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Analyzing competition between High Speed Rail and Bus mode using market entry game analysis

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Abstract

The introduction of High Speed Rail (HSR) changes the dynamics of the passenger transport therefore understanding the market scenario after the entry of the HSR is of utmost importance. In this study, a market entry game is analysed in the context of High Speed Rail competing with the bus mode on the Bangalore-Mysore corridor. The game is modelled as an extensive form game whose outcome will determine the strategies of the players in the competitive scenario. A discrete choice model is constructed using revealed and stated preference data to compute the modal share in the hypothetical scenario. Utilities in terms of profit for each mode is calculated using assumed cost functions for different strategies of the mode operators. These utilities are then used to form the basis for the extensive form game for the market entry.
The extensive form game (with and without perfect information) is analyzed by computing the sub game perfect Nash equilibrium of the game which determines best strategies for each player under different demand scenarios. This study therefore provides a scientific tool for policy makers to analyze best strategies for players under different demand scenarios thereby aiding in decision making.

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Keywords: HSR; Discrete Choice Model; Mode Choice; Game Theory; Extensive Form Game; Nash Equilibrium; Inter-modal Competition

1. Introduction

High speed rail (HSR) system has been globally proven to be an efficient transportation mode to fulfill the demand gap for faster intercity movement of passenger traffic. Thus, in order to cater to the ever increasing passenger traffic

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and demand for better services, the Government of India is exploring the option of introducing HSR system as a sustainable mode of transportation.

The Indian Railways' vision 2020 envisages the following on High Speed Corridors: "India is the only country among the major nations of the world which do not have a high speed rail corridor. In order to escalate the speed of the corridors Indian Railway will follow a two-step approach. Based on the feasibility of the passenger corridors, speed will be raised to either 160-200 kmph using conventional technology or up to 350 kmph by building state-of-the-art high-speed corridors through on PPP mode in partnerships with the State Governments. By 2020, at least four corridors of 2000 km would be developed and planning for 8 other corridors would be in different stages of progress." High Speed Rail Corporation of India Limited (HSRC) has been formed on the directions of Ministry of Railways, Government of India, for development and implementation of high speed rail projects. HSRC mentions the railway budget speech 2012-2013 which states the issue of capital intensiveness and innovative funding mechanism to make this project a reality. Ministry of Railways, Railway Board has decided to carry out the prefeasibility study for Diamond Quadrilateral Network of High Speed Rail connecting four major metro and growth centers of the country i.e. New Delhi – Mumbai – Chennai – Kolkata – New Delhi. High-speed corridors have been proposed and are under prefeasibility studies. Six corridors have already been identified for technical studies on setting up of HSR as shown in Table 1.

Table 1. Proposed corridors for technical studies

High-Speed Corridor	Route	Stations	Speed (kmph)	Length (km)
Howrah-Haldia	Howrah-Haldia	TBD	250-300	135
Delhi-Patna	Delhi-Agra-Kanpur-Lucknow-Varanasi-Patna	TBD	200-350	991
Delhi-Amritsar	Delhi-Chandigarh-Amritsar	TBD	TBD	450
Hyderabad-Chennai	Hyderabad-Dornakal-Vijayawada-Chennai	TBD	TBD	664
Pune-Mumbai-Ahmedabad	Pune-Mumbai-Ahmedabad	7	300-350	650
Chennai-Bangalore-Coimbatore-Ernakulam	Chennai-Bangalore-Coimbatore-Ernakulam	TBD	350	649

While there is a considerable amount of studies on HSR in developed nations especially the European countries, very little is available for the developing nation's scenario. . Roman et.al (2007) analysed the potential competition of the high-speed train with the air transport between Madrid and Barcelona. They developed a disaggregate demand model using mixed RP/SP data and obtained different willingness to pay measures for improving service quality. Demand responses to various policy scenarios that consider the potential competition between high-speed train and air transport were examined and concluded that the HST market share would not exceed 35%. This implied that low modal share and generally low rate of return on HST projects, cast doubts on the competition that HSTs can exert in markets characterized by high frequency air services. Shyr and Hung (2010) estimated the modal shares using discrete choice modelling by conducting revealed preference and stated preference survey and stated that if Taiwan High speed rail continues to increase its service frequency and lower its promotion prices, the chances of airline market to compete with HSR is very slim. They incorporate co-operative game theory to study the coalition structures between the airlines predicting that to maintain profitability, airlines would have to unify as an alliance and cut their daily flights by 50%. For given payoff values, Shapley value is computed in order to solve the profit distribution problem. Raturi et al. (2013) incorporated a game theoretic approach to investigate the competition between HSR and bus system for Bangalore-Mysore corridor. Value of time approach was used to compute the modal share in the hypothetical scenario. They used hypothetical data to illustrate the importance of sunk cost and different strategies in the decision of HSR to enter or stay out of the market. They modelled the competition scenario as an extensive form game and the sub-game perfect Nash equilibrium was found out by backward induction.

Discrete choice model is better alternative to value of time approach to compute the modal share as it takes individual characteristics into account. Zito et al. (2011) used a game approach to model airline choices in a duopolistic market. They formulated a bi-level optimization program to maximize profit for the operator and maximizing consumer surplus for the users. M Bierlaire (2001) used a RP/SP survey of long distance road and rail travellers to investigate the entry of Swiss metro in the market. He explored the stability of the modelling results with respect to different approaches of capturing the heterogeneity in the data. The results indicated a relative stability of the relative parameter values and nearly consistent results with regards to the assessment of parameter significance. VOT distribution significantly affect the profitability of various differentiated bus services was concluded by Yang et.al after examining the effect of value of time (VOT) distribution on price and quality competition among differentiated bus services in a simple corridor. They assume that for a given continuous distribution of VOT, users will minimize their individual generalized trip cost and divide themselves in the available modes of transportation which differ in monetary cost and travel time. Results showed that as the VOT standard deviation becomes smaller *i.e.* more homogeneous and users are more confined to higher VOT , normal bus services will suffer a deficit in business and will be driven out of the market. Thus assumption of VOT distribution parameters is crucial and will vary from corridor to corridor. Adler et.al. (2010) developed a methodology to assess infrastructure investments and their effects on transport equilibria. The operators maximized best response functions via prices, frequency and mode sizes. They applied the methodology to all 27 European Union countries and concluded that development of HSR should be encouraged across Europe if the objective is to maximize social welfare. Impact of deregulation of the bus market in terms of profits and social cost to the society by modelling the strategic interactions between the operators in the bus market was assessed by Wang et.al (2005). Assuming value of time distribution as uniform they calculated the modal share for optimized fare and frequency which maximizes their profit. They analyzed the extensive form game between the incumbent and the entrant for various strategies. Incumbent has three strategies namely monopolist, accommodation and deterrence whereas the entrant has two options of entering the market or staying out of the market. They concluded that deterrence is the dominant strategy in many market scenarios which is best for the society whereas accommodation occurs when the sunk cost is low and demand is high. Natural monopoly arises when sunk cost is high and route density is low. Fu et.al. (2012) investigated the effects of HSR services on Chinese airlines. They suggested that HSR services will be competitive in short to medium distance city pairs, diverting the traffic to rail. They also indicated that to compete airlines must transform their point to point networks to effective hub and spoke networks.

2. Theoretical Framework

Utility depends on consumption of continuous goods and on the characteristics of discrete alternatives. Discrete choice models assume utility-maximizing behavior by the decision maker (McFadden, 1974). It states that the utility of alternative j for individual n has the expression given in equation (1):

$$U_{nj} = V_{nj} + \epsilon_{nj} \tag{1}$$

Where, $\boldsymbol{V_{nj}}$ is the representative or systematic utility observed by the analyst of individual n for alternative j and $\boldsymbol{\epsilon_{nj}}$ is a random term that includes unobserved effects. $\boldsymbol{V_{nj}}$ depends on the observable attributes of alternative j, $\boldsymbol{X_{nj}}$, as well as on the socioeconomic characteristics of individual n.

The dependent variable represents individual's choices. Estimation provides the probability distribution of the dependent variable for every individual observation. Hence, the probability that individual n chooses alternative j is given in equation (2):

$$P_{nj} = P\left(V_{nj} + \epsilon_{nj} \geq V_{ni} + \epsilon_{ni}\right) \forall\ i\ \neq j \tag{2}$$

By far the easiest and most widely used discrete choice model is logit. Its popularity is due to the fact that the formula for the choice probabilities takes a closed form and is readily interpretable (Kenneth Train, 2009). McFadden (1974) completed the analysis by showing that the logit formula for the choice probabilities necessarily implies that unobserved utility is distributed extreme value. The logit model is obtained by assuming that each ε_{nj} is independently, identically distributed extreme value. The distribution is also called Gumbel and type I extreme value. The density for each unobserved component of utility is given in equation (3)

$$f(\varepsilon_{nj}) = e^{-\varepsilon_{nj}} e^{-e^{-\varepsilon_{nj}}} \tag{3}$$

By assuming the variance is $\pi^2/6$, we are implicitly normalizing the scale of utility and the difference between two extreme value variables is distributed logistic (Ben Akiva, 1985). Hence the choice probabilities are given in equation (4) by

$$P_{nj} = \frac{e^{V_{nj}}}{\Sigma e^{V_{nj}}} \tag{4}$$

which is the logit choice probability.

3. Case Study

A case study of Bangalore-Mysore corridor has been taken for the entry of HSR. The corridor length for both highway and railway is approximately 150 km. The major modes of travel between these cities are Bus, Train and Car. There are no airline services between the two cities. The travel time for bus and train is approximately 3 hours whereas car mode being faster takes around 2.5 hours to travel between the cities.

Revealed preference (RP) survey was conducted with an objective to study the socio economic characteristics and travel behavior of the passengers traveling between Bangalore and Mysore. Stated preference (SP) survey aimed to analyze the preference of the passengers and their willingness to shift to HSR, from their current mode for the same trip, when provided with different choice situations. RP data were obtained from a survey that collected information about travel behavior using the principal modes: car, bus and conventional train. The survey of bus, train and car users involved personal interviews. The questionnaire collected information about trip details, household information and personal information. Travel time has been divided into two components: In-vehicle-time and Out-vehicle-time.

SP data were collected via personal interviews and the respondent were given different choice scenarios and their willingness to shift to the hypothetical mode was noted. The attributes of the HSR system that were varied were travel cost and travel time. Two levels of the travel time by HSR has been taken *i.e.* 30 minutes and 45 minutes (Based on the definition of a high speed rail and its minimum speed requirement- first level speed assumed was 300 kmph and second level speed assumed was 200 kmph). Two levels of fare structure were taken *i.e.* low fare, high fare. The cost of low fare was Rs. 450 and for high fare cost was Rs. 600. The cost levels were decided based on the average cost of HSR system in china and then converted for Indian scenario (Fu et. al, 2012). Thus combining two levels of time and two levels of fare, total choice situations per respondent were four giving a total of 1196 observations.

4. Mode choice model

The process of pooling RP and SP data and estimating a model from the pooled data is called data enrichment. This process originally was proposed by Morikawa (1990), whose motivation was to use SP data to help identify parameters that RP data could not, and thereby improve the efficiency (*i.e.,* obtain more precise and stable estimates) of his model parameters. The use of RP/SP data to estimate choice models requires that the variances of the error terms in two data sets (Ben Akiva et. al, 1990) to satisfy the following as shown in equation (5):

$$\sigma_{\epsilon}^2 = \lambda^2 \sigma_{\eta}^2 \tag{5}$$

where λ is an unknown parameter, and ϵ and η are the error terms of the RP and SP utilities. Hence, to mix the data we postulate the following utility functions for alternative j:

$$U_j^{RP} = V_j^{RP} + \in_j \tag{6}$$

$$\lambda U_j^{SP} = \lambda(V_j^{SP} + \eta_j) \tag{7}$$

where U_j^{RP} and U_j^{SP} are the utilities for the RP and SP data sets in equation (6) and equation (7) respectively. Here the scale for RP data set is normalized to one. If we assume that the error terms in equations (6) and (7) are IID extreme value type 1 (EV1) within both data sources that are associated, respectively, with scale factors 1 and λ, the corresponding choice models can be expressed as follows (Louviere et.al, 2000). Equation (8) and Equation (9) shows the choice model probability for RP and SP data respectively.

$$P_j^{RP} = \frac{\exp\,(\alpha_{RPj} + \beta^{RP} X_j^{RP})}{\sum_{i \in C^{RP}} exp\,(\alpha_{RPi} + \beta^{RP} X_i^{RP})}, \quad \forall j \in C^{RP} \tag{8}$$

$$P_j^{SP} = \frac{\exp\,[\lambda(\alpha_{SPj} + \beta^{SP} X_j^{SP})]}{\sum_{i \in C^{SP}} exp\,[\lambda(\alpha_{SPi} + \beta^{SP} X_i^{SP})]}, \quad \forall j \in C^{SP} \tag{9}$$

where j is an alternative in choice sets C^{RP} or C^{SP}, αs are data source-specific alternative-specific constants (ASCs), β^{RP} and β^{SP} are utility parameters. It is important to note that the choice sets need not be the same in the two data sources, and in fact the alternatives need not be the same. Indeed, one attraction of SP data is their ability to manipulate and observe the effects on choice of introducing new products/brands and/or removing existing ones from consideration (Louviere et.al, 2000).

M Bierlaire (2001) explored the modelling results with respect to different approaches of capturing the heterogeneity in the data. He estimated the parameters using BIOGEME where the heterogeneity in RP and SP data were captured using scale parameters for different groups and allows to avoid complicated tricks based on nested structures in the presence of heterogeneous populations.

Modal utility is defined in terms of the mode attributes as well as the socioeconomic characteristics of the individuals. A linear-in-the-parameter specification is taken to compute the utility. The model involves 7 alternatives; the present modes in RP context and the present modes plus the hypothetical mode, HSR, in SP context. Utility for each mode in RP context is given in equation (10). Each utility function corresponding to SP data is multiplied by a parameter λ. Thus the utilities in SP context are non-linear as shown in equation (11). All alternatives are not available together. For respondents of a RP survey, only modes in RP context are available. For respondents of a SP experiment, modes in SP context are available. The explanatory variables are Alternative specific constant for each alternative, travel cost, in vehicle travel time, out vehicle travel time and household income. The ASC of car/RP was fixed to zero.

$$U_j^{RP} = ASC_j^{RP} + \beta_1 \times InTime_j + \beta_2 \times OutTime_j + \beta_3 \times Cost_j + \beta_4 \times Income \tag{10}$$

$$U_j^{SP} = \lambda(ASC_j^{SP} + \beta_1 \times InTime_j + \beta_2 \times OutTime_j + \beta_3 \times Cost_j + \beta_4 \times Income) \tag{11}$$

4.1 Estimation and Simulation

The underlying structure of the model is assumed to be multinomial logit model and the model have been estimated using 1196 observations, corresponding to RP and SP data collected from commuters between the two cities using BIOGEME. Table 2 shows the estimated parameters of the mentioned model.

All parameters have the expected sign and are significant at the 95% confidence level. Also, the t-test of the λ parameter shows that it is significantly different from 1.The model is then used to simulate for different choice scenarios and thus finding the modal share in the corresponding scenarios. Table 3 shows the modal share for the competing modes in different choice scenarios.

Table 2. Estimation Results

Parameter		Value	t-test
ASC for Bus in RP context	ASC_BUS_RP	-0.469	-1.27
ASC for Bus in SP context	ASC_BUS_SP	-0.280	-0.00
ASC for Car in RP context	ASC_CAR_RP	0.00	
ASC for Car in SP context	ASC_CAR_SP	0.391	0.00
ASC for HSR in SP context	ASC_HSR_SP	0.218	0.00
ASC for Train in RP context	ASC_TRAIN_RP	-0.519	-1.40
ASC for Train in SP context	ASC_TRAIN_SP	-0.329	-0.00
In vehicle travel time	β_1	-0.563	-2.82
Out vehicle travel time	β_2	-0.490	-2.83
Travel cost	β_3	-0.339	-3.12
Household Income	β_4	-0.0337	-1.82
Scale parameter SP	λ	3.99	3.11

Rho-square: 0.257; **Adjusted rho-square**: 0.250

Table 3. Modal Share.

Choice Scenario	Modal Share (percent)	
	Bus	**HSR**
Bus = Rs. 200; HSR = Rs. 450	12.65	67.38
Bus = Rs. 240; HSR = Rs. 450	7.87	71.25
Bus = Rs. 200; HSR = Rs. 600	33.21	24.67
Bus = Rs. 240; HSR = Rs. 600	23.17	29.11

5. Cost and Payoff Functions

The daily operating cost of a transport carrier which includes the direct operation costs which consist of fuel cost, labour cost and maintenance cost is taken up from the literature. The daily operating cost of bus services is obtained from the annual KSRTC report (2013). Since India doesn't have a HSR system, its operating cost is taken up from the literature corresponding to foreign conditions and then converted for Indian conditions (Levinson et.al, 1997). According to previous empirical experience, the design load factors often lie between 70%~80% for freeway and bus. As for railway, there is no design load factor to be used in the study because the scheduling of railway operations is usually unrestricted by design load factor (Shyr et.al, 2010). The daily operating cost of the operators shown in equation (12) can be determined by taking average direct operation cost per trip (a_j) multiplied by the frequency of the mode.

$$DOC_j = a_j \times f_j \tag{12}$$

$$f_j = Round \left\{ {}^{q_j}/_{Seat_j \times L_j} \right\} \tag{13}$$

where q_j is the demand for the respective mode and f_j is the frequency of the mode as in equation (13). $Seat_j$ and L_j are the capacity and load factor for each mode respectively. Table 4 gives the detail of the numerical data for competing modes used in the following analysis.

Table 4. Data for competing modes

Variable	Category	Value
Travel Time (hours)	Bus	3
	HSR	0.5
Operating Cost (Rs./seat-km)	Bus	0.583
	HSR	2.75
Capacity	Bus	50
	HSR	750
Load Factor	Bus	0.75
	HSR	1
Demand (Passengers/day)	Low	5000
	High	10000

Equation (14) provides the payoff function for each operator is estimated by calculating the net revenue which is daily total revenue generated minus the daily operation cost for a mode. Sunk cost for HSR is not considered in the daily profit equation and is assumed to be subsidized by the Indian government.

$$\pi_j = P_j \times q_j - a_j \times f_j \tag{14}$$

For computing the payoff for each operator, two levels of demand is assumed *i.e.* Low demand and High demand. Table 5 shows the payoff for each mode operators in different choice scenarios.

Table 5. Payoff for different choice scenarios and demand levels

Choice Scenario	Profit (Rupees)			
	Low Demand		High Demand	
	Bus	HSR	Bus	HSR
Bus = Rs. 200; HSR = Rs. 450	52217	-30825	104233	247725
Bus = Rs. 240; HSR = Rs. 450	46430	56475	92859	112500
Bus = Rs. 200; HSR = Rs. 600	135303	121650	274781	243300
Bus = Rs. 240; HSR = Rs. 600	142520	254250	284799	509100

These payoff values becomes the basis for the game theoretic analysis between the competing modes.

6. The Game

A game in the everyday sense is "a competitive activity in which players contends with each other according to a set of rules" (Martin J. Osborne, 2003) and game theory is a way to mathematize these strategic interactions among players and finding the outcome of a game. In this study, High speed rail is entering the market thereby creating a competitive scenario for the incumbent (Bus Mode) hence resulting in an entry game. Modelling the entry game as an extensive form game, in the first stage the entrant has two strategies whether to enter or stay out of the market. If the entrant stays out of the market then the profit for the entrant is zero whereas for incumbent it is the profit in the current scenario. If the entrant enters the market, in this scenario; the incumbent i.e. Bus mode operators has two strategies; High and Low Fare. After the Incumbent plays its strategy, HSR operators have two strategy in each node to play i.e. High and Low Fare. This situation may be modelled as the following extensive game with perfect information given in figure 1.

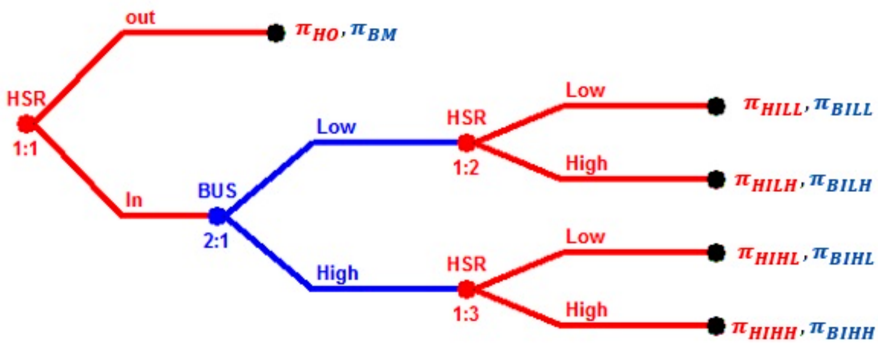

Figure 1 Extensive Form Game

where π_{HO}, π_{BM} is the payoff for HSR and Bus respectively in the first strategic scenario i.e. Out-Monopolist. Similarly for other scenarios payoffs are mentioned.

After computing the payoff of the modes, the game outcome can be determined by solving the extensive form game for different choice scenarios. Nash equilibrium can be computed to determine the outcome of the game. Nash equilibrium is a strategy profile with the property that no player can induce a better outcome for himself by changing his strategy, given the other players' strategies. The notion of Nash equilibrium ignores the sequential structure of an extensive game; it treats strategies as choices made once and for all before play begins. In an equilibrium that corresponds to a perturbed steady state, the players' behaviour must correspond to a steady state in every sub-game, not only in the whole game (Martin J. Osborne, 2003). Thus the notion of Sub-game equilibrium comes into picture. A sub-game perfect equilibrium is a strategy profile with the property that in no sub-game can any player 'i' do better by choosing a different strategy, given that every other player j adheres to their strategies. A sub-game perfect equilibrium(s) of the game will be the outcome(s) of the extensive form game and the operators can fix their payoff function maximizing variables accordingly.

6.1 Low Demand Game with complete Information

Analyzing the extensive form game when the demand is low and all the players have complete information about the actions of the other players. Payoffs are given in the extensive form game in figure 2.

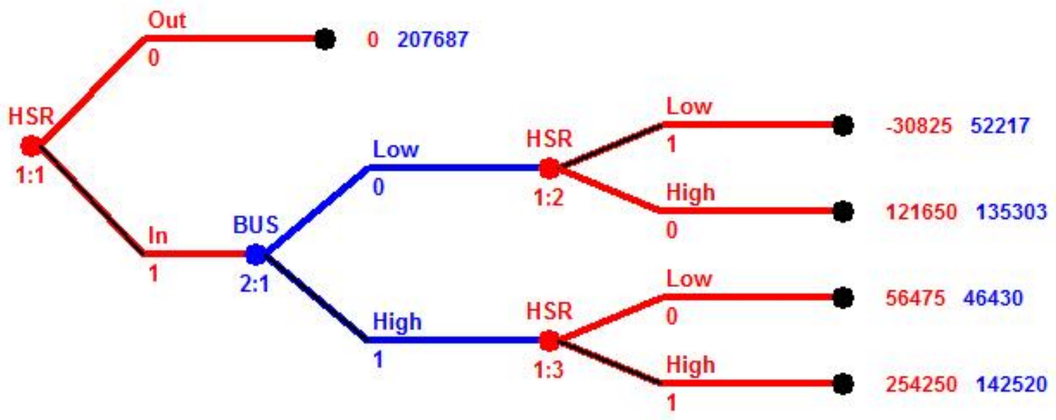

Figure 2 Low Demand Game with complete information

The Nash equilibrium strategies are highlighted by black lines in the extensive form game. In the above game the Nash equilibria of the game are (In,High-Low); (In,High-High). The Nash Equilibrium (In,High-Low) is not a subgame perfect nash equilibrium (non credible threat) therefore the outcome of the game is (In, High-High) which implies that HSR is going to enter the market and then the best strategies for both the players is to charge High fare.

6.2 High Demand Game with complete Information

Analyzing the extensive form game when the demand is low and all the players have complete information about the actions of the other players. Payoffs are given in the extensive form game in figure 3. Analyzing the Outcome of the game by computing subgame perfect Nash equilibrium.

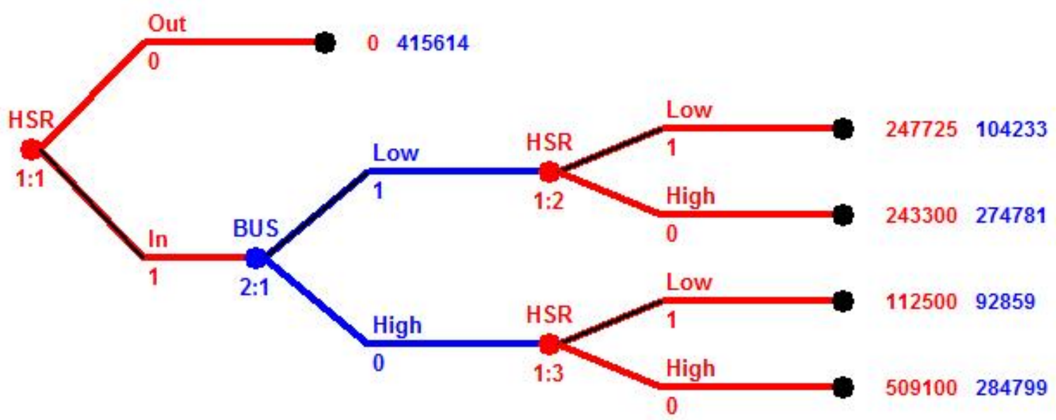

Figure 3 High Demand Game with complete information

The Sub game perfect outcomes of the game are (In, Low-Low) and (In, High-High).

6.3 Low Demand Game with incomplete Information

When the players are not aware of the actions taken by the other players then we have to analyze the game as an incomplete information game. Then the nodes in the second level are indistinguishable and are joined by dotted lines as in figure 4.

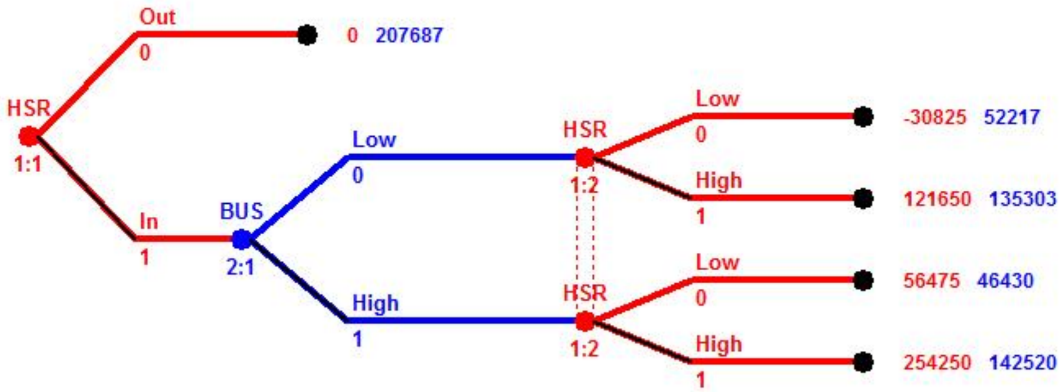

Figure 4 Low Demand Game with Incomplete Information

This game has only one Nash Equilibrium i.e. (In, High-High) with payoffs 254250, 142520 for HSR and Bus respectively.

6.4 High Demand Game with incomplete Information

Similar analysis is done for the high demand scenario and the outcome is similar to strategy form game. The high demand game is analogous to a Bach or Stravinsky game. This game has three Nash equilibriums, two

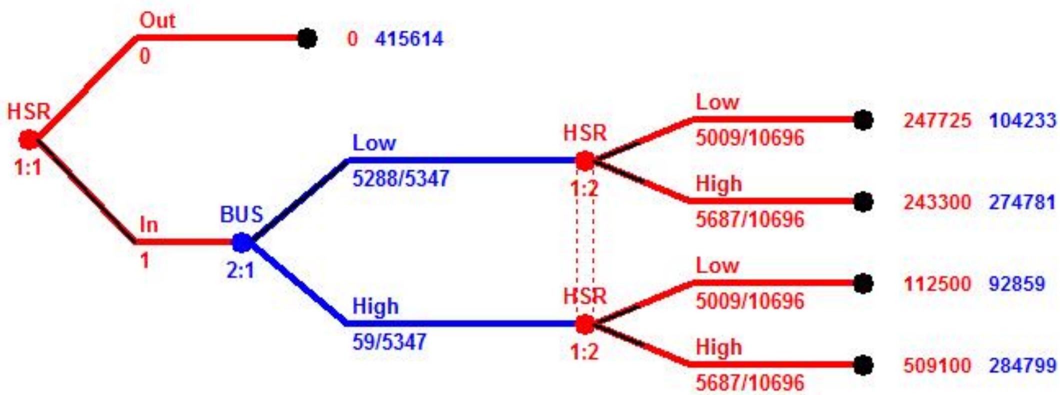

Figure 5 High Demand game with Incomplete Information

pure strategy Nash equilibrium and one mixed strategy Nash equilibrium (figure 5). Table 6 shows the three Nash equilibriums of the high demand game.

Table 6. High demand Game equilibriums.

Equilibrium	Probability			
	Bus: Low	Bus: High	HSR: Low	HSR: High
1	1	0	1	0
2	0	1	0	1
3	0.988	0.012	0.47	0.53

This shows that (Low, Low); (High, High) are two pure strategy Nash equilibrium of the high demand game. There is one mixed strategy Nash equilibrium for this game which can be interpreted as the probability with which the bus operator will play Low and High strategy is 0.988 and 0.012 respectively. Similarly HSR operator will play Low and High strategy with a probability of 0.47 and 0.53 respectively. The expected payoff for Bus and HSR operator for the mixed strategy Nash equilibrium is Rs. 104233 and Rs. 247725 respectively.

This analyses shows that strategy of one player is depended on the other player. Different demand levels will elicit different Nash equilibriums. It also shows the importance of different demand levels on the outcome of the game. The strategy of each player could change dynamically with the varying demand levels and thus the game theoretic analysis will help in providing a scientific tool for the operators to maximize their payoff values.

7. Summary and Conclusions

This paper analysed the competition between Bus mode and HSR along the Bangalore-Mysore corridor utilizing disaggregate demand models using a mixed RP/SP database. The model parameters have the expected signs. Scale parameter for SP data set was found out to be significant. The resulting model was used to simulate modal share for different choice scenarios. Game theory analyses helps in understanding the strategic interaction among the players competing to maximize their payoffs. The conclusions of the study is as follows:

- Travel time parameter value show that disutility corresponding to out-vehicle travel time is nearly same as the disutility for in-vehicle travel time, thus suggesting that for the new mode to be attractive, efficient feeder services to the HSR system should be provided.
- Given the high operating cost of HSR per trip, HSR system will run in losses when the demand is low even if the mode share is as high 71%. There is a considerable reduction in modal share for HSR when the fare level is high but the profits goes up except in high demand level when the bus operator plays a low fare strategy.
- Different demand level eliciting different Nash equilibriums can have important implications on decision making for the operators.
- In the first level of the extensive form game, HSR best response is to enter in all the different scenarios.
- In complete information game, when the demand is low the Nash equilibrium of the game is (In, High-High) whereas for the high level demand game there are two Nash equilibriums, *i.e.* (In, Low-Low) and (In, High-High) implying HSR decision to select fare will depend on what level the bus operators are fixing the fare.
- In incomplete information game, when the demand is low the Nash equilibrium of the game is the same as the complete information game i.e. (In, High-High) whereas for the high level demand game, the outcome is similar to a strategic form game with three Nash equilibria, *i.e.* (In, Low-Low) and (In, High-High) and one mixed strategy Nash equilibrium i.e. $\{(0.988, 0.012)\ ;\ (0.47, 0.53)\}$.
- Dynamic pricing could be adopted by the operators by analysing the variation in demand levels with respect to days of a week or holiday seasons.
- A mixed strategy Nash equilibrium can be the outcome of the game in a long run where each player will play different strategy probabilistically and therefore will correspond to expected payoffs for each player.

- This study will provide a scientific tool to the policy makers to take the decision to invest in HSR system by understanding the market scenario after the entry of the new system.

This study can further enhanced by taking multiplayer competition on a different corridor where airlines also enters the competition scenario.

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