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Review of the PhD Dissertation

Dissertation title: **Urban Transportation Poverty: A Model for Assessing Transportation Poverty in Metropolitan Areas**

Author: **M.Sc. Eng. Ahmed Nasreldin Hamed Ahmed Ismail Eliwa**

1. Preliminary remarks

This review was commissioned by the Scientific Council of the discipline of Civil Engineering, Geodesy and Transport of the Warsaw University of Technology, based on Resolution No. 162/2025 of 4.11.2025 (Letter from Przewodnicząca Rady Naukowej Dyscypliny Inżynierii Lądowej, Geodezja i Transport, dr hab inż. Katarzyna Osińska-Skotak, prof. PW, dated 19.11.2025).

This reviewed dissertation, supervised by Mariusz Kostrzewski, Ph.D., M.Sc., has been published in form of the book in the field of science: Engineering and Technology by the Warsaw University of Technology, 2025.

The book consists of 144 pages, including text and 14 tables, 28 figures, 161 literature positions and 3 appendices: (Appendix A–C).

2. Evaluation of the Dissertation Structure and Content

The dissertation addresses the measurement and mitigation of urban transportation poverty through a three-layer framework: (i) a conceptual model that clarifies the multidimensional nature of deprivation (mobility, accessibility, affordability, exposure to externalities), (ii) a formal mathematical model that defines indicators and a composite Transportation Poverty Index (TPI), and (iii) a simulation-based implementation in PTV VISUM for the Warsaw metropolitan context (18 districts). The work is well structured (including introduction and 7 chapters followed by conclusions with future research directions) written in clear academic style, with bilingual abstract, comprehensive lists of tables and figures, and a rich reference section.

In **introduction** to his thesis the author M.Sc. Eng. Ahmed Nasreldin Hamed Ahmed Ismail Eliwa justifies taking up the ambitious and important topic of Transportation Poverty, which perfectly fits the needs of both theoreticians and practitioners dealing with the planning of sustainable, fair urban transport. Urban transportation poverty is a growing yet often overlooked issue that affects the quality of life in metropolitan areas.

The author defines transportation poverty as an outcome of insufficient accessibility and service quality within reasonable thresholds of time and cost, linking it to social exclusion and mobility justice. Transportation poverty, as the author claims, has become a major issue in urban development, affecting social fairness, accessibility, and economic inclusion. He analyses transportation poverty using a structured framework that includes literature reviews, planning processes, conceptual and mathematical models, and simulation-based modelling and testing.

Three research questions guide the study: measurement of transportation poverty via indicators and simulations; methodological suitability of PTV VISUM for equity analyses; and actionable recommendations for vulnerable districts. The author situates the thesis at the intersection of engineering methods and equity-oriented planning, explicitly aiming to produce a decision-support tool for public authorities.

Chapter 1 – Evaluation of Literature Review

The rich Literature Review (161 positions, pp.108-123) in **Chapter 1** systematizes terminology (transport disadvantage, accessibility poverty, mobility poverty, affordability, exposure to externalities) and collates risk indicators (e.g., car ownership, transport expenditure share) and measurement approaches. It highlights limitations of single-dimension indices and underscores the need for integrated measures. The author synthesises strands from transport engineering, geography, and public policy, emphasising that fairness considerations require metrics that combine time, cost, and service factors with distributional impacts. This chapter establishes the theoretical imperative for a composite index and a calibrated modelling pipeline.

Chapter 2 – Evaluation of Aim, Objectives, Scope, and Thesis

Chapter 2 formulates the ambitious central thesis: mathematical programming and computer simulation can be combined to develop an assessment model of transportation poverty for agglomerations, usable as a decision-support tool. Sub-goals include: data preparation (variables, constraints, objective functions), construction of conceptual and formal models, and their implementation in a simulation environment. The author delineates scope conditions and clarifies the intended policy interface of the resulting tool.

Chapter 3 – Infrastructural Urbanism: Integrating City Development with Regional Connectivity

In this chapter the author expands the contextual foundations: how planning processes (data collection and analysis, goal setting, evaluation of alternatives, stakeholder engagement, implementation) shape accessibility outcomes over time. It outlines consequences of inadequate planning including spatial inequality, environmental injustice, and safety deficits, and catalogues

potential government responses: improvements to public transport supply, innovative mobility solutions, targeted infrastructure investments, and equity-focused regulations. The discussion frames transportation poverty as both a social challenge and a policy design problem.

Chapter 4 – Conceptual Model

The author proposed the original conceptual model which creates the methodological foundation for assessing the degree of transportation poverty. The major components proposed by the author, which interact to depict the problem of transportation poverty are related to population socio-economic data. This conceptual model defines an end-to-end analysis sequence: trip generation, trip distribution, mode choice, network assignment, and accessibility/outcome assessment. Data inputs combine OpenStreetMap (road/pedestrian/bicycle networks and points of interest) and ZTM infrastructural data (lines, stops, timetables, fares, capacities). Six key performance indicators (KPIs) structure the evaluation: Average Journey Time (JRT), Riding Time (RIT), Origin Waiting Time (OWT), Transfer Waiting Time (TWT), Service Frequency (SFQ), and Journey Distance (JRD). The model includes a feedback loop to inform scenario testing and iterative refinement.

Chapter 5 – Mathematical Model

The formal mathematical model presented in this work constitutes the original contribution of the author. This originality lies both in the conceptual framework and in the methodological integration of key transport-related dimensions, which, as the author claims, have not been addressed collectively in previous research. The formalization assigns quantitative definitions to each dimension: mobility as an inverse of travel time; accessibility as a probability-weighted function of route availability, frequency, reliability and user constraints; affordability as the ratio of transport cost to income relative to a threshold; and exposure to externalities as a weighted sum (e.g., congestion, emissions, noise, safety risks). The composite TPI aggregates normalised indicators via explicit weights, enabling citywide and district-level comparisons over time. Thresholds partition TPI into low, moderate, and high transportation poverty, facilitating communication to policy audiences. The model fills an evident gap in the existing body of knowledge and offers a novel perspective on the transportation poverty problem.

Chapter 6 – Building a Simulation Model: Simulations and Testing

The simulation is implemented in PTV VISUM with 18 district-based traffic analysis zones (TAZs) in Warsaw Metropolis and ≈960 centroid connectors for realistic access to public transport stops. The public transport network includes 326 lines and 12,487 stops grouped into 11,637 stop areas, supporting robust transfer modelling. Demand is derived from population using ≈3 trips/person/day; attractions are balanced with centre-weighting (Śródmieście +50%, Wola +30%, Ochota +10%), followed by normalization. The OD matrix explicitly includes 10% intra-zonal trips. Each KPI is computed for three time periods: AM peak (7–9), PM peak (15–17), and off-peak.

Chapter 7 – Application of the Model and Results

Results reveal a persistent central–peripheral divide. Central districts (e.g., Śródmieście, Ochota, Żoliborz) exhibit shorter JRT/RIT, lower OWT/TWT, higher SFQ, and shorter JRD, reflecting dense, reliable multimodal services. Peripheral districts (e.g., Wawer, Ursynów, Ursus) show longer journeys, higher transfer/waiting burdens, and weaker off-peak frequencies. Composite TPI rankings place Ochota and Śródmieście among the least deprived, while Wawer, Ursynów, and Ursus are consistently the most deprived. Temporal analysis indicates that outbound PM reliability and off-peak service reductions disproportionately affect peripheral residents.

The chapter synthesises findings across periods and offers district groupings by mean TPI (low/moderate/high deprivation). It further argues that structural drivers (distance to core, network coverage, mode availability) interact with temporal dynamics (frequency and reliability variations), implying that both spatially targeted and time-sensitive interventions are necessary.

Conclusions (from the dissertation)

The dissertation contributes: (i) a theoretically grounded, multidimensional formal model; (ii) an operational composite index (TPI) embedded in a simulation workflow; (iii) an empirically validated ranking and diagnosis for Warsaw; and (iv) a policy-oriented perspective that connects indicators to actionable levers (coverage, frequency, fare policy, and network redesign). Limitations acknowledged by the author include reliance on quantitative inputs, limited incorporation of qualitative user experience, the single-city scope, and scenario constraints related to future metro lines.

3. Originality and Significance Evaluation

The formal, composite treatment of transportation poverty and its seamless integration into VISUM-based simulation **constitute a substantive and original contribution**. Few studies in the Central and Eastern European context provide district-level, time-of-day sensitive rankings coupled with an explicit equity lens. The work advances the state of practice by enabling direct use in policy appraisal and scenario testing.

4. Evaluation of Novel Methodology and Methods Applied

The dissertation introduces a novel methodological framework by integrating a conceptual qualitative model with a formal mathematical model and with a simulation-based approach in PTV VISUM. This multi-layer design is innovative for several reasons: it operationalizes multidimensional indicators (mobility, accessibility, affordability, externalities) into a composite Transportation Poverty Index (TPI); embeds the model in a widely used transport planning tool for scenario testing; and incorporates temporal granularity (peak vs. off-peak) and spatial detail (18 districts). The modelling chain is transparent and well-documented. Indicator definitions, normalization choices, and aggregation into TPI are clearly stated. The supply network is comprehensively represented, and demand construction is justified for a strategic model. The

inclusion of three time periods and six KPIs provides multi-angled evidence that can be triangulated in decision processes.

The approach is transparent, reproducible, and policy-oriented, enabling decision-makers to evaluate interventions such as frequency adjustments and fare policies. Overall, the methodology is original, rigorous, and highly relevant for equity-focused transport planning.

5. Empirical Adequacy and Interpretability

Findings cohere with known spatial structure in Warsaw and are reported in a manner accessible to both technical and non-technical audiences. The district-level rankings and temporal contrasts are persuasive, offering a nuanced understanding of deprivation patterns and their operational causes (transfers, waiting times, service frequency).

Strengths of this dissertation lays in the multi-dimensional approach to the transportation poverty and in building the successive formal model easily implemented in urban planning practice. Both the formal mathematical model and its implementation can be applied as a decision support tool for decision-making analysis related to the reconfiguration of transportation in urban transport systems aiming to lower the problem of transportation poverty.

Several points needs to be enlisted as **original achievements of the author**, namely:

- Comprehensive up to date literature review and clear identification of research gap,
- Integrated, multidimensional framework bridging theory and decision support,
- Original formal model and composite index integrating multiple dimensions,
- Clear indicator set (JRT, RIT, OWT, TWT, SFQ, JRD) and composite TPI enabling comparison across space and time,
- Realistic representation of public transport supply (lines, stop areas, transfers),
- Temporal analysis capturing PM reliability and off-peak frequency effects,
- Directly applicable to policy (coverage, frequency, affordability measures),
- Policy relevance and practical applicability for metropolitan planning.

6. Limitations, Language and Formulation Issues

There are some **limitations** of the model, which the author claimed that they should be taken into consideration during the future studies. The dissertation is limited by reliance on quantitative data. The inclusion of qualitative factors such as perceived safety and comfort will need further exploration of mobility behavioral factors of citizens, especially to increase variability of trip choices, which would be beneficial to walking or biking. Future research should incorporate agent-based modelling and qualitative surveys to capture lived experiences.

Despite the fact that dissertation was written in the very good scientific language and was easy to read, some linguistic and stylistic inaccuracies were noted. Examples include:

- Page 15: 'Urban transportation poverty refers in the actual dissertation to the systematic investigation...' → Suggested: 'In this dissertation, urban transportation poverty refers to the systematic investigation...'
- Page 17: Overly long sentence on PTV VISUM → Suggested split into two sentences for clarity.
- Page 20: 'Urban transportation poverty is often defined as inadequate access to basic opportunities as a result of a combination of limited mobility alternatives, poor accessibility, and high costs has resurfaced...' → Suggested: 'Urban transportation poverty, often defined as inadequate access to basic opportunities due to limited mobility alternatives, poor accessibility, and high costs, has resurfaced...'
- Page 78: 'This limitation is addressed in the next section (Section 5.3.3)' → Should be (Section 6.3.3).
- Inconsistent capitalization of "Transportation poverty Index" → Should be "Transportation Poverty Index (TPI)" throughout.

These issues do not undermine scientific value but affect slightly clarity and professional tone.

7. Questions on Policy Implications and Recommendations

The detailed analysis of the dissertation text leads to some detailed questions, which are enlisted below. Those questions are expected to be answered during the public defense.

- 1) Regarding spatial targeting: How to prioritize peripheral districts (e.g., Wawer, Ursynów, Ursus) for increased frequency, reduced transfer penalties, and improved feeder connectivity?
- 2) Regarding affordable access: Recommended is consideration of income-differentiated fares or targeted subsidies where affordability indicators flag excessive burden relative to income. Which are the best practices in this issues and where they were successively incorporated?
- 3) Regarding monitoring safety issues and non-motorized mobility: How to Institutionalise periodic recomputation of TPI to track progress and support transparent, evidence-led resource allocation?

8. Final Recommendation

The dissertation of Mr. Ahmed Eliwa, MSc, Eng. meets and exceeds doctoral standards in the field of transportation engineering. It delivers a novel, operational, and policy-relevant framework for assessing transportation poverty and provides convincing empirical results for Warsaw.

I recommend admitting the thesis to public defence and, upon successful defense, awarding the PhD degree.

I also recommend this dissertation of Mr. Ahmed Eliwa, MSc, Eng., to be awarded as a Distinguished doctoral thesis, taking into account that the reviewed work presents an original scientific solution with a high, above-average level of an important issue for the scientific discipline of civil engineering, geodesy and transport, has a high editorial level and is an example of incorporating ethical values (social justice, equality and care for the quality of life of city and metropolis residents) into engineering solutions in transport.

The Overall Transportation Poverty Index (TPI) elaborated by the author is a comprehensive tool for assessing and quantifying the multidimensional concept of transportation poverty. Transportation poverty is redefined by the author as more than just a lack of transportation; it has numerous interconnected characteristics, including mobility, accessibility, price, and exposure to externalities such as pollution or noise. This multidimensional aspect of the Overall Transportation Poverty Index is the most valuable and promising result not only of this dissertation, but among all research results in the field internationally. For the first time it created the practical tool and methodology for testing and planning an equal, sustainable and fair distribution of transportation in urban spaces.

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Konkluzja (po polsku)

Na podstawie przeprowadzonej analizy stwierdzam, że rozprawa doktorska spełnia wszystkie wymogi formalne i merytoryczne stawiane pracom na tym poziomie. Praca charakteryzuje się wysoką wartością poznawczą i praktyczną, innowacyjnością oraz rygiorem metodologicznym. Wyniki badań mają istotne znaczenie dla polityki transportowej i planowania przestrzennego. **Rekomenduję dopuszczenie rozprawy do publicznej obrony oraz nadanie stopnia doktora po jej pomyślnym zakończeniu.**

Biorąc pod uwagę iż recenzowana praca prezentuje oryginalne rozwiązanie naukowe o wysokim, ponad przeciętnym poziomie istotnego zagadnienia dla dyscypliny naukowej inżynieria lądowa, geodezja i transport, ma wysoki poziom edycyjny i jest przykładem włączenia wartości etycznych (sprawiedliwości społecznej, równości i dbałości o jakość życia mieszkańców miast i metropolii) do rozwiązań inżynierskich w transporcie, **wnioskuję o rozważenie wyróżnienia pracy doktorskiej pana mgr inż. Ahmeda Eliwa.**

Ogólny Indeks Ubóstwa Transportowego (TPI) opracowany przez autora jest kompleksowym narzędziem do oceny wielowymiarowej koncepcji ubóstwa transportowego. Autor redefiniuje ubóstwo transportowe jako coś więcej niż tylko brak transportu; ubóstwo transportowe charakteryzuje wiele powiązanych cech, w tym mobilność, dostępność, cenę oraz narażenie na czynniki zewnętrzne, takie jak zanieczyszczenie powietrza czy hałas. Ten wielowymiarowy aspekt Ogólnego Indeksu Ubóstwa Transportowego jest najcenniejszym i najbardziej obiecującym dla rozwiązywania problemów zubożenia transportowego wynikiem nie tylko tej rozprawy, ale wszystkich wcześniejszych wyników badań w tej dziedzinie na świecie. Po raz pierwszy autor stworzył praktyczne narzędzie i metodologię testowania oraz planowania równego, zrównoważonego i sprawiedliwego transportu w obszarach miejskich.

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