The effects of increased rail access charges on intercity rail price and supply

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1. Introduction

The European Commission has over the past decades promoted a vertically separated railway market, where rail operators are separated from the public infrastructure manager. In deregulated railway markets, rail access charges that accurately reflect the marginal social cost are indispensable for giving the rail operators the right incentives when determining key variables, such as frequencies and fares. Yet, many countries, for instance Sweden or the UK, have track charges far below the marginal social cost (Nash et al. 2018). One of the reasons to why some countries apply lower than optimal track charges is the notion that fares would otherwise increase and supply decrease. In this paper, we explore how track charges affect frequencies and fares set by the rail operator.

The very few studies (for instance Sanchez-Borrás et al. 2010 and Ljungberg, 2013) that assess the effects of rail access charges on market prices and demand assume that increases in charges are explicitly passed on to the consumers in form of higher fares. However, no study has explored if and how fares are connected to changes in track charges in a deregulated railway market. Price increases will generally depend on the monopolistic power of the operator. On-track competition is generally scarce in the railway sector but can still be found in some corridors. Still, irrespective of the intra-modal competition, an operator will always face competition from other modes of transportation. Therefore, to assess whether an operator will increase prices and decrease supply, the railway market ought to be studied in relation to other modes and not in isolation. This study explores how the impact of track charges depend on the competition between different modes.

We set up a demand-supply model calibrated with data from the Stockholm-Gothenburg corridor which is operated by commercial operators (similar models include Parry & Small, 2009; Basso & Silva, 2014; Tirachini, et al, 2014 and Börjesson, et al, 2017). Corridors operated by profit-maximizing operators have so far been neglected within the transport optimal pricing literature, mainly due to the lack of ticket price data which commercial operators consider confidential. Our contribution to the literature is that we use a unique set of price data collected from operators' websites from Vigren (2017) which enables us to analyse and compare optimal fares and frequencies set by commercial operators.

2. The model and data

The operator's optimal rail supply and fares are modelled by calibrating a demand and supply model with three modes (car, bus, air, and rail) in the corridor between the two largest cities of Sweden. We categorize two demand segments (business and private travellers) and we include peak and off-peak periods. For the demand calculation, a nested logit model structure is used with time of the day choice on the upper level and mode choice on the lower level. The utility function $U_{qm}^{j} = V_{qm}^{j} + \epsilon$ expresses preferences of user group j in period q using mode m where the generalized cost is

$$V_{qm}^{j} = \frac{1}{\mu^{j}} (\theta_{qm}^{j} + p_{qm}^{j} + t_{qm}^{j} + w_{qm}^{j} + a_{qm}^{j}). \quad (1)$$

μ^{j} is the marginal utility of income for demand segment j, θ_{qm}^{j} represents the alternative-specific constant, p_{qm}^{j} is the monetary cost of the trip, t_{qm}^{j}, w_{qm}^{j}, and a_{qm}^{j} represent the total in-vehicle travel time cost, total waiting and scheduling delay cost and the total access cost.

To illustrate the effect of implementing higher rail access charges, we calculate profit- maximizing fares and frequencies under different levels of charges. The rail access charges applied today for the Stockholm-Gothenburg corridor internalize the maintenance cost. However, the cost of congestion on the rail tracks is not included. There are indications that the marginal crowding cost on Swedish railways to be as large as 200-500 percent of the current track charge τ_q^0 (Ait-Ali et al., 2020). Since the marginal crowding cost is uncertain, we simulate several scenarios assuming marginal crowding cost within this broad range.

Since we model a commercial line in a deregulated railway market, we are interested in capturing the behaviour of the profit-maximizing operator. We set up the optimization problem such that the train operator maximize its producer surplus PS. Decision variables are rail fares $p_{q,m=r}^{j}$ (four variables) and train frequencies $f_{q,m=r}$ (two variables) where the train frequency is constrained to take only integer values. The objective function is

$$PS_{m=r} = \sum_{jq} D_{q,m=r}^{j}\, p_{q,m=r}^{j} - \sum_{q} k_{q,m=r}\, f_{q,m=r}, \tag{2}$$

which corresponds to the rail operators' revenues and costs. $k_{q,r}$ is the operating cost for rail and includes costs for rail access charges τ_q. We simulate following scenarios:

Scenario (1a). Optimization of PS with current rail access charges, $\tau_q = \tau_q^0$.
Scenario (1b). Optimization of PS, assuming that rail access charges are two times higher than current rail access charges, $\tau_q = 2\tau_q^0$.
Scenario (1c). Optimization of PS, assuming that rail access charges are five times higher than current rail access charges, $\tau_q = 5\tau_q^0$.
Scenario (1d). Optimization of PS, assuming that rail access charges are five times higher in peak, $\tau_{q=p} = 5\tau_q^0$; and two times higher in off-peak, $\tau_{q=o} = 2\tau_q^0$.

The first step of the optimization problem is to calibrate the model for the Stockholm-Gothenburg corridor, with current demand, fares, frequencies and rail access charges. We calibrate the mode choice constants θ_{qm}^{j} by using least square, such that the current user equilibrium is retrieved given the current demand and fares. The data for demand and fares are obtained from, among others, the Swedish Transportation Administration, Vigren (2017) and Swedish Transport Agency (2015). Rail operator costs are based on data from the official Swedish CBA guidelines (Swedish Transport Administration, 2018) and the values of time are from Börjesson & Eliasson (2014) and Börjesson (2012), adjusted to present monetary value.

3. Results

Table 1 presents the results of each scenarios' optimization problem where the optimal outputs are given at the top of the table, followed by the change in consumer surplus obtained from the logsums, operators' revenues and operating costs, track charges, number of travellers for each mode and the train occupancy. For a comparison, the baseline parameters used in the model calibration are given in the first column.

The results identify several important findings. First, increased charges have a small effect on rail fares. A closer comparison reveals that the operator is increasing fares for private travellers but reducing fares for business travellers. In scenario (1c) for instance, where charges are at their highest, optimal fares for private travellers increase with 5 percent in peak and stay unchanged in the off-peak. For business travellers however, the opposite is the case: optimal fares decrease with 7 percent in peak and 13 percent in the off-peak. This is explained by the decline in frequency. In the particular case of scenario (1c), frequency declines with 9 departures/day, corresponding to a 30 percent decline comparing to (1a). The decline in frequency leads to longer waiting times between departures and increases the scheduling delay cost for the consumers. Hence, in order to attract more rail transit users, it will be optimal for the operator to reduce the business fare. In this way, the user group that the operator can make most profits on (business travellers) are not enticed to other modes. Considering the large increase in operators' costs due to the increase in rail access charges (for instance, in 1c, the rise in rail access charges cause a 72-percentage increase in the total operating cost comparing to the baseline), the charges in fares are quite modest. The effect on frequency is, on the other hand, more substantial. Number of departures are reduced by 8, 30 and 20 percent in scenarios (1b), (1c) and (1d) respectively.

Another finding is that number of rail trips decline with increased charges. Total number of rail trips decline with 5 percent in (1b), 18 percent in (1c) and 12 percent in (1d). As expected, reductions in rail passenger volumes are larger in (1c), given the more vigorous increases in charges. In (1d), the time-differentiated charges even out passenger volumes across the two periods as rail travellers move from the peak to the off-peak (46 percent of total number of trips are in off-peak now, comparing to 39 percent in baseline). The modal splits indicate that rail continues to have the largest market share despite increases in rail access charges.

Moreover, profits are declining with increased rail access charges. Profits drop with 18k, 59k and 43k in scenarios (1b), (1c) and (1d) respectively (corresponding to 12, 40 and 30 percent decline). This is due to: i) the revenue downturn caused by the decline in frequency and thus by the decline in number of rail trips; and ii) the increase in total operating cost due to the increase in rail access charges. From the results above, we can therefore conclude that increased charges will have a larger effect on operator's profits, than on the fares payed by the consumers. Since consumers have preferred departure times, a commercial operator will strive to set the train frequency so that it captures as many passengers as possible. If the operator's costs increase, in our case with increased rail access charges, the operator will simply cut the most unprofitable departures, rather than increasing fares. The operator will also reduce prices for certain groups to counteract the increase in the waiting and scheduling delay cost. The competitive position of the alternative modes plays a large role in the setting of prices, which we show with our sensitivity analysis.

3.1. Sensitivity analysis: The role of air traffic, autonomous cars and longer trains

We define three additional scenarios to explicitly assess the effects of increased or decreased intermodal competition and the implications of running longer trains.

Air traffic. In scenario (2a), we effectively eliminate the air mode by increasing the generalized travel cost for air to the extent that no travellers choose air. The scenario could represent a scenario without air mode or were air has been outcompeted. We assume current track charges and optimize PS. As expected, the reduction in competition results in rail fare increases. Fares in (2a) increase across user groups and periods (compared to scenario 1a). For private trips the fares increase with 9 and 11 percent. For business trips, fare increases are higher, between 17 and 26 percent. This is because business travellers are less price sensitive and the air mode is of higher importance for them. The optimal frequency increases and is 17 departures/day in peak and 12 departures/day in the off-peak. The train occupancy rates increase slightly due to the higher rail ridership. Closer inspection of the number of trips in scenario (2a) show that rail trips increase, but not as much as car and bus trips. Modal splits show that for private peak, modal share for car increases with 15 percentage points while the modal share for rail increases only with 5 percentage points. Still, rail counties to have the largest market share in the corridor. Due to the increased number of departures, higher fares and thus higher demand for rail, operators' profits increase. Comparing to the reference scenario, profits increase with 63 k and are highest in relation to the rest scenarios. This results to a negative change in consumer surplus.

Table 1. Results

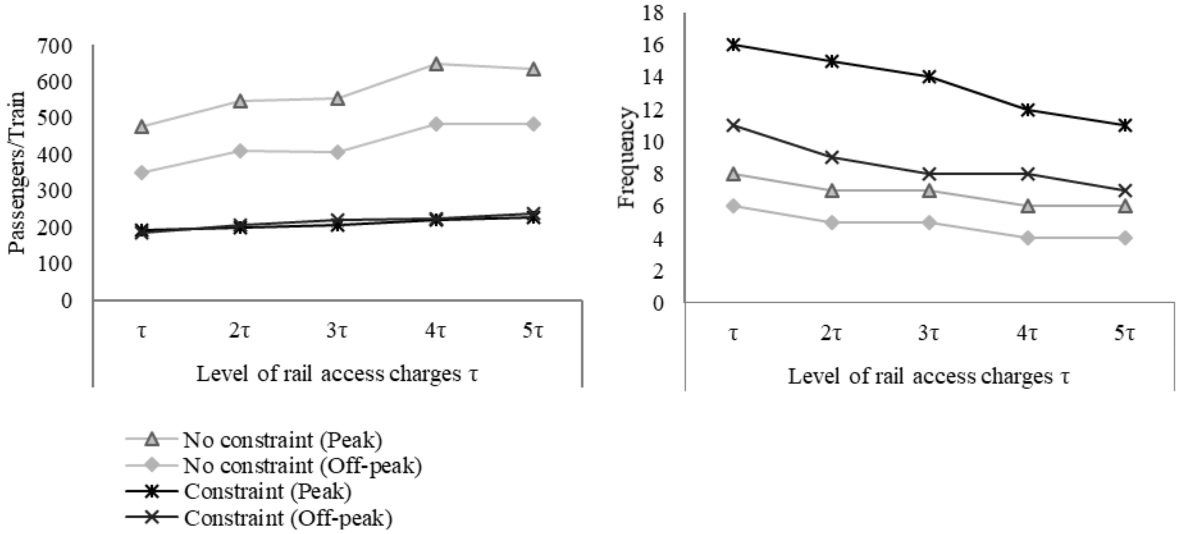
	Baseline	**(1a)**	**(1b)**	**(1c)**	**(1d)**	**(2a)**	**(3a)**
Rail fare private peak (€/trip)	40	42	42	44	45	46	31
Rail fare private off-peak (€/trip)	39	33	33	33	33	37	19
Rail fare business peak (€/trip)	95	86	85	80	81	109	59
Rail fare business off-peak (€/trip)	95	84	81	73	77	99	43
Rail frequency peak (train/day)	14	16	15	11	11	17	9
Rail frequency off-peak (train/day)	12	11	9	7	10	12	4
CS change (€/day)	0	16 636	10 480	-6 308	1 129	-28 303	27 214
Revenues (€/day)	238 947	252 607	241 261	206 907	219 767	323 402	76 137
Operating cost (€/day)	82 519	88 312	79 894	59 472	66 099	94 522	44 844
Track charges (€/day)	17 049	17 831	31 835	59 582	50 446	19 136	8 698
PS (€/day)	139 379	146 463	129 533	87 852	103 222	209 743	22 596
Total welfare (€/day)	139 379	163 100	140 013	81 545	104 351	181 441	49 809
Change in Total welfare (€/day)*	0	23 721	634	-57 834	-35 028	42 062	-89 569
Number of trips							
Rail private peak	1992 (55.3)**	1870 (53.9)	1830 (52.0)	1425 (41.2)	1366 (41.3)	2055 (60.2)	385 (9.4)
Bus private peak	55 (1.5)	55 (1.6)	58 (1.6)	70 (2.0)	66 (2.0)	90 (2.6)	3 (0.1)
Air private peak	778 (21.6)	775 (22.3)	818 (23.2)	983 (28.5)	939 (28.4)	0 (0)	45 (1.1)
Car private peak	774 (21.5)	771 (22.2)	814 (23.1)	978 (28.3)	935 (28.3)	1270 (37.2)	3648 (89.4)
Rail private off-peak	1707 (50.9)	1958 (56.2)	1777 (51.8)	1580 (45.2)	1966 (53.9)	2171 (61.4)	490 (17.1)
Bus private off-peak	387 (11.5)	358 (10.3)	389 (11.3)	450 (12.9)	395 (10.8)	572 (16.2)	30 (1.0)
Air private off-peak	722 (21.5)	668 (19.2)	726 (21.1)	840 (24.0)	737 (20.2)	0 (0)	56 (1.9)
Car private off-peak	538 (16.0)	498 (14.3)	541 (15.8)	626 (17.9)	549 (15.1)	795 (22.5)	2296 (80.0)
Rail business peak	892 (55.9)	1172 (72.6)	1162 (71.6)	1076 (66.2)	1066 (66.6)	1261 (80.1)	902 (55.9)
Bus business peak	1 (0.1)	1 (0)	1 (0)	1 (0)	1 (0)	2 (0.2)	0 (0)
Air business peak	578 (36.2)	363 (22.5)	378 (23.3)	449 (27.7)	438 (27.4)	0 (0)	57 (3.5)
Car business peak	126 (7.9)	79 (4.9)	82 (5.1)	98 (6.0)	96 (6.0)	312 (19.8)	654 (40.5)
Rail business off-peak	99 (82.5)	87 (84.7)	76 (81.1)	72 (77.1)	100 (85.8)	111 (78.2)	40 (37.9)
Bus business off-peak	1 (0.8)	1 (0.7)	1 (0.9)	1 (1.1)	1 (0.7)	2 (1.5)	0 (0)
Air business off-peak	6 (5.0)	4 (4.4)	5 (5.4)	6 (6.5)	5 (4.1)	0 (0)	1 (0.6)
Car business off-peak	14 (11.7)	10 (10.2)	12 (12.6)	14 (15.3)	11 (9.5)	29 (20.3)	64 (61.4)
Train occupancy peak (%)	74	68	72	82	80	70	51
Train occupancy off-peak (%)	65	67	74	85	74	68	48

*Notes: *Change in total welfare indicates difference in total welfare from baseline. **Modal shares as a percentage of total number of trips in a demand segment (for instance for private travellers in peak) in parenthesis.*

Autonomous cars. Scenario (3a) represent a situation with autonomous electric cars, where the generalized cost decreases substantially due to i) lower pecuniary driving cost and ii) lower travel time cost because the travel time can be used productively or for entertainment. We assume that the pecuniary driving cost ($p^{j}_{q,m=c}$) reduces by 50 percent compared to the main analysis and that value of in-vehicle time for car would correspond to that of rail ($\beta^{j}_{q,m=c} = \beta^{j}_{q,m=r}$). We assume current track charges and optimize PS (corresponding to scenario 1a). Optimal fares and frequencies for rail decrease significantly in (3a). Fares decrease between 27 percent and 49 percent and optimal frequency decreases to 9 departures/day in peak and 4 departures/day in the off-peak. Unsurprisingly, number of rail trips drop significantly. Rail shares decline between 17 and 47 percentage points. At the same time, number of car trips increase, for instance for private peak, number of trips increase from 771 to 3648 (around 373 percent). Even demand for air drops significantly, losing market shares to car. Hence the introduction of autonomous electric cars would have significant implications for long-distance travel as rail and air would lose large market shares. This shows the large impacts of private car on inter-city travel and its value for private travellers.

Longer trains. To demonstrate whether the operator can easily extend its trains in case of increased rail access charges, we assume that the length of the trains is extended so that there effectively is no capacity constraint. Figure 1 illustrates how passengers/train and frequency varies with and without a capacity constraint (charges are increased incrementally in the range of 100-500% of current charges). Number of passengers/trains increase more substantially in the case when there are no capacity constraints while the reduction in frequencies is less substantial. The opposite holds true for the situation with capacity constraints. These results support the idea that in case of increased charges, the operator will run longer trains to counteract the rise in their operating costs.

Figure 1. Impacts of no capacity constraints resulting from increased charges



4. Conclusions

It is generally considered that increases in rail access charges will be passed on to rail users in form of higher fares. This study has therefore set out to analyse the effects arising from increased rail access charges on rail ticket prices and frequencies. This study has shown that increased charges have a small effect on rail fares. Increasing charges with 200-500 percent give rather modest increases in fares for private travellers and even reduces fares for business travellers. The resulting reductions in rail traffic are between 5 and 18 percent which are quite moderate comparing to the findings in Sanchez-Borras et al. (2010) which suggest that demand would increase between 20 and 60 percent if rail access charges were decreased in certain European corridors. Furthermore, we observe that the effect on frequency is more substantial. Our findings suggest that a profit-maximizing operator will cut number of services rather than raising fares because higher fares would weaken rail's competitive position and entail market share losses. In contrast, if intermodal competition reduces or increases, prices can be altered more easily.

The policy conclusions based on our results are to implement optimal rail access charges. Time-differentiated charges or a peak congestion fee are to be considered as well, since there are larger welfare gains in implementing lower congestion charges in off-peak. In addition, further research is needed for pinpointing the true cost of congestion as it will constitute an important issue for decision-makers in the railway industry.

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