefulness, 0.189 for behavioural intention) are close to the unadjusted figures, indicating the model is not overfitted.

Table 5. Bootstrapped path coefficients, model SM (n = 212, nboot = 5,000). β = standardised path coefficient; SE = bootstrap standard error. $p < 0.001$; ns = not significant. f^2 = effect size (0.02 small, 0.15 medium, 0.35 large).

Path	β	SE	t	p	95% CI	Result	f^2
CTX.15min → PEOU [H1]	0.281	0.058	4.890	<0.001	[0.164, 0.391]	Supported	0.118
CTX.Infra → PEOU [H2]	0.417	0.054	7.659	<0.001	[0.304, 0.519]	Supported	0.269
PEOU × CTX.Weather → BI [H3]	0.065	0.160	0.410	0.682	[−0.203, 0.283]	Not Supported	0.019
Attitude → PEOU	0.222	0.059	3.766	<0.001	[0.104, 0.333]		0.076
Attitude → Perceived Usefulness	0.285	0.066	4.326	<0.001	[0.153, 0.412]		0.100
PEOU → Perceived Usefulness	0.488	0.057	8.618	<0.001	[0.370, 0.594]		0.284
PEOU → BI (direct)	0.086	0.091	0.951	0.342	[−0.095, 0.258]	ns	—
Perceived Usefulness → BI	0.308	0.091	3.377	<0.001	[0.117, 0.471]		0.047
CTX.Weather → BI (direct control)	0.093	0.079	1.180	0.238	[−0.062, 0.246]	ns	—

5. Discussion

5.1 Infrastructure Quality as the Dominant Contextual Driver

The finding that CTX.Infra (β = 0.417) exerts a stronger effect on PEOU than CTX.15min (β = 0.281) is consistent with the structural deficiencies of Romanian urban transport documented by Nastacă and Simion (2025) and Andrei and Luca (2022). As Figure 1 illustrates, several CUNBM campus locations already exceed the 15-minute pedestrian threshold, suggesting that spatial proximity is partially constrained by geography regardless of perception. Yet even students objectively close to campus perceive sustainable modes as cognitively demanding if bus schedules are unreliable, stops are poorly located, or the network fails to cover key residential-to-campus corridors — a pattern consistent with the barriers to urban mobility planning identified by Bezerra et al. (2020) in SMC contexts. Improving infrastructure does not shift attitudes directly but reduces the perceived cognitive burden of adoption, operating precisely on the PEOU pathway that TAM identifies as the most tractable entry point for external interventions (Davis, 1989; Venkatesh & Davis, 2000).

5.2 The Null Weather Moderation: Structural Barrier Interpretation

The absence of a significant moderating effect of CTX.Weather on the EoU-to-BI relationship (β = 0.065, p = 0.682) does not support H3, but two features of the study mean the result should be read as inconclusive rather than as evidence that weather does not matter. First, as noted in Section 4.1, CTX.Weather did not meet conventional reliability standards, and an interaction term built on an unreliable moderator is attenuated

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toward zero by construction — consistent with the wide confidence interval in Table 5 ([−0.203, 0.283]). Second, data were collected between March and May 2026, entirely outside the winter conditions to which H3 refers; respondents were asked to report a generalised perception of adverse weather during a mild season rather than while experiencing it. However, Hudde's key insight is instructive: weather's effect on cycling is mediated by mobility culture, not by weather perception alone. In Baia Mare, where sustainable modes are in an early adoption phase and mobility culture is not yet established, weather may suppress actual behaviour on specific adverse days without filtering the cross-sectional intention measure — a mechanism consistent with the behavioural intention vs. actual use distinction highlighted by Sopjani et al. (2020). Future research using longitudinal or experience-sampling designs, administered under conditions confirmed to be adverse, could disentangle these interpretations.

To document that this interpretation rests on the observed conditions rather than on assumption, Figures 3 and 4 characterise the objective climate of Baia Mare over the twelve months surrounding data collection (Open-Meteo historical archive; 47.66° N, 23.57° E). Figure 3 shows the monthly temperature profile: mean temperature falls below freezing only in January, while the survey window (March–May) sits firmly in the mild part of the year. Figure 4 summarises daily conditions through a descriptive weather-harshness index combining temperature, snowfall, rainfall and wind; harsh days (index above 0.12) cluster almost entirely in December–February, whereas the shaded survey period contains very few. These figures are descriptive context, not additional model variables: they confirm that respondents formed their weather judgements in mild spring conditions and never during the winter to which H3 refers, which is precisely why the null moderation is treated as inconclusive.

Figure 3. Monthly temperature profile, Baia Mare (May 2025 – May 2026). Mean daily temperature falls below 0 °C only in January; the March–May survey window lies in the mild season. Source: Open-Meteo historical archive.

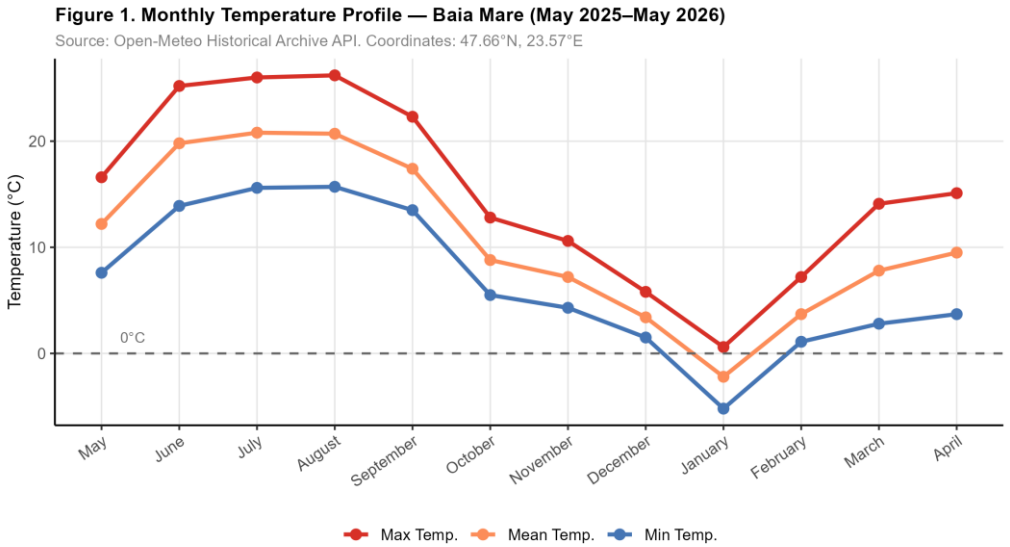
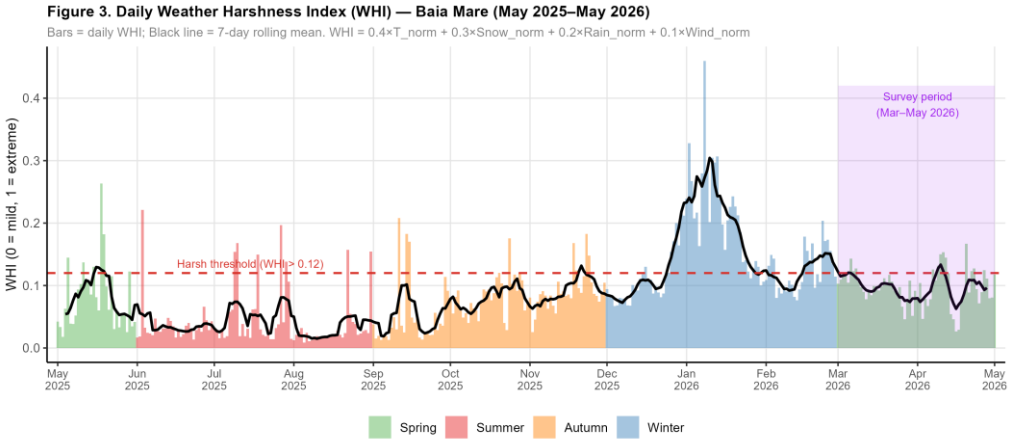


Figure 4. Daily weather-harshness index (WHI), Baia Mare (May 2025 – May 2026). WHI is a descriptive composite of temperature, snowfall, rainfall and wind (0 = mild, 1 = extreme); harsh days (WHI > 0.12) concentrate in winter, and the shaded survey period contains almost none. The index is used for descriptive context only and does not enter the structural model.



5.3 Core TAM Pathways and 15-Minute City Accessibility

The confirmation of H1 ($\beta = 0.281$, $p < 0.001$) validates the 15-minute city framework as a cognitive accessibility construct within the TAM. This finding complements the spatial analysis of Profiroiu et al. (2025) for Bucharest and the network-based evaluation of Zhang et al. (2023): proximity to services is not merely a planning benchmark but a

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psychologically operative antecedent of ease-of-use perception. The PEOU → PU path (β = 0.488) and PU → BI path (β = 0.308) confirm the canonical TAM sequence. The non-significant direct PEOU → BI path is consistent with indirect-only mediation through PU — the pattern identified by Davis (1989) as the model's strongest form. Attitude's total indirect effect on BI (β = 0.144) confirms that predispositions toward sustainable mobility translate into intention exclusively through the TAM cognitive pathways, consistent with findings by Calotă et al. (2025) and Văduva et al. (2023) in Romanian institutional contexts. The indirect effect of PEOU on behavioural intention through perceived usefulness (0.488 × 0.308 = 0.150) is positive while the direct path is non-significant, a pattern the literature terms indirect-only mediation; a full bootstrapped test of the specific indirect effect is left to future work with a larger sample.

5.4 Limitations

Several limitations warrant acknowledgement. The sample is restricted to students at a single institution in one Romanian city, limiting generalisability. CTX.15min and CTX.Weather exhibit AVE values below 0.50, addressable through future scale refinement. The cross-sectional design precludes causal inference and does not capture full seasonal variation — a limitation particularly relevant given Hudde's (2023) emphasis on seasonal behavioural dynamics. Behavioural intention may diverge from actual transport use, especially on adverse weather days, a gap best addressed through longitudinal or GPS-based diary designs. Because all constructs were measured with a single self-report instrument at one point in time, common method bias cannot be excluded and may inflate the observed relationships; self-reporting error and the well-known gap between stated intention and actual behaviour should therefore be borne in mind when reading the results.

A further limitation concerns objective measurement. Objective accessibility values from the Sony CSL 15-minute City platform and a daily meteorological series for Baia Mare were compiled alongside the survey but were omitted from this version to respect the length limits for submissions; future versions will integrate them to benchmark the perceptual constructs directly. Full objective mobility instrumentation (for example GPS travel diaries) remains costly and difficult to deploy at the scale of a student cohort, and the present study is offered as a small, replicable step toward combining perceptual and objective layers rather than as a definitive account.

6. Conclusions

This study has tested an Extended TAM for sustainable urban mobility adoption among university students in Baia Mare, Romania, using PLS-SEM on a sample of 212 respondents with 5,000 bootstrap iterations. Two of the three hypotheses were supported, with the third yielding a theoretically informative but inconclusive null result.

Perceived 15-minute city accessibility (β = 0.281, $p < 0.001$) and perceived public transport infrastructure quality (β = 0.417, $p < 0.001$) are both positively associated with Perceived Ease of Use through the TAM external variable pathway. Infrastructure quality

emerges as the stronger predictor — consistent with the structural deficiencies documented in Romanian SUMPs (Andrei & Luca, 2022) and the accessibility gaps mapped for Romanian cities (Profiroiu et al., 2025). The adverse weather moderation hypothesis is not supported ($\beta = 0.065$, $p = 0.682$). We interpret this cautiously rather than as the study's central claim: given the low reliability of the weather construct and the spring timing of data collection, the result cannot establish that weather perception fails to filter the PEOU-to-BI pathway, only that no such moderation was detected in these conditions. It is consistent with Hudde's (2023) insight that weather effects on sustainable mobility are mediated by cultural and infrastructural factors rather than operating as direct psychological moderators.

For university mobility planners and urban policymakers in CEE transitional cities, the findings point to where students' perceived barriers are concentrated: improving public transport service quality is associated with the greatest gains in students' PEOU, followed by place-based accessibility improvements. Future research should replicate this model across multiple CEE SMCs, develop validated scales for CTX.15min and CTX.Weather, and extend the causal chain from intention to actual behaviour through longitudinal designs.

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