Development of integrated demand and station choice models for local railway stations and services

Marcus Young

Transportation Research Group University of Southampton

4 October 2017





The railway in Britain has experienced considerable growth in recent years



Data source: Office of Rail and Road

Data source: Railfuture

Growth looks set to continue, with new stations and lines under consideration and being campaigned for



Source: www.railengineer.uk

NEWS

There could be 12 new railway stations built in Wales

The locations under consideration include three in Cardiff and two each in Swansea and Wrexham

28.07.17

DfT names five winners of fresh £16m stations fund

New and potential line re-openings

Demand forecasts for new stations have sometimes not performed well



Trip end models are typically used in the UK to forecast demand for new local stations

New Station/Line	Methodology Used	
Alloa	No Information supplied	
Aylesbury Vale Parkway	Trip rate and accessibility modelling (using HEXs	
Chandlers Ford	Logit model, trip rate model and MOIRA	
Coleshill Parkway	Trip rate model and logit mode choice	
Corby	Trip rate, MOIRA and station access model	
East Midlands Airport Parkway	GIS catchment analysis, elasticity based model & airport mode share assumptions	
Ebbw Valley Line	Logit model and uplift for trip generation	
Edinburgh Crossrail	No Information supplied	
Edinburgh Park	Trip rate and logit mode choice	
Glasshoughton	Trip rate	
Imperial Wharf	RAILPLAN strategic forecasting model	
Larkhall-Milngavie	4 stage land use model	
Laurencekirk	Trip rate	
Liverpool South Parkway	Elasticity based model, airport accessibility model, mode switch (logit) model	
Mitcham Eastfields	Trip rate	
Shepherds Bush	Trip rate	
Vale of Glamorgan Line	Trip rate	
Warwick Parkway	Parkway Access Model and Mode/Route Choice models	



% DIFFERENCE FROM FORECAST

This presentation will focus on the development of improved national trip-end models



Addressing the station catchment problem



Calibrating a national trip end model using probabilistic catchments



Applying the model to generate forecasts

This research builds on previous work to calibrate a national trip-end model for local stations

$$\ln \hat{V}_i = \alpha + \left(\ln \sum_{z}^{Z} P_z w_z\right)^{\beta} + \ln F_i^{\gamma} + \ln T_i^{\delta} + \ln J_i^{\zeta} + \ln P k_i^{\eta} + T e_i^{\kappa} + E l_i^{\nu} + B_i^{\tau}$$

- V = annual entries/exits for Category E & F stations (England and Wales)
- Z = all zones where the closest station is station i
- z = census output area
- **P** = Resident population
- w = decay function (distance/time based)
- F = Weekday train frequency
- T = Distance to nearest Cat A-D station
- J = Jobs within 2 minute drive of station
- Pk = No. of parking spaces
- B = Travelcard boundary (y/n)
- Te = Terminus station (y/n)
- El = Served by electric trains (y/n)



In reality station catchments are more complex entities, they overlap and stations compete



Revised model uses postcode as zone and weights population by probability using a station choice model

$$ln\hat{V}_i = \alpha + \left(ln\sum_{z}^{Z} Pr_z P_z w_z\right)^{\beta} + lnF_i^{\gamma} + lnJ_{it}^{\eta} + lnPk_i^{\eta} + Te_i^{\kappa} + El_i^{\nu} + B_i^{\tau}$$

Z = all zones with station *i* in their choice set *z* = unit level postcode (1.4 million)

Calibration dataset - 1,792 Category E and F stations in mainland GB



A station choice model was calibrated using 14,422 observations from on-train passenger surveys

$$Pr_{nik} = \frac{exp(N_k^{\beta} + \sqrt{D_{ik}}^{\gamma} + U_k^{\delta} + \ln F_k^{\zeta} + C_k^{\eta} + P_k^{\iota} + T_k^{\kappa} + B_k^{\lambda} + \ln A_k^{\mu})}{\sum_{k=1}^{K} exp(N_k^{\beta} + \sqrt{D_{ik}}^{\gamma} + U_k^{\delta} + \ln F_k^{\zeta} + C_k^{\eta} + P_k^{\iota} + T_k^{\kappa} + B_k^{\lambda} + \ln A_k^{\mu})}$$

K = 10 nearest stations to each postcode Pseudo R² = 0.71



A postcode probability table was then generated for every postcode in mainland GB



A railway station choice predictor app was create using R Shiny to aid interpretation



Railway station choice predictor

-

Enter Postcode

B74 4PX

The nearest station to B744PX is BUL and the nearest major station is BSW (by distance)

Predictions

Model calibration results

Railway staton choice predictions

crscode	station	probability
BKT	BLAKE STREET	0.34
FOK	FOUR OAKS	0.25
BUL	BUTLERS LANE	0.20
SUT	SUTTON COLDFIELD	0.14
WYL	WYLDE GREEN	0.03
CRD	CHESTER ROAD	0.02
ERD	ERDINGTON	0.01
SEN	SHENSTONE	0.00
PRY	PERRY BARR	0.00
HSD	HAMSTEAD (BIRMINGHAM)	0.00

Select model

Combined (TE24)

Predict station choice

A probabilistic catchment was then defined for every station in the calibration dataset

$$ln\hat{V}_i = \alpha + \left(ln\sum_{z}^{Z} Pr_z P_z w_z\right)^{\beta} + lnF_i^{\gamma} + lnJ_{it}^{\eta} + lnPk_i^{\eta} + Te_i^{\kappa} + El_i^{\nu} + B_i^{\tau}$$



The trip end model was calibrated using both deterministic and probabilistic catchments



Postcodes (probabilistic) $R^2 = 0.851$, AIC = 3763Postcodes (deterministic) $R^2 = 0.843$, AIC = 3848

Output areas (deterministic) $R^2 = 0.822$ (different dataset)

A methodology was then developed to generate demand forecasts for new stations using the new models

Identify unit postcodes within 60 minutes of proposed station

Find 10 nearest stations for each postcode

Retain postcodes with proposed station in choice set

Calculate probabilities using station choice model

Run trip end model to generate forecast

Case study: forecasts were generated for the Borders Line which opened in 2015



Various catchment representations for Tweedbank station



Various catchment representations for Galashiels station



Under-forecast for Galashiels may be due to new parking, bus interchange and tourism



New interchange at Galashiels – 1400 bus departures per weekday

Galashiels' gateway to the Borders



New 43 space Pay and Display car park opposite interchange What was the main method of transport that you used for your journey to the train station today? (Respondents)



■Walk ■Car (parked at station) ■Car (dropped off) ■Bicycle ■Bus ■Other / Prefer not

Source: Borders Railway Year 1 Evaluation, June 2017

A methodology has also been developed to model abstraction from existing stations



In conclusion, results suggest it is possible to develop a robust and transferable national forecasting model

This may be preferable to models developed on an ad hoc basis

Useful 'sense-check' model to assess reliability of local models

Opportunity to extend approach to flow models



Questions?