

Transport and gender inequality in public transportation in the 21st century

This paper presents 3Es (Efficiency, Effectiveness & Equity) framework for assessing and gaging the inclusion of women needs as users of the urban public transportation system. The 3Es framework involves assessment of levels of effectiveness, efficiency, and equity as three constituents of fairness features and also mechanisms of their application. A set of allocated fairness characteristics are used as inputs while the outputs are the key drivers for supporting fairer inclusion of women with the aim of increasing the satisfaction and the percentage of women using public transport services; hence, a better gender-equitable transportation system. The developed impact assessment framework provides a set of guidelines for transport professionals, policymakers and transport organisations on how to allocate resources to achieve transport equity and address gender gaps in the transportation system.

In diesem Beitrag wird ein 3E-Bewertungsrahmen (Efficiency, Effectiveness & Equity) zur Bewertung und fairen Berücksichtigung der Bedürfnisse von Frauen als Nutzerinnen des öffentlichen Nahverkehrs entwickelt. Der 3E-Bewertungsrahmen umfasst die drei Themenbereiche Effektivität, Effizienz und Gerechtigkeit als drei Merkmalsdimensionen von Fairness sowie deren praktische Umsetzung. Diese Fairness-Merkmale werden als Eingabegrößen verwendet, während das Ergebnis die Schlüsselfaktoren für eine gerechtere Inklusion von Frauen repräsentieren, mit dem Ziel, die Zufriedenheit und den Frauenanteil als ÖV-Nutzer zu erhöhen. Dadurch soll das öffentliche Verkehrsangebot geschlechtergerechter werden. Der entwickelte Bewertungsrahmen stellt einen Leitfaden für Verkehrsexperten, politische Entscheidungsträger und Verkehrsbetriebe dar, wie Ressourcen zugewiesen werden können, um mehr Mobilitätsgerechtigkeit zu erreichen und geschlechtsspezifische Ungleichheiten im öffentlichen Verkehrssystem zu beseitigen.

1 Introduction

Assessment of transportation schemes are often carried out using the concept of equity. Equity in transport and accessibility has been discussed in a number of dimensions such as social equity, vertical equity, horizontal equity, etc. (Geurs, Dentinho and Patuelli 2016). According to Di Ciommo and Shiftan (2017), the current tools and procedures used for assessing the impact of planned transport interventions (infrastructure and services) do not sufficiently address issues related to equity. The complexity of quantifying the impacts of travel behaviours on the environment and society makes the incorporation of equity mathematically challenging, as such issues related to equity are not addressed sufficiently in the appraisal and assessment of transport interventions and policies.

In this paper, we attempt to extend the existing impact assessment framework to incorporate transport equity concerns (Di Ciommo and Shiftan 2017). As a result, the framework will help transport organisations better understand the benefits of equitability of resource allocation and use. Based on a set of factors (fairness characteristics) which are relevant for improving women's inclusion in the railway public transport system, an assessment of interventions (fair-

ness measures) is made from the aspect of efficiency, effectiveness and equity. Therefore, the framework answers whether planned interventions are: i) Efficient (how productive are the measures proposed – how much does it cost to produce more inclusive transport systems?). ii) Effective (do the measures proposed produce the desired outputs, outcomes and gender-related benefits or impact?), and iii) Equitable (do the measures achieve the specific goals of addressing specific gender-related needs?). As a result, Bayesian Network based simulation approach generates an order of fairness measures hierarchized from the aspect of efficiency, effectiveness and equity. The paper structure includes the literature review, methodology, results and discussions and conclusion sections.

2 Literature review

Transport infrastructure, design and services are a mean to improve the general well-being of people by facilitating access to economic and social benefits, and thus should be designed to best meet the needs of people in general, and individuals in particular, taking into account gender, age, identity, culture, ethnicity, in ways that are equitable, affordable, and responsive to all groups

(Zhongming et al. 2019). Men and women have many common needs regarding access to and use of public transport systems. However, it has been noted that daily mobility patterns for women with primary care duties are generally more complex than men as they attempt to combine domestic and care giving tasks with paid employment, income-earning activities, and community and so-

■ Verfasser

Dr Augustus Ababio-Donkor

aadonkor@knust.edu.gh

Department Civil Engineering
Kwame Nkrumah University of
Science and Technology
GH-Kumasi

Prof. Wafaa Saleh

w.saleh@napier.ac.uk

Transport Research Institute
Edinburgh Napier University
10 Colinton Road
EH10 5DT
UK-Edinburgh

Prof. Milos Milenkovic

m.milenkovic@sf.bg.ac.rs

Prof. Nebojsa Bojovic

nb.bojovic@sf.bg.ac.rs

University of Belgrade
Faculty of Transport and Traffic Engineering
Vojvode Stepe 305
RS-11000 Belgrade

Figure 1: General Methodology for defining, clustering and hierarchizing the FCs

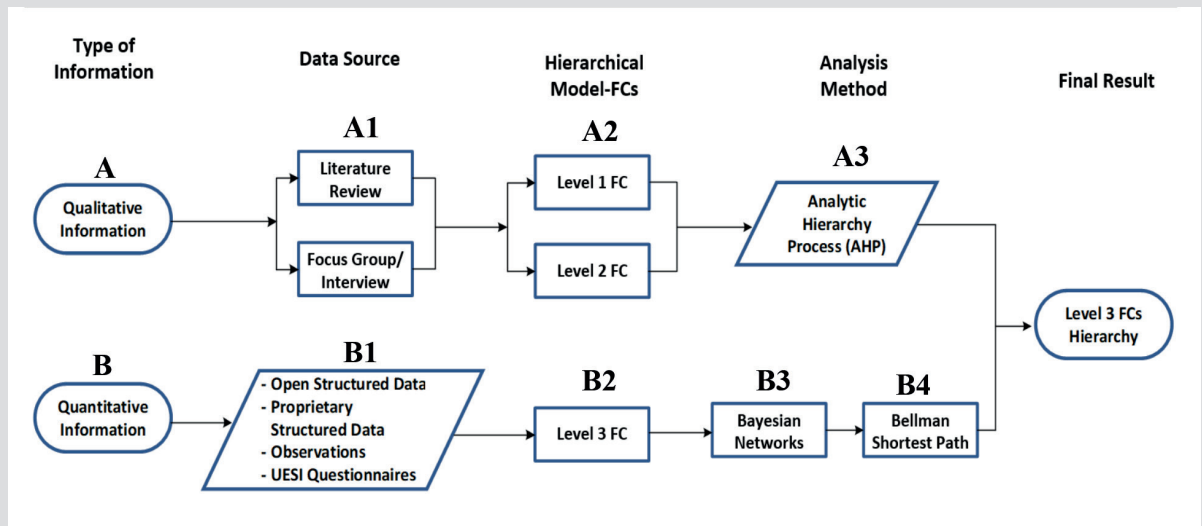
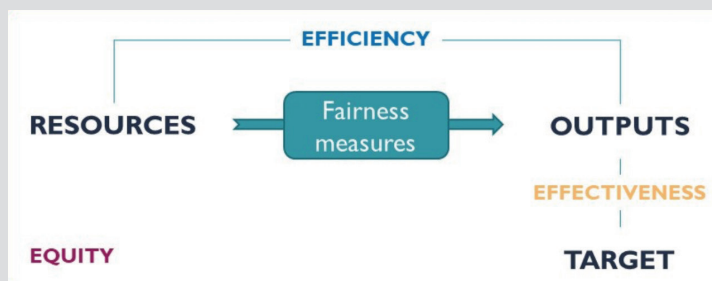


Figure 2: Efficiency, Effectiveness & Equity framework for inclusive transport system



cial obligations (Hjorthol 2008). It has also been highlighted that for many women their travel patterns involve more combined and frequent trips than those taken by men (Asian Development Bank 2013).

In a published UK's report, it was stated that 64 % of women of all ages experienced unwanted sexual harassment in public places, which is the same as in the USA. A survey in 2014 found that 65 % of women were harassed. Additionally, 35 % of women have experienced unwanted sexual touching (Kearl 2016), highlighting the importance of improving safety for women in the public transport system. Safety solutions should come from holistic approaches, better environment, better design, better interactions in the stations and in open spaces, rather than security approaches including camera surveillance, grids, situational prevention and defensible spaces that tend to create more anxiety than safety. Railway stations and connection corridors to subways and buses can cause anxiety that is related to safety perception, and lack of comfort and accessibility. More adaptation of infrastructure and services to women's needs is a key (Duchène 2011). Lowering the sense of anxiety is strongly related to urban design. Well-articulated actions could influence the sense of safety and the security of women

both as users and as security personnel, encompassing all equipment (lifts, ticketing machines, ticketing barriers, escalators, lights, doors, cameras, etc.). In a transport project developed in Liaoning (China), women defined some of the main problems of bus stops in their city, which were: lack of security when using buses, poor lighting, long waiting times due to infrequent services, lack of paths and pedestrian crossings to access bus stops (Duchène 2011). Martens (2017) defines fair transportation system as "a system that provides a sufficient level of accessibility to all under most circumstances". Current planning tools for transport infrastructure and services do not sufficiently consider equity and the complexity in identifying the impacts of travel behaviour on the society, environment and equity. Instead of using only Cost-Benefit Analysis (CBA) which does not account for equity, a combination of CBA with MCDM in single evaluation framework was proposed (Di Ciommo and Shiftan 2017 and Collier and Zhuang 2010). Travel time savings is still the main variable used in transport models which favours the well-placed in society. Lucas et al. (2019) proposed a set of different methods to support equitable decision making in transport. The authors suggested that equity analysis should be targeted at

the transport-poor who lacks the opportunities to access the needed transportation services and facilities and those whose mobility needs are not met by available services. Golany and Tamir (1995) suggested that public resource allocation should be based on the maximisation of social welfare, in relation to equity. The authors further proposed a three-dimensional model involving equity, efficiency and effectiveness (3Es) for resource allocation (Golany and Tamir 1995; Athanassopoulos 1998, 1995a). The 3Es approach has been used in different planning settings including transport, environment and healthcare (Aday et al. 1999; Andrews and Walle 2012; Davis et al. 2013) and agro-industry (Pasgaard et al. 2016). Martens (2007) proposed a new framework that incorporates equity analysis into the CBA framework. Pascual et al. (2010) analysed relationships between equity and efficiency in Payments for Ecosystem Services (PES) in order to account for equity issues (Martin et al. 2014).

However, to the best of the authors' knowledge there are no contributions that consider the development of an inclusive public transport system based on the 3Es perspective. Therefore, this paper performs equity analysis as part of the cost-benefit analysis (equity-efficiency-effectiveness analysis) to ensure a fairer public transport system.

3 Methodology

This section is divided into two subsections: Section 3.1 summarizes the process for defining, clustering and hierarchizing the Fairness Characteristics (FCs) while Section 3.2

discusses the proposed 3Es (Efficiency, Effectiveness and Equity) framework, which is the focus of this paper.

3.1 Hierarchy of Factors Influencing Gender Fairness

The methodology adopted for the definition, clustering and hierarchizing the factors or variables (Fairness Characteristics, FCs) influencing the mobility decision-making process of women with the objective of improving women's inclusion in the transport system is credited to Braun and Clarke (2006). The list of the most relevant Fairness Characteristics (FCs) or women needs was obtained from quantitative data analysis using Analytic Hierarchy Process (AHP) and machine learning techniques and from qualitative data analysis (through the interdisciplinary analysis, focus groups and semi-structured interviews). The most relevant Fairness Characteristics (FCs) were weighted and hierarchized using the AHP (Poveda-Reyes et al. 2021) and Bayesian Network (BN) analysis (Molero et al. 2021). For each FC, a set of interventions (Fairness Measures, FMs) were designed for implementation to ensure equity in the transport system. In order to, BNs were used to simulate the impact of FMs implementation. Inferences for assessment of measures for more inclusive public transport system were made by sampling with the Bayesian model that best fit the data. The best model was determined by calculating the Akaike Information Criterion (AIC) of each network (Molero et al. 2021): (Akaike 1974), where k represents the number of BN variables in the model and L is the maximum likelihood function, which estimates the goodness of fit of the BN model. The selection of the Bayesian model is based on criteria of lowest AIC. Then, by simulations of the selected BN model the evaluation of the impact of changes in influence of one variable on the probabilities of the values of other variables is performed. These simulations allow the calculation of effectiveness, efficiency and equity of the FMs as explained in the following section. The full details of the method used have been discussed in García-Jiménez et al. (2020), Santarremigia et al (2020), Molero et al. (2021) and Poveda-reyes et al. (2021), and will not be repeated in this paper. The general framework is summarised in Figure 1.

Effectiveness indicator with data filtered for women						
Fairness Characteristics						
Fairness Characteristics Code (FC Code)	Level 1 Fairness Characteristics	Level 2 Fairness Characteristics	Level 3 Fairness Characteristics	Fairness Measure	Most probable value BEFORE investment	Most probable value AFTER investment
FC316	Safety and security	Harassment	Complaint information point in case of violations to personal safety	Improve response time of security staff	7	8
Indicator calculation for FC316 – (Using data from Users and Employees Satisfaction Index–UESI survey)						
Probability to get a score between 1-4 BEFORE investment (P _{Low_Before})	Probability to get a score between 1-4 AFTER investment (P _{Low_After})	Gradient	Probability to get a score between 5-8 BEFORE investment (P _{High_Before})	Probability to get a score between 5-8 AFTER investment (P _{High_After})	Gradient	KPI
(A)	(B)	(C = B – A)	(D)	(E)	(F = E – D)	(G = F – C)
FC322 – UESI						
0.272031	0.101594	-0.170436	0.727969	0.898406	0.170436	0.340873
FC111 – UESI						
0.0727969	0.034211	-0.038586	0.927203	0.965789	0.038586	0.077172
FC115 – UESI						
0.247126	0.125344	-0.121782	0.752874	0.874656	0.121782	0.243565
FC116 – UESI						
0.130268	0.102363	-0.0279052	0.869732	0.897637	0.0279052	0.0558105
FC112 – UESI						
0.0728	0.06133888	-0.01145803	0.9272029	0.0265451	-0.9006578	0
FC315 – UESI						
0.197318	0.147954	-0.0493643	0.802682	0.852046	0.0493643	0.0987286
FC114 – UESI						
0.239464	0.125667	-0.113796	0.760536	0.874333	0.113796	0.227593
FC316 – UESI						
0.270115	0.235639	-0.0344762	0.729885	0.764361	0.0344762	0.0689524
					SUM KPI	1.1126945

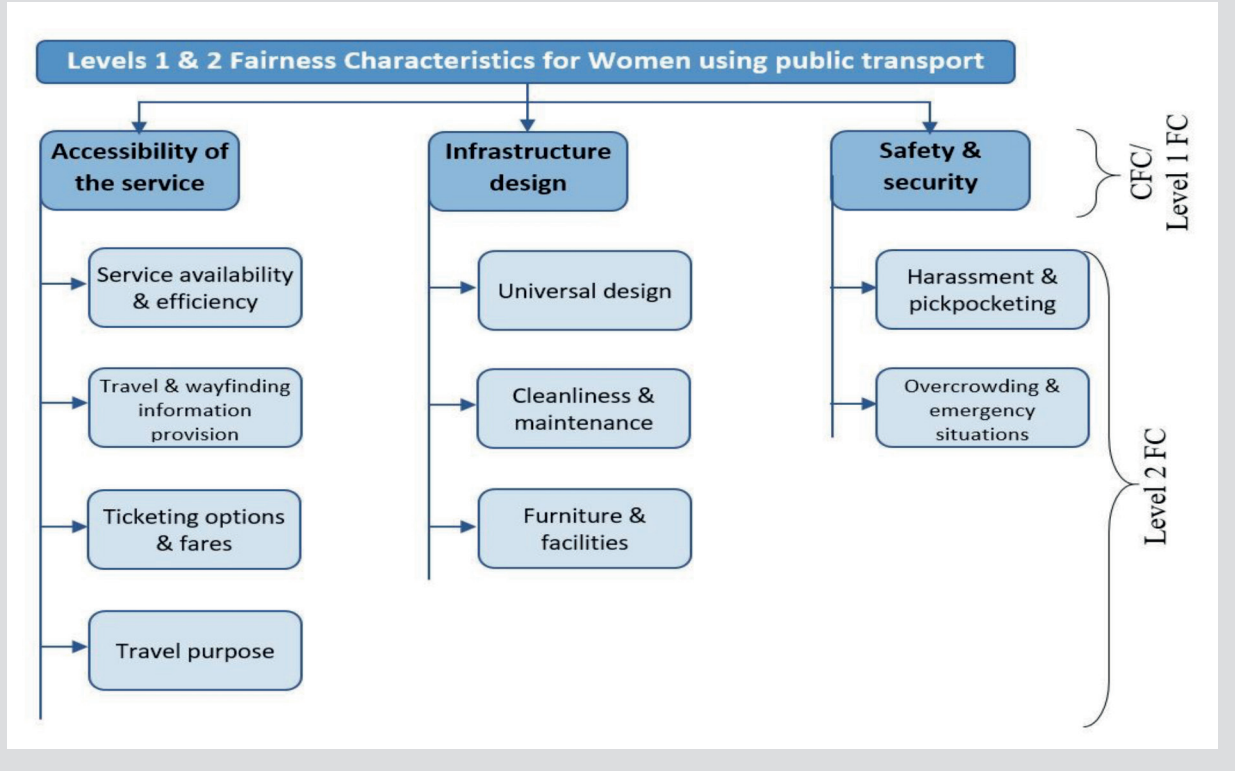
Table 1: Effectiveness indicator calculation

3.2 3Es-based framework for inclusiveness in public transport

The framework proposed in this section represents a comprehensive approach for identifying the interventions which should be implemented in order to improve the level of inclusion in the transport sector.

3Es framework is based on assessing the impact in three dimensions: Effectiveness, Efficiency and Equity. For each of these dimensions the set of fairness measures will be selected and estimated. Fairness Measures (FMs) represent the set of proposed interventions aimed to increase the fairness and inclusion from a gendered perspective in the

Figure 3: Fairness Characteristics (FC)



transport sector (Garcia-Jimenez et al. 2020). Fairness measures are defined based on prioritizing the most important needs and barriers (fairness characteristics (FCs)) women face as users of the transport systems. Figure 2 illustrates the concept of 3Es.

Evaluation of fairness measures through the lens of efficiency is conducted in order to check whether a specific fairness measure makes the best use of resources. Evaluation of effectiveness reveals if a fairness measure results in significant achievement of the project objectives. Finally, an equity focus can determine if resources are distributed across groups fairly (Aday et al. 2004). Efficiency or production efficiency (PE), is related to cost-effectiveness and measured by the ratio of produced outputs (i.e., service delivery) to the required inputs (such as labour, infrastructure, vehicle design, and capital investment) (Chen et al. 2019).

A. Calculation of the Effectiveness

Effectiveness represents the ratio of actual outputs (impacts generated by proposed measures and the a priori determined objectives). The main objective is to improve satisfaction of participants in transport systems (as passengers or as users). To obtain the effectiveness of one FM, we focus on how the implementation of a FM to improve

one of the top ten fairness characteristics (FC) influences the probabilities of the possible satisfaction scores of the other nine of top ten FCs for a specific profile. After instantiating the value of one Bayesian Network (BN) variable associated to the FC, we obtain the probabilities of the other 9 of the top 10 FCs variables before and after doing the investment in implementing the FM, defining the effectiveness indicator as the addition of the differences between these 2 probabilities for all these 9 Top 10 FCs. We instantiate the value of FC = 1 to the maximum satisfaction score, assuming the implementation of a Fairness Measure (FM) or recommendation:

$$\text{Effectiveness}_{\text{FM}} = \sum_{\text{FC}=2}^9 \text{Prob}_{\text{After}} - \text{Prob}_{\text{Before}}$$

Prob_{After} : Probability after implementation of fairness measure

Prob_{Before} : Probability before implementation of fairness measure

Practically, instead of:

$$\text{Prob}_{\text{After}} - \text{Prob}_{\text{Before}}$$

We use:

$$\nabla_{\text{Low}} = P_{\text{LowAfter}} - P_{\text{LowBefore}}$$

$$\nabla_{\text{High}} = P_{\text{HighAfter}} - P_{\text{HighBefore}}$$

Where:

∇_{Low} and ∇_{High} represent low and high gradient, respectively;

P_{Low} and P_{High} are probabilities of LOW sa-

tisfaction score (between 1 and 4) and High satisfaction score (between 5 and 8).

Therefore, the formula for the Effectiveness of FM is given by:

$$\text{Effectiveness}_{\text{FM}} = \sum_{\text{FC}=2}^9 \nabla_{\text{High}} - \nabla_{\text{Low}}$$

Table 1 presents the calculation of the Effectiveness indicator of fairness characteristics (FC316) for women (using only data filtered for women). The Effectiveness indicator of the FC for men is also calculated by repeating the process using data filtered for only men. Table 3 shows the effectiveness indicators for the top 10 FCs for women and men.

B. Calculation of the Efficiency

Efficiency represents the ratio between produced outputs and required inputs. Since the produced outputs in this specific application correspond to the value of effectiveness, efficiency can be estimated as the ratio between effectiveness and the total costs of a specific FM.

We assumed that all FMs represent point-input continuous-output investments, the cost is calculated by applying a capital recovery factor ($A/P, i \%, n$) where P present value of an investment in a fairness measure, A is equivalent annual value obtained for a constant interest rate $i = 5 \%$ and respective economic life of investment n .

Table 2: Hierar-
chized List of the
top 10 Fairness
characteristics

PROFILE: WOMEN as a Homogeneous Group						
FC Code	Level 1 Fairness Characteristics	Level 2 Fairness Characteristics	Level 3 Fairness Characteristics	Fairness Measures	Norm. Weight	Rank
FC321	Safety and security	Overcrowding	Offer adequate personal space	Staff present to provide real-time assistance to people who need assistance	0.03615	1
FC323			Improved layout of seating (longitudinal seating included less social interaction compared to transverse seating)	Improve seating design that fulfils the need and/or with appropriation given to pregnant women, persons/carers with toddlers, disabled persons, etc.	0.03022	2
FC322			Improved ventilation and air-conditioning	Improve cross-ventilation and air-conditioned environments suitable for different seasons	0.02843	3
FC111	Accessibility	Service efficiency and availability	Walking time from the points of interest to the public transport access points	Availability of information that indicate and allows access to key destination	0.02606	4
FC116			Integration with other modes of public transport including bus, train, alternative shared mobility service,...	Adapted connection paths and access points to all users (including people with reduced mobility, women with children...)	0.02606	5
FC316	Safety and security	Harassment	Complaint information point in case of violations to personal safety	Improve response time of security staff	0.02541	6
FC315			Visibility of the surrounding area of the station	Increase lightning in the stations and their surroundings	0.02525	7
FC115	Accessibility	Service efficiency and availability	Number of service available within the transport infrastructure	Display the next services in the station.	0.02507	8
FC112			Reliability of the available service modes	Coordinated timetables between the different transport modes in the stations.	0.02409	9
FC117			Integration with alternative shared mobility	Introduce special points/docks of shared mobility in each station	0.02409	10

Hence, the formula for the Efficiency indicator is given by:

$$\text{Efficiency}_{\text{FM}} = \frac{\text{Effectiveness}_{\text{FM}}}{\text{Cost}_{\text{FM}}}$$
; where Cost_{FM} represents cost of implementing the fairness measure.

C. Calculation of the Equity

The equity indicator is obtained as the ratio between the Effectiveness KPI for a specific profile of women and the same specific profile of men (For instance: Ratio between women and men with disabilities living in rural areas). Hence, the formula for the Equity KPI is given by:

$$\text{Equity}_{\text{FM}} = \frac{\text{Effectiveness}_{\text{FM}_{\text{Woman}}}}{\text{Effectiveness}_{\text{FM}_{\text{Men}}}}$$

Equity ratios higher than 1 indicate that the

implementation of a FM (recommendation) improves the satisfaction of women more than the satisfaction of men and close the gender-equity gap and therefore, more preferable. In contrary, equity ratio lower than 1 lead to unsatisfactory results.

4 Results and Discussion

The objective of this case study was to investigate women's needs and barriers as users of urban public transport infrastructures and services. The study applied the framework presented in the preceding sections of this report to identify the key drivers for supporting the inclusion of women as users to support the development of gender-equitable transport planning policies. More precise-

ly, the 3E-based framework is used to select the measures to increase the satisfaction and the percentage of women using metro and commuter railway public transports.

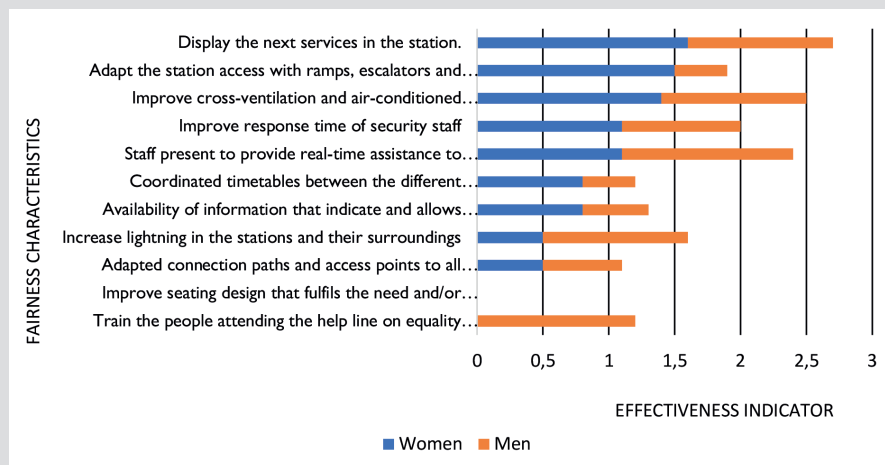
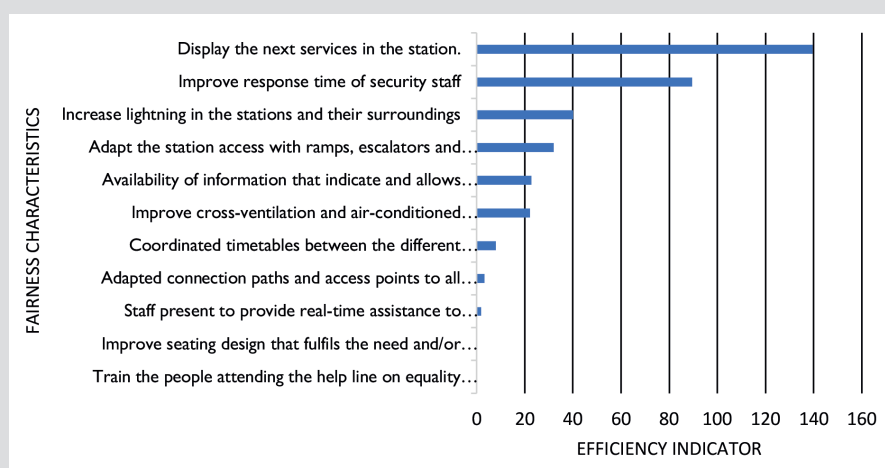
The data gathered from literature review focus groups discussion /interviews (Refer to Steps A1 and A2 of Figure 1) allowed the definition of three Cluster of Fairness Characteristics (CFC) or Level 1 FCs and nine Level 2 FCs using the chi-square test (García-Jiménez et al. 2020). Figure 3 shows the identified Level 1 and Level 2 FCs validated by a panel of experts.

Fairness characteristics (FCs) and Fairness Measures (FMs)

Fairness characteristics that reflect the preferences of women as users of public trans-

Table 3: Efficiency, Effectiveness & Equity (3Es) KPI for Public Transport – Railways

Fairness characteristics Code	EFFICIENCY, EFFECTIVENESS & EQUITY KPI				
	EFFECTIVENESS INDICATOR		EQUITY INDICATOR	COST (€/YEAR)	EFFICIENCY INDICATOR
	Women (A)	Men (B)	A/B	G	A/G
FC114	1.5	0.4	3.4	4610	32.0
FC115	1.6	1.1	1.5	121	1309.5
FC321	1.1	1.3	0.9	57600	1.9
FC322	1.4	1.1	1.2	6168	22.1
FC111	0.8	0.5	1.5	3560	22.7
FC116	0.5	0.6	0.9	16803	3.2
FC316	1.1	0.9	1.2	1190	89.5
FC315	0.5	1.1	0.5	1361	40.1
FC112	0.8	0.4	1.7	9393	8.1
FC323	0.0	0.0	0.0	613	0.0

**Figure 4:** Ranking of fairness measures by Effectiveness indicator**Figure 5:** Ranking of fairness measures by efficiency

FC (Fairness Measure). The top 10 FCs shown in the table are hierarchized by criterion weight. The results indicate that most women are concerned about their security and safety while using public transport services. Women prefer to have adequate personal space to avoid overcrowding. Having enough personal space reduces the likelihood of direct physical contact, groping, or leering at the station or while on the carriage by other passengers. Since the data was collected during the peak of covid-19, it is also believed that users' perception and needs might have been influenced by their concerns about infections and requirement for social distances. The top three highest ranked FCs are factors referring to level 2 fairness characteristics related to "overcrowding". The results indicate that women are more particular about their safety and security as well as the accessibility of public transport platforms and services.

The effectiveness of the proposed interventions in above for the associated FC is measured by the extent to which the FC achieves the specific objective of the case study (Table 4, Athanassopoulos 1998). Figure 4 illustrates the rank of fairness measures by their effectiveness indicators. Fairness measure (which corresponds to fairness characteristic FC115 => Display the next services in the station) represents the most appreciated improvement from the aspect of women, as well as in total (by combined satisfaction of men and women). Measures related to seating design (FC323) and the presence of supporting staff at the stations trained on equality and gender (FC318) are

port infrastructure were defined based on the methodology discussed in Section 3.1. Table 2 shows the top 10 Factors (level 3 FCs) out of 67 level 3 FCs obtained from both the qualitative and quantitative data

collected through AHP and BNs analysis, respectively. The table shows the level 1, level 2 and level 3 FCs for women as users of public transport services, including the proposed interventions to address each level 3

the least appreciated from the aspect of women.

Efficiency or production efficiency (PE), is related to cost-effectiveness and measured by the ratio of produced outputs (i.e., service delivery) to the required inputs (such as labour, infrastructure, vehicle design, and capital investment) (Chen et al. 2019). The study seeks to provide information on the possible resources required to implement each proposed fairness measure and which fairness measure is cost-effective in achieving the objectives of the case study (Athanasopoulos 1998).

Figure 5 summarises the 3Es computational results for all FCs in terms of efficiency. The highest efficiency is assigned to the fairness measure that enables an enhanced provision of train service related information in stations (FC115). Since this measure requires investments on a specific railway line or a network as a whole, it includes significant investments also. The least efficient are the measures related to seating design (FC323) and to training the supporting staff in stations (FC318).

In general terms, equity is related to how resources are distributed throughout society according to the needs of people (Athanasopoulos 1998; Murray and Davis 2001). The Equity Indicators indicates which of the proposed FMs promote fairness in the delivery of the transport service to all groups of women and the extent to which they contribute to the achievement of the defined objectives. The rationale is to advocate for investments and allocation of resources to implement the proposed interventions/FMs with the potential of benefiting the disadvantaged and closing the gender disparities in the delivery of transport services. The Equity indicator provides information for maximizing the fairness of distribution and minimizing disparities across groups such as disparities between racial, ethnic, age, and socioeconomic groups.

Figures 6 summarise 3Es computational results for all FCs in terms of equity. The ranking of FMs significantly differs from that of effectiveness and efficiency. In terms of equity, the most important are those measures related to appropriate station access (ramps, escalators and lifts for persons with disabilities) which corresponds to FC114, coordination of timetables between the different transport modes in stations (FC112) and the availability of information that indicates and allows access to key destination (FC111).

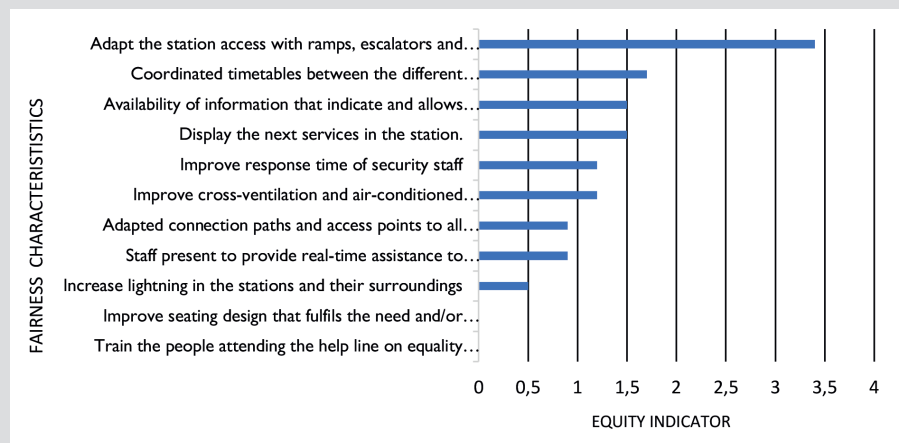


Figure 6: Ranking of fairness measures by equity

In terms of least preferred measures from the equity aspect, the situation is the same as in the case of efficiency and effectiveness indicators.

5 Conclusions

3E framework proposed in this paper answers whether planned interventions or fairness measures for higher inclusiveness in public transport are Efficient, Effective and Equitable. The results of the analysis suggest that women have accessibility challenges, which should be understood in the context of the family and caring responsibilities of women constructed by societal norms. Specific attention should be focussed on level of services (accessibility and availability), safety and security, and information provision. The key Fairness Characteristics (FCs) with the potential to deliver equity for women as users of public transport services relates to accessibility of the stations which corresponds to “FC114: Adapt the station access with ramps, escalators and lifts for users with special needs.”, “FC112: Coordinated timetables between the different transport modes in the stations.” and “FC111: Availability of information that indicate and allows access to key destination. The results further indicate that 20–80 % of the top 10 FCs changed in the hierarchized list, therefore the Top 10 FCs are sustainable in the mid-term. The results also show that 40 % of the Top 10 FCs for POLISH and SPANISH women are different for women using public transport services. We believe this could be due to the significant difference in the level of infrastructure between the POLISH and the SPANISH rail sector. Future research should be encouraged to re-

veal further understanding and achievement of fairer and gender equal public transportation system. Geographical differences and social factors should also be further investigated.

Reference

- Ad a y, L. A. et al. (1999): ‘A framework for assessing the effectiveness, efficiency and equity of behavioral healthcare’, *The American Journal of Managed Care*, (25–44)
- A k a i k e, H. (1974): ‘A new look at the statistical model identification’, *IEEE Transactions on Automatic Control*, 19(6), pp. 716–723. doi: 10.1109/TAC.1974.1100705
- A n d r e w s, R.; V a n d e W a l l e, S. (2012): *New Public Management and Citizens’ Perceptions of Local Service Efficiency, Responsiveness, Equity and Effectiveness (Working Paper 7)* (No. COCOPS Working Paper Nr 7)
- Asian Development Bank. (2013): *Gender tool kit: Transport*. Asian Development Bank. Retrieved from Link
- A t h a n a s o p o u l o s, A. D. (1998): ‘Decision support for target-based resource allocation of public services in multiunit and multilevel systems’, *Management Science*, 44(2), pp. 173–187. doi: 10.1287/mnsc.44.2.173
- B r a u n, V.; C l a r k e, V. (2006): ‘Using thematic analysis in psychology’, *Qualitative Research in Psychology*, 3(2), pp. 77–101. doi: 10.1191/1478088706qp063oa
- C h e n, Y. et al. (2019): ‘Assessing accessibility-based service effectiveness (ABSEV) and social equity for urban bus transit: A sustainability perspective’, *Sustainable Cities and Society*, 44(August 2018), pp. 499–510. doi: 10.1016/j.scs.2018.10.003
- D a v i s, P.; M i l n e, B.; P a r k e r, K.; H i d e r, P.; L a y - Y e e, R.; C u m m i n g, J.; G r a h a m, P. (2013): *Efficiency, effectiveness, equity (E3). Evaluating hospital performance in three dimensions*. *Health Policy*, 112(1–2), 19–27
- Z h u a n g, Z. Y.; C o l l i e r, P. M., *Resource Allocation Decisions in the Public Sector: A Model Based on a Study of Policing* (June 17, 2010). Available at SSRN: <https://ssrn.com/abstract=1626070> or <http://dx.doi.org/10.2139/ssrn.1626070>

- Di Ciommo, F.; Shiftan, Y. (2017): 'Transport equity analysis', *Transport Reviews*, 37(2), pp. 139–151. doi: 10.1080/01441647.2017.1278647
- Santarremigia, F. E., Poveda-reyes, S.; Molero, G. D.; Ababio-Donkor, A.; Gorini, A.; Hail, Y.; García, E.; Recio, L.; Leva, M. C. (2020): DIAMOND: D2.1 Use-cases Definitions: Vol. 3/2019
- Duchène, C. (2011): Gender and transport, International Transport Forum Discussion Paper, No. 2011-11, Organisation for Economic Co-operation and Development (OECD), International Transport Forum, Paris, <https://doi.org/10.1787/5kg9mq47w59w-en>
- García-jiménez, E. et al. (2020): 'Methodology for Gender Analysis in Transport: Factors with Influence in Women's Inclusion as Professionals and Users of Transport Infrastructures', *Sustainability*, pp. 1–34. doi: 10.3390/su12093656
- Geurs, K. T.; Dentinho, T. P.; Patuelli, R. (2016): 'Accessibility, equity and efficiency', in *Accessibility, equity and efficiency. Challenges for Transport and Public Services*, pp. 3–8
- Golany, B.; Tamir, E. (1995): 'Approach Evaluating Efficiency-Effectiveness-Equality Trade-offs: A Data Envelopment Analysis Approach', 41(7), pp. 1172–1184
- Hjorthol, R. J. (2008): 'Daily mobility of men and women: A barometer of gender equality', in Uteng T. P. and Cresswell T. (eds.), *Gendered mobilities*, Farnham, UK, Ashgate
- Kearl, H. (2016): The UK's First National Street Harassment Study. Available at: <http://stopstreetharassment.org/2016/03/uknationshstudy>
- Martens, K. (2007): Integrating equity considerations into the Israeli cost-benefit analysis Guidelines for practice
- Martens, K. (2017): 'Transport justice: Designing fair transportation systems', in *Transport justice: designing fair transportation systems*, p. 17. Available at: LINK
- Martin, A.; Gross-Camp, N.; Kebede, B.; McGuire, S. (2014): Measuring effectiveness, efficiency and equity in an experimental payments for ecosystem services trial. *Global Environmental Change*, 28, 216–226
- Molero, G. D.; Poveda-reyes, S. et al. (2021): 'Computational solutions based on bayesian networks to hierarchize and to predict factors influencing gender fairness in the transport system: Four use cases', *Sustainability (Switzerland)*, 13(20). doi: 10.3390/su132011372
- Murray, A. T.; Davis, R. (2001): 'Equity in Regional Service Provision', *Journal of Regional Science*, 41(4), pp. 557–600. doi: 10.1111/0022-4146.00233
- Pasgaard, M.; Sun, Z.; Müller, D.; Mertz, O. (2016): Challenges and opportunities for REDD+: A reality check from perspectives of effectiveness, efficiency and equity. *Environmental Science & Policy*, 63, 161–169
- Pascual, U.; Muradian, R.; Brander, L.; Gómez-Baggethun, E.; Martín-López, B.; Verma, M.; Polasky, S. (2010): The economics of valuing ecosystem services and biodiversity. *The economics of ecosystems and biodiversity: Ecological and economic foundations*, 183–256
- Poveda-reyes et al. (2021): 'Computational Solutions Based on Bayesian Networks to Hierarchize and to Predict Factors Influencing Gender Fairness in the Transport System: Four Use Cases', *Sustainability*
- Zhongming, Z.; Linong, L.; Xiaona, Y.; Wangqiang, Z.; Wei, L. (2019): Development Without Women Is Not Development: Why Gender Matters to the Asian Development Bank