13 IMPACT-2 methodology to include customer experience improvements in modal shift estimations

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13.1 Introduction

Traditionally, railway innovations have been evaluated based on their technical and economic improvements using key performance indicators (KPIs) such as improvements in capacity, punctuality, and life-cycle cost. Many innovations developed within the European-wide railway research programme Shift2Rail are however focused on improving the experience for railway customers, such as easier ticket booking, more and better information before, during and after the trip, and increased comfort with e.g., wireless internet connection during the trip. Such improvements are not captured by the traditional KPIs. To estimate the potential of Shift2Rail innovations to encourage modal shift and increase rail demand, customer experience improvements need to be included in modal shift analyses. In this paper, the methodology developed within the IMPACT-2 project regarding how to include customer experience improvements in modal shift estimations is described. Furthermore, challenges and constraints for the Customer Experience Model and Modal Shift Model within the IMPACT-2 setting are discussed.

13.2 Background – The IMPACT-2 project

As part of the cross-cutting activities of the Shift2Rail Joint undertaking (S2R), the IMPACT-2 project focuses, inter alia, on the analysis of the socio-economic impacts of the S2R innovations and their impact assessment through the implementation of Key Performance Indicators (KPIs) on System Platform Demonstrators (SPDs). Thereby, the project aims to develop SPD use cases, to carry out an integrated assessment of the S2R innovations based on three KPIs: life-cycle cost, capacity, and punctuality & reliability, as well as to estimate the effects of S2R innovations on customer experience and to calculate the modal shift from competing modes to rail resulting from the Shift2Rail innovations.

As shown in Figure 13-1, three models were developed within the IMPACT-2 project based on S2R objectives: the KPI model, the Customer Experience Model (CE Model), and the Modal Shift Model. The KPI Model estimates the impact of S2R innovations on the S2R targets of halving life cycle costs, doubling capacity and increasing punctuality by 50%. It is the aim of the KPI model to show the maximum achievable improvement as a priority for the respective KPI. In addition to the classic KPIs that focus on economic aspects of the S2R innovations, the Customer Experience Model was developed to consider secondary benefits in terms of customer

satisfaction. The Customer Experience Model specifically identifies areas with high potential for improvement, e.g., increasing the customer satisfaction for the use of the rail system. Finally, the Modal Shift Model was developed to reflect the impact of S2R innovations on the modal shift using the results of the other two models as input.

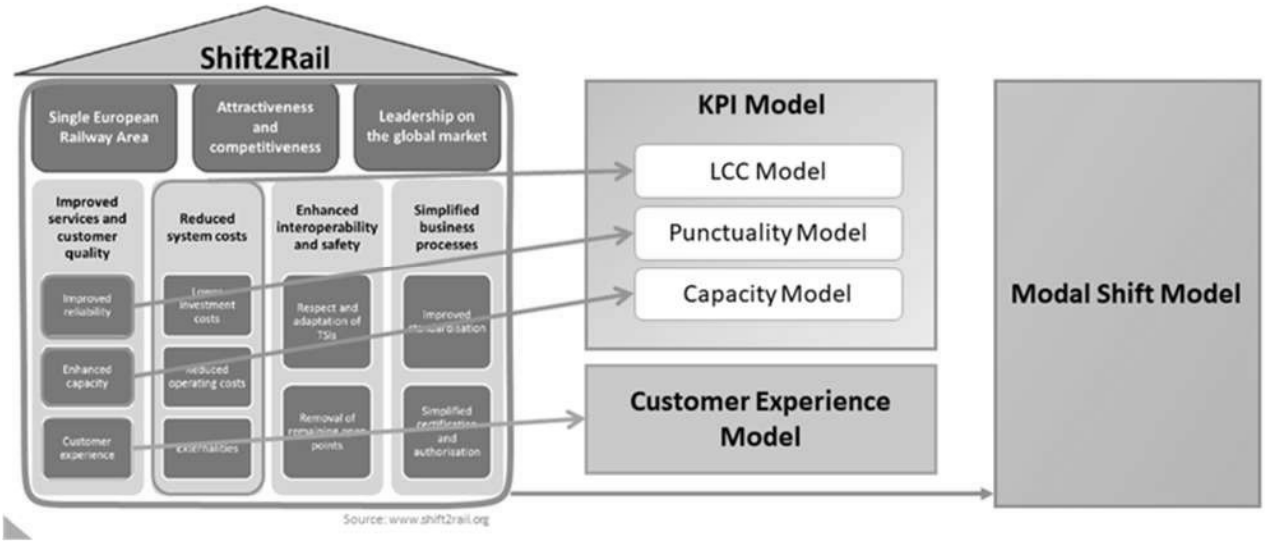

Figure 13-1: Overview of Shift2Rail objectives and the IMPACT-2 models.

13.3 Modelling of customer experience improvements

The interrelation between the three IMPACT-2 models is shown in Figure 13-2. The S2R innovations are developed in five Innovation Programmes (IPs). IP1, IP2, IP3, and IP5 are mainly evaluated for their economic impact in terms of LCC, capacity and punctuality through the KPI model. As IP5 deals with freight traffic only, it is not relevant for this paper. Innovations developed in IP4 (and some of the IP1-3 innovations) are assessed using the Customer Experience Model to determine the reduction of barriers for rail passengers. Finally, using the results from the KPI Model and the Customer Experience Model, the Modal Shift Model determines the outcome of the modal shift to rail transport due to the S2R innovations.

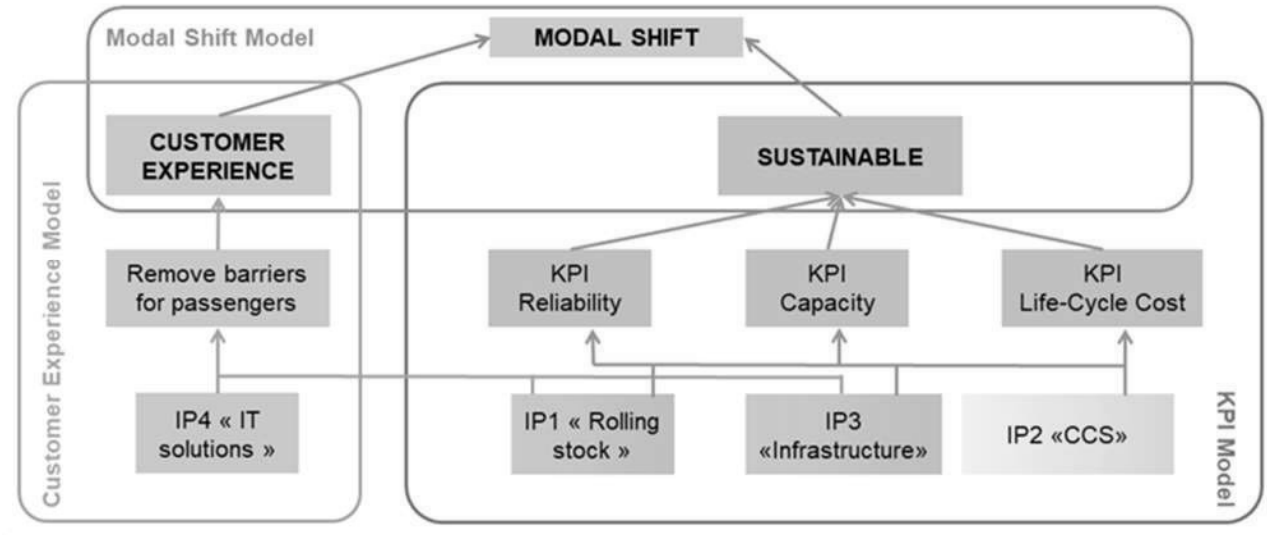

Figure 13-2: Interrelation between the IMPACT-2 models of Shift2Rail for passenger transport.

While Shift2Rail innovation programmes focus on projects' output (e.g., demonstrators, prototypes, reports, etc.), the IMPACT-2 project (part of the cross-cutting activities) concerns how Shift2Rail projects deliver value at the railway system level when combined all together. This approach allows to compute the benefits customers will take advantage and to assess the subsequent modal shift. The IMPACT-2 analysis is centred around four SPD use cases: high-speed passenger rail, regional passenger rail, metro, and rail freight. The Customer Experience Model is not developed for the rail freight SPD since the CE model focuses on passenger satisfaction. Therefore, the focus in this paper is on the first three of these SPDs.

When launching the IMPACT-2 project, a change has taken place in innovation thinking going from an emphasis on technical/economic value only to a broader societal value, i.e., how innovation is perceived from the customers' perspective. However, the connection between these two approaches was missing. The evaluation of customer experience improvements relates to the way customers respond to innovations. The existing literature on innovation management mainly focuses on:

- Value hypotheses (Reis, 2011): how innovation delivers value to customers when they are using it, and how to validate these hypotheses by setting up pragmatic tactics such as speeding up development cycle time with "fail fast" approaches, focusing on actual customers' behaviour rather than on what they are asking for, developing minimum viable products to field-test unfinalized products, dwindling batch sizes, etc.

- Growth hypotheses (Moore, 1991; Rogers, 1962): how innovation is spreading and how it is continuously deployed to meet the needs of increasing number of customers. Innovation lifecycle theories highlight the importance of upstreaming metrics on customer behaviour by building processes flexible enough to systematically test assumptions all over innovation lifecycles.

Innovation management literature focuses on innovative products and services showing a clear set of characteristics against which customer behaviour (willingness to pay -WTP) is assessed. The WTP acts as evidence that innovative products/services deliver value for customers, and it is then translated into financial metrics by feeding Business Models developed at the company level (by definition).

As these approaches (i.e. combining value hypotheses and growth hypotheses) do not fit the requirements of the task definition of IMPACT-2, the Customer Experience Model is based on a "project portfolio approach" which assesses additionality effects between barriers to improve customer experience and improvements in customer experience. Figure 13-3 shows the overall approach of the Customer Experience Model.

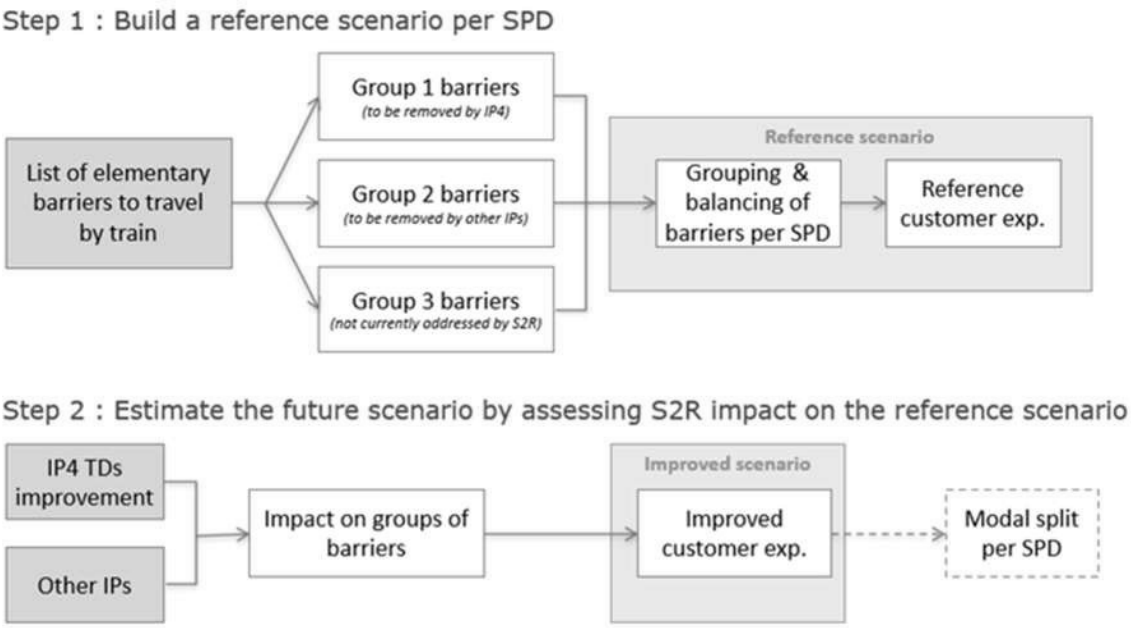

Figure 13-3: Overall approach of the Customer Experience Model of Shift2Rail.

In the first step, a baseline scenario per SPD was developed. Hence, a collection of 250 elementary barriers to travel by train was carried out and then allocated to three different groups, namely barriers that can be removed by IP4, barriers that can be removed by other IPs and barriers that are not addressed by S2R. Following in step two this grouping of barriers, so called "Areas of Major Potential Improvement (AMPIs) were determined and allocated into three CE variables: Booking & Ticketing, Information and Comfort & Service, as shown in Figure 13-4.

Booking and ticketing	Information	Comfort & services
Personalized booking	Real-time information	Train layout
Integrated ticket system	Travel assistant	Train noise
Multimodal shopping	Information on ancillary services	Station design
Simple ticket(s) purchase	Navigation pre/during trip	Station services
Offer adapted to my need	Support in disruption	
AMPIs related to IP4		AMPIs related to IP1 & IP3

Figure 13-4: From elementary barriers to AMPIs

In this process, the customer experience was broken down into its components to identify the data distribution.

ELEMENTARY BARRIERS			1= relevant to Group XXX, 0 = not relevant						
				Group1	Group2			Group3	
Obstacles	Activities	Source	Type	IP4	IP1	IP2	IP3	No	Us
Access with many luggage	Pre-trip	NEAR2050 Final conf	Access/exit to the station				1		1
Aggravating noise of trains breaking/ departing	On-Trip	Impact-1 DL 2.4			1				1
Annoying passengers	On-Trip	Impact-1 DL 2.4						1	1
Babycare services	On-trip	NEAR2050 Final conf	Services on board					1	1
Bad lighting	On-Trip	Impact-1 DL 2.4						1	1
Bad odors	On-Trip	Impact-1 DL 2.4						1	1
Bad Weather	On-Trip	Impact-1 DL 2.4							0
Barriers	On-Trip	Impact-1 DL 2.4					1		1
Bicyles transport	On-trip	NEAR2050 Final conf	Services on board					1	1
Bike defect	On-Trip	Impact-1 DL 2.4						1	1
Bike Path in bad condition	On-Trip	Impact-1 DL 2.4						1	1
Booking mistake	Pre-Trip	Impact-1 DL 2.4		1					1
Booking seat facilities	Pre-trip	NEAR2050 Final conf	Travel planning	1					1
Bus Station too far	On-Trip	Impact-1 DL 2.4						1	1
Bus Station too far	On-Trip	Impact-1 DL 2.4							0
Cafetaria	On-trip	NEAR2050 Final conf	Services on board					1	1
Check baggage	Pre-trip	NEAR2050 Final conf	Station services					1	1
Closseness from home to the station	Pre-trip	NEAR2050 Final conf	Access/exit to the station					1	1

Figure 13-5: Input data for the CE Model (i.e., components of the customer experience)

Subsequently, the input data was then quantified by determining the relative share of each barrier in customer dissatisfaction, setting this share to 100% in the baseline scenario. In the second step, the relative contribution of Shift2Rail projects to the reduction of these barriers (i.e., customer dissatisfaction) was determined. In the future scenario, the data collection process was standardised by centralising the data from the Shift2Rail innovation programme managers and collected on an annual basis. Figure 13-6, Figure 13-7, and Figure 13-8 shows the CE Model improvement values for the year 2021 for SPD1 high-speed, SPD2 regional, and SPD3 metro respectively. Nevertheless, it should be mentioned, that the outcomes of the Customer Experience Model must be taken with care due to the absence of real-life counterfactual scenarios and the correlation of improvements in customer experience with Shift2Rail projects implementation, allowing to retrieve growing numbers which cannot be verified ("vanity metrics").

S2R Ips	Unit	AMPI	Unit	Baseline	Improved
					59%
				100%	41%
IP1,2,3	%			19%	1%
Improved Confort and services		Station_Design	%	24%	0%
Improved Confort and services		Station_Services	%	53%	0%
Improved Confort and services		Train_Layout	%	12%	3%
Improved Confort and services		Train_Noise	%	12%	1%
IP4	%			81%	58%
Booking & Ticketing		Personalized_booking	%	9%	6%
Booking & Ticketing		Integrated_ticket_system	%	10%	6%
Improved Information		Real-time_information	%	14%	10%
Booking & Ticketing		Multimodal_shopping	%	9%	8%
Improved Information		Travel_assistant	%	11%	7%
Improved Information		Info_on_ancillary_services	%	7%	3%
Improved Information		Navigation_pre/during_trip	%	9%	7%
Improved Information		Support_in_disruption	%	15%	12%
Booking & Ticketing		Simple ticket(s)_purchase	%	10%	6%
Booking & Ticketing		Offer_adapted_to_my_need	%	8%	5%

Figure 13-6: CE Model Improvement values for SPD1

S2R Ips	Unit	AMPI	Unit	Baseline	Improved
					59%
				100%	41%
IP1,2,3	%			19%	1%
Improved Confort and services		Station_Design	%	26%	0%
Improved Confort and services		Station_Services	%	58%	0%
Improved Confort and services		Train_Layout	%	8%	4%
Improved Confort and services		Train_Noise	%	8%	3%
IP4	%			81%	58%
Booking & Ticketing		Personalized_booking	%	9%	6%
Booking & Ticketing		Integrated_ticket_system	%	10%	6%
Improved Information		Real-time_information	%	12%	9%
Booking & Ticketing		Multimodal_shopping	%	11%	9%
Improved Information		Travel_assistant	%	12%	8%
Improved Information		Info_on_ancillary_services	%	6%	3%
Improved Information		Navigation_pre/during_trip	%	10%	7%
Improved Information		Support_in_disruption	%	14%	12%
Booking & Ticketing		Simple ticket(s)_purchase	%	10%	7%
Booking & Ticketing		Offer_adapted_to_my_need	%	7%	5%

Figure 13-7: CE Model Improvement values for SPD2

S2R Ips	Unit	AMPI	Unit	Baseline	Improved
					55%
				100%	45%
IP1,2,3	%			25%	1%
Improved Confort and services		Station_Design	%	28%	0%
Improved Confort and services		Station_Services	%	63%	0%
Improved Confort and services		Train_Layout	%	5%	1%
Improved Confort and services		Train_Noise	%	5%	3%
IP4	%			75%	54%
Booking & Ticketing		Personalized_booking	%	6%	4%
Booking & Ticketing		Integrated_ticket_system	%	11%	7%
Improved Information		Real-time_information	%	11%	8%
Booking & Ticketing		Multimodal_shopping	%	14%	12%
Improved Information		Travel_assistant	%	10%	7%
Improved Information		Info_on_ancillary_services	%	3%	1%
Improved Information		Navigation_pre/during_trip	%	13%	10%
Improved Information		Support_in_disruption	%	13%	11%
Booking & Ticketing		Simple ticket(s)_purchase	%	14%	9%
Booking & Ticketing		Offer_adapted_to_my_need	%	5%	3%

Figure 13-8: CE Model Improvement values for SPD3

Decreasing the barriers to travel by train to 0 at the end of Shift2Rail would not suggest that there are no more barriers but only that all barriers clustered in group 1 and group 2 (compare Figure 13-3) have been removed. This is likely an underestimation of the effect of Shift2Rail on customer experience since the implementation of additional projects ("IKAA") that also contributes to the Shift2Rail Master Plan (Shift2Rail JU, 2019) are not taken into account in group 1 and group 2 barriers.

13.4 Including customer experience in the IMPACT-2 Modal Shift Model

As was discussed in the previous section, the customer experience improvements developed within the IMPACT-2 project are aggregated into three variables: Booking & Ticketing, Information, and Comfort & Services. These customer experience variables are not only result output but also inputs to the IMPACT-2 Modal Shift Model, along with the KPI variables (IMPACT-2, 2019) for reduction of average delay (punctuality), improvement in maximum usable track capacity (capacity) and reduction of track and operational costs (life-cycle cost), see Figure 13-9.

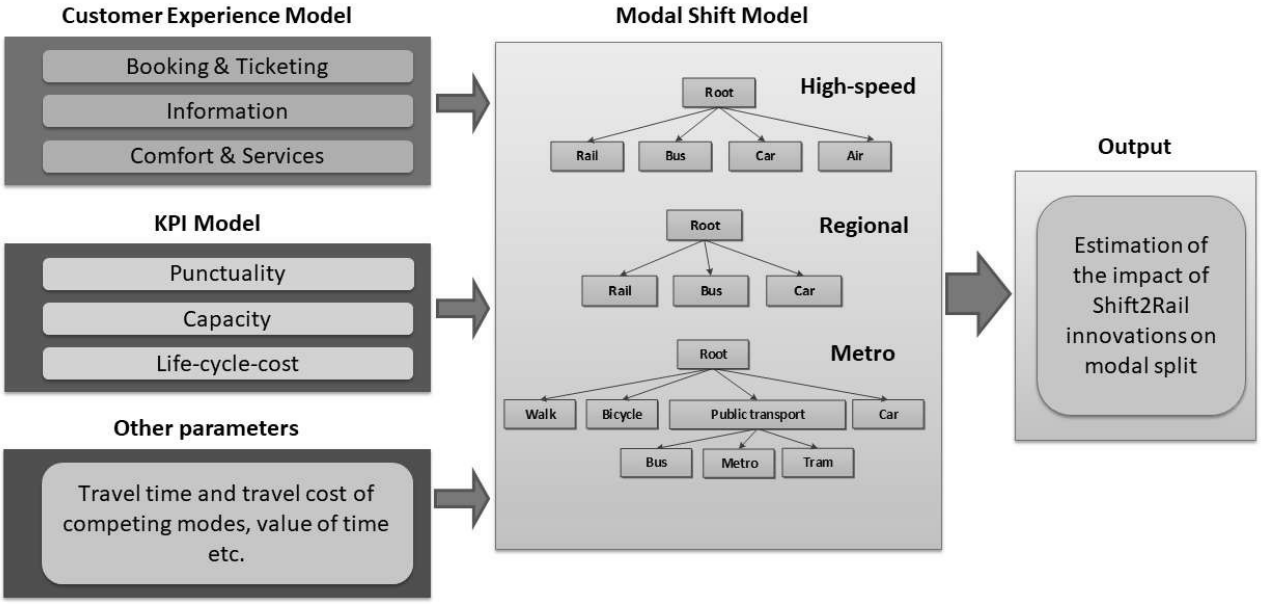

Figure 13-9: Overview of the IMPACT-2 Modal Shift Model for evaluation of Shift2Rail innovations' effects on modal split.

In the IMPACT-2 Modal Shift Model, discrete choice logit models (McFadden, 1974; Train, 2003) are utilized to determine the number of passengers choosing rail in situations with and without Shift2Rail innovations. This way, the Shift2Rail innovations' effects on modal shift can be assessed. The modal shift analysis is conducted for the three different passenger SPDs described in Section 1. Competing modes differ depending on the SPD, e.g., long-distance bus, car, and air are the competing modes in the high-speed use case, see Figure 13-9.

For the IMPACT-2 SPD use cases, utility functions were set up which include customer experience variables, as well as traditional level-of-service variables such as travel time, waiting time, and travel cost. Customer experience variables were included as nominal variables, which are 1 in the baseline and 2 in the Shift2Rail situation, which corresponds to 100% improvement of customer experience barriers (see Section 2). An improvement from Shift2Rail innovations regarding e.g., Booking & Ticketing will thereby increase the utility of rail for the traveller compared to the utility of competing modes. It should be mentioned that the SPD use cases within IMPACT-2 are railway corridors and as such specific: the high-speed use case refers to a high-frequency line in a dense area where demand exceeds capacity, the regional use case is a low-frequency line with capacity limitations at one of the nodes, and the metro use case refers to a line which is already optimised capacity-wise. The possibilities for a metro demand increase

is therefore limited. There are many other types of lines in Europe and the effect of improving customer experience will differ depending on the specific SPD use case. Also, from a customer perspective, the whole trip from door-to-door is important. This is only partly considered in the Modal Shift Model by including average measures of access/egress opportunities and waiting times. For example, none of the SPD use cases included an interchange between two trains.

As there were no possibilities to conduct a large travel behaviour survey within the project IMPACT-2, the valuation of improvements in travel time, waiting time and travel cost consequently are taken from standard values used in national planning. Therefore, the variation in preferences across travellers due to e.g., different socio-economic situations are not considered. Three different standard value of time sets were used as a sensitivity analysis, reflecting the conditions in France, Sweden, and the Eastern European Union (EEU). The valuation of improvements in customer experience variables in comparison to travel time and travel cost improvements was taken from an expert workshop conducted during the IMPACT-2 project. In the workshop, descriptions of the current as well as the improved (Shift2Rail) situation for Booking & Ticketing, Information, and Comfort & Services were presented to the experts. On the example of Comfort & Services in the high-speed use case, the improved situation included WIFI, more comfortable seats, noise and vibration mitigation systems, accessibility for all passengers, shopping facilities in the stations, improved signs with route information, and more seats in the stations. The experts were then asked to state the maximum increase in ticket price that would make them prefer the improved service, i.e., the willingness to pay. Due to the limited participation of experts, the monetary valuation of the customer experience variables was validated against available literature on related customer improvements studies (Cartenì et al., 2017; Jou et al., 2013; Watkins et al., 2011). The validation showed similar levels on the monetary valuation of customer experience improvements when the workshop results were compared to valuations from literature.

As three different sets of valuations for value of time, but only one set of valuations for customer experience improvements from one workshop were compared in a sensitivity analysis, the results seemed to show larger effects of customer experience improvements in an EEU setting compared to the French and Swedish setting. In order for the values to be comparable, workshops on the monetary valuation of customer experience improvements need to be conducted for EEU conditions. These workshops could not be carried out within the framework of IMPACT-2.

13.5 Discussion

With the CE model a tool has been developed which has been tailored to the needs of IMPACT-2. Within the given time and budget, it fulfils the requirements of capturing the improvements of the qualitative KPI developed in the IPs. Nevertheless, there is room for improvement. The approach of the Customer Experience Model is difficult to extend to the whole Shift2Rail programme due to several reasons:

The first reason is overlapping/missing data. The architecture of the Shift2Rail programme has been designed from a technology-provider perspective and therefore, the impact of each single Shift2Rail project on customer experience may be direct, indirect, or interrelated with other

projects. Moreover, improvements in customer experience often result from several innovations being deployed altogether and establishing links with each single Shift2Rail project is difficult.

Second, the CE model interacts with two other models (i.e., the KPI Model and the Modal Shift Model) which both assume Shift2Rail innovations are fully deployed (i.e., comparing the railway systems in 2013 and 2050) to upstream data on the Shift2Rail "high-level KPIs". This approach set boundaries for the developed CE model that are contrary to existing literature on innovation management which focuses on phasing the deployment of innovations across different user groups, such as innovators/early adopters/early majority/late majority/laggards (Moore, 1991), over time to ensure gradual market uptake. Customer experience is therefore challenged between two extreme cases: The baseline railway system in 2013 (without Shift2Rail innovations) and the improved railway system when all Shift2Rail innovations are fully deployed. In the absence of simultaneous counterfactual situations to compare customer experience with, it is not possible to in-field measure how customer experience will improve (i.e., no ability to set test-group/control-group) and it must be considered that customer preferences (i.e., distribution data) remain constant over time.

Furthermore, the modelling activities of IMPACT-2 have been designed to assess baseline/improved scenarios among 3 different passenger transport use cases (called "System platform demonstrators – SPDs", see Section 13-1). SPD characteristics have been described in previous IMPACT-2 deliverables, but these characteristics are technical/economic, and they foresee no data on customer profiles and behaviours. Given the inability to carry out customers surveys on virtual scenarios (by definition), it is therefore not possible to upstream real-life customer data into the modelling activities.

Additionally, assessing customer experience entails using appropriate metrics (and changing metrics if customers find valuable changes over time) for each customer group (different customer groups may have different preferences and different sensitivity to the outcomes of innovation projects). But market surveys meeting such requirements would be expensive and would generate significant input data, thereby raising the issue of comparability (how to capture meaningful insight into all input data at the railway system level?). Within IMPACT-2, the output of the customer experience must be reduced to a low number of manageable variables (three) to be subsequently integrated into the Mode Choice Model, see the green box with CE variable inputs in Figure 13-9.

Assessing improvements in customer experience entails to quantify current customer experience, which requires extensive data on the one hand on customers' profiles which may vary geographically, e.g., from one country to another, from one railway line to another, etc and on the other hand on customers' behaviour which may vary with time, especially as the Shift2Rail programme extends over eight years.

Moreover, the systemic nature of the railway industry (rolling stock, infrastructure, CCC systems) and the number of stakeholders involved in delivering/operating the system components makes it difficult to upstream data on how customer experience will be improved by Shift2Rail innovation programmes because:

- Deploying innovation projects in the railway industry requires long incubation/development processes before being able to launch the industrialization phase. This phasing of activities and their duration hardly allow to follow up and upstream KPI on customers experience over the innovation projects' lifetime (up to 15-20 years).

- Ability to upstream indicators on customer experience is limited by:

    - Legal issues such as Intellectual Property Rights on projects' results for each stakeholder participating in the Shift2Rail programme.

    - Confidentiality issues such as sharing sensitive data on customer profiles and preferences with other stakeholders involved in the same industry (and necessity to monitor each single data flow).

    - The number of barriers to customer experience that have been identified within the IMPACT-2 project (around 250 different barriers, 130 of which could be dealt with by at least one of the Shift2Rail projects).

The CE model developed within the framework of the IMPACT-2 project faces the difficulty to merge various input parameters – some of which interrelate with each other – into a consistent model interconnected with two other models. In order to circumvent these difficulties, the model is based on several simplifications related to its general architecture (simplification related to the innovation lifecycle process), to its input data (simplification of the distribution of barriers to customer experience) and to its improvement data (S2R projects' contribution to address these barriers).

13.6 Conclusions

In this paper, the methodology developed within the IMPACT-2 modelling system for capturing customer experience improvements has been shown when conducting modal shift analyses of railway innovations. Furthermore, challenges and constraints when developing the models have been discussed.

Estimation of modal shift effects arising from future implementation of railway innovations is a very complex topic and several simplifications need to be made to be able to conduct such an analysis, specifically when data availability is scarce. Early in the IMPACT-2 project it was however realized that customer experience improvements were important for modal shift and needed to be included in the analysis. This is supported by the results of the Modal Shift Model (IMPACT-2, 2020) showing that customer experience improvements have substantial impacts also in relation to the more traditional KPI variables such as capacity, punctuality and life-cycle cost.

Regarding lessons learnt from including customer experience improvements in modal shift analyses, it seems as though the aggregation of customer experience variables into three major areas was a wise choice, since combined with three SPD use cases, it still gives rise to nine different monetary valuations of improved offers to the customers, for which data had to be

provided. The method to include customer experience improvements in modal shift analyses has been described in this paper and seems to work well. It should however be noted that the methodology is simplistic in many ways and can in the future be improved by:

- Considering the dynamics of uptake of customer experience innovations over time – not only the baseline and full deployment situations
- Including a larger variety in customer preferences/valuations instead of using standard national valuations
- Focusing more on the whole journey, i.e., door-to-door travel
- Considering a larger set of use cases that reflects conditions on more lines in Europe

Although the method described in this paper has its drawbacks, it manages to combine both traditional KPI measures and more novel customer experience measures concerning the attractiveness of the railway journey, into inputs for modal shift estimations, showing the importance of development of both technical and passenger-oriented innovations, in order to increase the competitiveness of European rail.

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