Embedding a Model in Urban Commons: Transportation Game in a Megacity Setting

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Abstract: - The paper focuses on transport as one of the most valuable urban commons in the emerging Megacity of Hyderabad in India. The authors build upon a game dealing with transportation as a common pool resource. The game design is supported by real data taken from a travel demand modeling software and further enhanced by information gathered through institutional analysis conducted using the Institution of Sustainability (IoS) framework [1]. The main objective of this experimental tool is to study the typical social dilemma in an urban transport setting, where individual optimum clashes with the group's optimum. This clash might finally result in a tragedy of the urban commons not because of technical constraints but due to institutions (or the lack thereof) shaping the choices of the commuters. The game is about the mode and route choice of the employee given the worst condition that he/she need to go to his/her office in morning peak time, so that it delivers his/her social behavior. The players' preferences of transport modes and routes are controlled by transport parameters namely vehicle and travel cost, road capacity, travel time, speed and air pollution. Three sets of rounds are played under three different concepts. Namely: a) an open access situation where all players freely choose their modes and routes without communicating with each other, b) restricted/regulated access by imposing traffic and transport rules/sanctions without communication and finally c) the introduction of communication and the possibility for them to craft their own rules or improve the existing ones. The overall goal of this game is to explore equilibrium on how to balance the individual and group profit avoiding a tragedy of urban commons. Finally the authors argue on the usefulness of context-dependent games as complementary tools to the currently employed transportation models. Such a holistic approach may include effects of rules in transportation by addressing institutional constraints in traffic solutions not captured by current practices and set up an integrated supportive tool for a sustainable traffic solution. Research for this paper was conducted under the German-Indian research project Sustainable Hyderabad - 'Climate and Energy in a complex Transition Process towards Sustainable Hyderabad. Mitigation and Adaptation Strategies by changing Institutions, Governance Structures, Lifestyles and Consumption Patterns', funded by the German Ministry of Education and Research (BMBF).

Keywords: urban commons, transportation game, transport mode and route choice, transport parameters, institutional analysis

1. Background of Transport game

Transport solutions, which are mostly proposed to address traffic congestion in the city of Hyderabad, India are the construction of flyover or the provision of additional lanes. However, the problem of traffic congestion is in existence and so the vehicle emission is still an uncontrollable pollution problem in the climate change context of the city [2]. One of the reasons could be that the existing traffic planning tools used in proposing these transport solutions address the theory of induced travel [3] without capturing the real social situation and communication among the vehicle user on road. This social situation and communication among the vehicle users on road reflects in their decisions over the selection of route, mode and also sometimes in the violation of traffic rules. This effect in the increasing volumes of vehicles on road in spite of the standard road capacity, traffic congestion in certain routes in spite of the provision of flyovers or additional lanes, creation of informal rules among road user in spite of existing formal traffic rules and thus resulting in vehicle emission in spite of the introduction of new vehicle technologies or the emission standards in the city [4]. There is need for a framework to simulate this real social interaction among road user and to incorporate it in the traffic simulation software for an efficient transport planning and thereby proposing sustainable traffic solutions in the city. The current research activity address this issue by developing a comprehensive integrated framework

with an institutional analysis mechanism capable of depicting the 'near to real' social interaction in the form a transport route-mode choice game based on a vehicle emission estimation. This framework can be used in combination with traffic simulation tools to compare the results with the actual scenario for an efficient analysis based solution [5]. The first step of the research methodology (Fig.1) towards developing this integrated framework is the vehicle emission estimation for the selected four representative stretches in Hyderabad, India. This is followed by the development of transport game with vehicle emission estimation as controlling transport parameters and playing the game with homogeneous and heterogeneous groups of vehicle drivers in Hyderabad. The results of the experiments would be compared with actual result obtained from the traffic simulation software. Finally, the vehicle emission measures would be recommended for the policy decision makers. This paper highlights about the development of transport game and analyze the results of experiments conducted with two homogeneous groups of students.

The developed transport game highlights decision of the road user in selecting the given transport modes and routes under the given constraints when they travel from origin to destination. The given routes would be a short route with high probability of congestion and

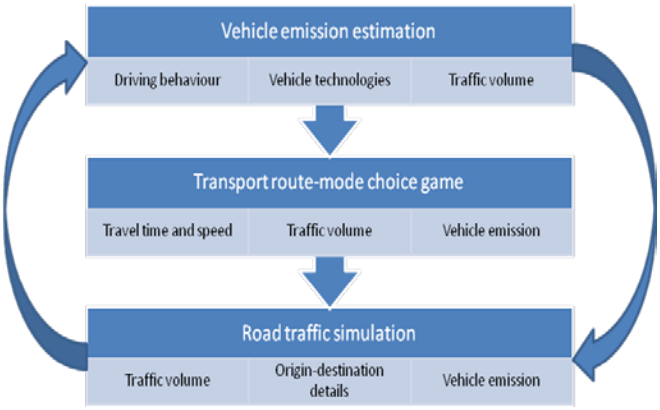


Fig.1 Research Methodology

longer route with less probability of congestion and given modes are passenger car and public transport bus. The reason for choosing passenger car is that it shares major part of road space with less occupancy and also from the results of vehicle emission estimation for the selected stretch (JN Road in Hyderabad), it is obvious that passenger car is the highest contributor of vehicle emission (Fig.2) mostly carbon pollutants. The control parameters in selecting these route and mode choices are the transport parameters namely vehicle and travel cost, road capacity, travel time, speed and air pollution.

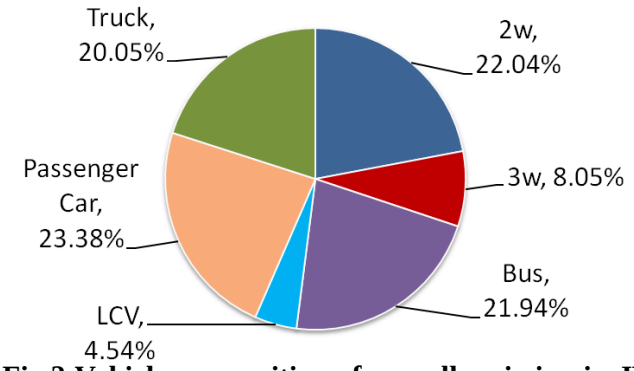


Fig.2 Vehicle composition of overall emission in JN Road

Initially, the ground data namely the driving pattern, the calculated vehicle emission quantity for the passenger car, travel time for transport game mechanism are obtained from process of vehicle emission estimation for a study stretch in Hyderabad. This would help in simulating the real traffic situation in the game and also help in finding the relation between their travel patterns with vehicle emission exposure. This obtained linkage between the calculated vehicle emission and the transport route-mode choice game is discussed in the following section

2. Materials and Methods

2.1 Transport game – Theory

The concept of transport game (Fig.3) is based on the Common Pool Resource (CPR) theory [6]. The roads are the man-made resource system, where its space acts as urban commons shared by heterogeneous groups of vehicles varied by shape, size, speed, age. Based on PIEV theory (Perception, Intellection, Emotion and Volition) [7], the drivers differ in their travel behaviour. This reflects in their varied decision over the available choice of routes and vehicle modes. When these drivers with varied decision decided to travel on road, then there might be two chances of occurrences. One is the tragedy of commons [8], might occur in the form of rivalry, resulting in traffic congestion, travel time delay, traffic violation and monetary cost involved in it. The other is that no problem of rivalry might occur resulting is no traffic congestion and hence every driver travel save their time and earn monetary benefits. The transport game is developed to test this hypothesis of how the behaviour of driver results in, when they decide to travel. The development of game is discussed in the next section.

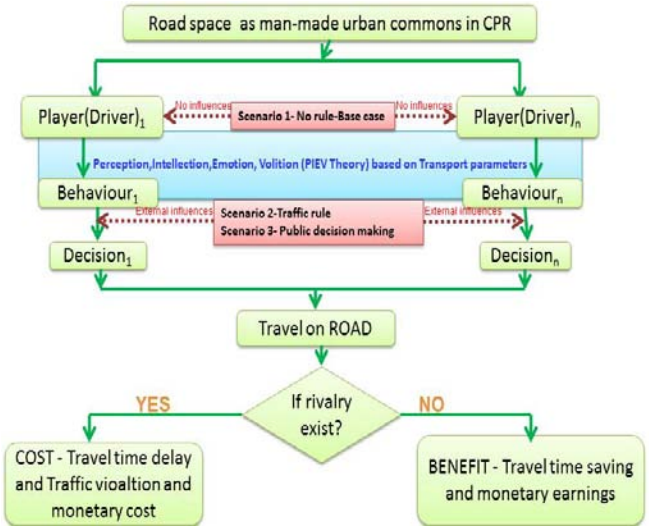


Fig.3 Transport game- Concept

2.2 Transport game - Theme

The main objective of this game is to show how the individual vehicle user choice of route and mode is influenced by the group choice. In the real world, vehicle user decides mode and route in order to reach any place in time as none of the them prefers to stay longer in roads. So the travel time is one of the important transport parameter from the demand-side perspective (vehicle user), in selecting their choices. This could be best depicted in Home-Work based travel trips [9], where each employee from different firms would tend to select the route and mode to reach their office in time. Moreover, from the road-side interview, it is obvious that this Home-Work based trip share nearly half a proportion of total trips in Hyderabad. Hence the developed transport game is based on Home-Work trips and is is designed under following assumptions:

Each player in the game:

- *-is assumed to be an employee in different firms and hence they don't know each other*
- *-have a car of his/her own and has an office at Khairatabad Circle, Hyderabad*
- *-is using one route and one mode to reach their office which is based on their decision of the given choices. In case of route it is either primary or secondary road and in case of mode it is either passenger car or public transport bus.*

2.3 Tranport game- Controlling parameters

2.3.1 Travel time

In the real world, many direct and indirect benefits are involved, when the vehicle user reaches early or on time to his/her office. This could be increase in his/her work efficiency, punctuality, promotion, increase in salary or bonus and thus increase his/her living status [9]. This strongly justifies the first hypothesis of the game that every vehicle user (all players) thinks rationally by assuming that particular route and mode would help him/her to reach early to his/her office, so that he/she can earn the above mentioned benefits. On the other hand, this directs to the second hypothesis of the game, that the rational thinking of all players leads to the urban tragedy in the form traffic congestion in the road and so all players reach late to their office and Hence the concept of early-delay based on the travel time crop up.

2.3.2 Travel cost and benefit

Among the above mentioned benefits, the monetary earnings could be easily simulated in the game, as it could best reflect the decision of players in selecting their choices. The monetary benefits in the game are designed as follows:

Each player will receive Rs.500 as their daily wage (Monday through Saturday) and the office time is 8h. This means that he/she should reach in time 8h.

- *If the player reaches in time to their office, i.e. 8h, neither gain nor lose*
- *If the player reaches earlier, i.e. 7.59h, he/she will gain Rs.10 bonus*

With the above monetary benefits, the travel cost and transport pricing is also associated as investment for all players in the game.

The travel cost is basically designed for the passenger car users, i.e. the player who choose choice 1 or 2. It includes vehicle operating cost (VOC) and travel time cost. The vehicle operating cost incurred by the players in the game who choose choice 1 or 2, includes both fixed and variable cost, where fixed cost is the road tax and the variable cost are maintenance, fuel and parking cost for the passenger car. The travel time cost is the delay cost paid by the players in the game when chooses choice 1 or 2. Hence this vehicle operating cost and travel time cost are applicable to all players who choose choice 1 or 2. This is designed in the game as follows:

Each player who choose choice1 or 2,

- *have to incur vehicle operating cost of Rs. 30 (50cent) which is the average fuel, maintenance and parking cost for all rounds in the game*
- *have to incur travel delay cost of Rs.10, for very one minute delay to their office, say if he/she reaches 8.02h, then he/she has to pay Rs.20*

The transport pricing includes the ticketing price for the service offered by public transport bus. In the game, this is applicable for the players who choose choice 3 which is designed as follows:

Each player who choose choice 3,

- *has to pay ticket price of Rs. 10 (17cent) (ticket price) for all rounds in the game*

2.3.3 Road capacity

From the perspective of supply side (infrastructure provision), the road capacity is one of the most important transport parameter, on which all road infrastructure facilities are designed [9]. When the traffic volume is less than the capacity of the road, then there is no requirement of any problem solving solutions like flyovers or addition of lanes etc., as the vehicle will travel with design speed of road and hence no delay, no bottlenecks and no vehicle emission pollution. All these traffic problems come in to the picture only when the traffic volume exceeds the road capacity.

As per Indian Road Congress manual [10], the arterial and sub-arterial roads vary on their speed and road capacity. Hence the road capacity in the game is assumed to be varied based on the nature of road. In the choices of route, two different roads are given. One is the short primary road (Arterial) and another is the long secondary road (Sub-Arterial). From the traffic volume survey carried out in the selected stretches for vehicle emission calculation, it is obvious that passenger car contributes a substantial share in overall vehicle composition and invade large amount of the road space and so the road capacity of the two given roads in the game are designed based on passenger cars. Since there is no car-sharing system involved in the game and also each own his/her car,the total number of players are assumed to be total number of passenger cars. This could be explained as follows:

Primary road capacity = 50% of total number of passenger cars (players)

Secondary road capacity = 40% of total number of passenger cars (players)

So, if the passenger car exceeds the above mentioned limit, then the traffic congestion arises and leads to delay in travel time.

2.3.4 Vehicle emission

The vehicle emission for one passenger car designed in this game is scaled from the vehicle emission calculation processed for Passenger Car in JN Road,Hyderabad. The vehicle emission scaling factor for one passenger car is shown in Table 1.

Table 1. Vehicle emission for Passenger car

Attributes	Estimated	Scaled
Nos	18,097	1
Overall Emission quantity	12,72,824 (g/day)	1.172 (g/min)

2.3.5 Average Speed

The average speed for the passenger car and traffic capacity is designed based on the calculated value obtained from the driving pattern survey conducted for vehicle emission (Fig.2) calculation of the selected stretch.

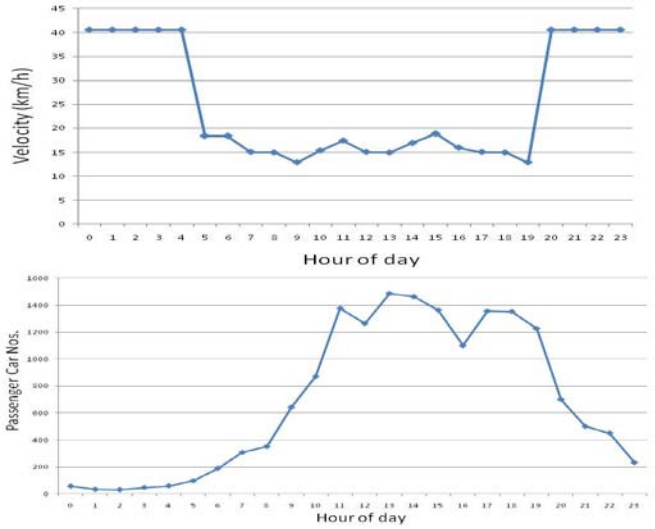


Fig.4 Hourly Speed profile and Traffic volume of Passenger Car in JN Road, Hyderabad

It is observed that the velocity of passenger car decreases with the increase in passenger car numbers. Hence in the game also it is designed that when the passenger car number increases, the speed decreases. The designed speed for one passenger car for the primary road in the game is 27.118km/h. This is the average velocity for the passenger car obtained from driving behaviour survey for JN road. As the secondary road will have relatively less design speed

than primary road, the speed for passenger car in the game is designed as 30% of the primary road speed, i.e. 30% of 27.118km/h, which is 8.1km/h. Based on this designed speed, the travel time and vehicle emission and the earnings are designed in the choice mechanism. If speed increases, travel time decreases and vice-versa. The above game parameters of vehicle emission and the vehicle speed is designed for one passenger car. So when all the players decided to go by passenger car either in primary or in secondary road, then vehicle speed decreases and their travel time increases and so they reach their office late. In addition to this, their exposure to vehicle emission will also increase. Based on the above all transport controlling parameters, the game mechanism is structured. This has been discussed briefly in the next session

2.4 Transport game- Choice mechanism

The mechanism for the transport game is designed based on the given choices of routes and modes of transport. As mentioned already, the given routes are the primary and secondary roads in Hyderabad and the given modes are the passenger car and public transport bus. Sufficient reasons for selecting these two routes and modes in the transport game have already been discussed in the previous sections. The following are the three choices, given for all the players to reach their office.

Choice 1- Use of passenger car and take primary road (Short route but more easily congested)

Choice 2-Use of passenger car and take secondary road (long route but less affected by congestion)

Choice 3- Take public transport bus that goes only on secondary road(long route but unaffected by congestion)

It is made that the transport parameters described in the previous section namely travel time, road capacity, vehicle emission and speed are the controlling parameters in the first two choices and it is assumed that there is no controlling parameter for the third choice, as in reality the public (here the game players) act as passengers in public transport bus and they are given services and are not allowed to make decisions on route. Moreover, when every one decide to travel by bus, then there will be no problem of traffic congestion or vehicle emission and the average speed would also be high, so they can reach in time. The mechanism is designed such that the controlling parameters namely travel time, speed , delay and vehicle emission are influenced by the percentage of choice of players. This developed mechanism for three choices to be used in transport game is shown in Table 2. The correlation between transport paramters which used in Table 2, for determining the total earnings or the cost of the each players are expressed in following equations:

$$T_{nc1 \text{ or } nc2} = L/(U_{nc1 \text{ or } nc2}*60) \quad (1)$$

$$V_{nc1 \text{ or } nc2} = 1.172 + [p_{nc1 \text{ or } nc2} * 1.172] \quad (2)$$

$$VE_{nc1 \text{ or } nc2} = V_{nc1 \text{ or } nc2} * T \quad (3)$$

$$E_{nc1} = T_{nc1=5} - T_{nc1=5-n} \quad (4)$$

$$E_{nc2} = T_{nc2=4} - T_{nc2=4-n} \quad (5)$$

$$D_{nc1} = T_{nc1=5} - T_{pc1=5+n} \quad (6)$$

$$D_{nc2} = T_{nc2=4} - T_{nc1=4+n} \quad (7)$$

$$EE_{nc1 \text{ or } nc2} = E_{nc1 \text{ or } nc2} * 10 \quad (8)$$

$$DC_{nc1 \text{ or } nc2} = D_{nc1 \text{ or } nc2} * 10 \quad (9)$$

where,T is the travel time in minutes, n is the index of the percentage of choice ranging from 1 to 10, c1 is the choice 1, c2 is the choice 2, L is the length of the road in meters, U is the designed speed of the primary or secondary road, V is vehicle emission of the passenger car with respect to the percentage of choice 1 or 2 selected by players in gram/min, p is the percentage of choice 1 or 2 selected by players, VE is the vehicle emission exposure of the players passing through primary or secondary road in grams, E is the early time which denotes the travel time saving in minutes, D is the delay time which denotes the increase in travel time in minutes, EE is the early earnings gained by the players due to travel time saving, and DC is the delay cost paid by the player from their salary due to the increase in travel time.

It is observed from the Table 2, that choice 1 seems to be more attractive for players but high risk is involved, when the percentage of choice 1 is more than 50%. This means that when more than half of the total players select choice 1, then they have to loose money from their salary for the delay in travel time. The choice 1 is compared with the primary short road in reality, where it influence the vehicle drivers, as it saves travel time but also associates high risk of congestion. In case of choice 2, the players do not earn more and at the same time they do not loose more, when the percentage exceeds 40%. Hence the intensity of risk is very less in case of choice 2. It represent the secondary road in reality, where it has longer travel time and lesser congestion. In choice 3, there is no mechanism, which involves no earnings and no delay cost and hence no risk. In reality, the public transport bus provided by Government has fixed time table schedule and routes; hence passengers are only given services to travel but not to select the time and route of travel of their choice.

Table 2. Developed choice mechanism for Transport Game

Choice 1 - CAR with Route 1 with length:1.800km								
Index	Percentage of Choice 1	Total Travel Time	Speed	Speed	Vehicle Emission	Vehicle Emission Exposure	Early '+'/ Delay '-'	Early Earnings/ Delay Cost
(n)	(p)	(T)	(u)	(U)	(V)	(VE)	(E/D)	(EE/DC)
(No)	(%)	(min)	(km/hr)	(m/s)	(g/min)	(g)	(min)	(Rs.)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1	1-10	4	27.000	7.50	1.172	4.7	26	260
2	11-20	10	10.800	3.00	1.406	14	20	200
3	21-30	15	7.200	2.00	1.524	23	15	150
4	31-40	20	5.400	1.50	1.641	33	10	100
5	**41-50**	**30**	**3.600**	**1.00**	**1.758**	**53**	**0**	**0**
6	51-60	60	1.800	0.50	1.875	113	-30	-300
7	61-70	60	1.800	0.50	1.992	120	-30	-300
8	71-80	80	1.350	0.38	2.11	169	-50	-500
9	81-90	100	1.080	0.30	2.227	223	-70	-700
10	91-100	130	0.831	0.23	2.344	305	-100	-1000

Choice 2 - CAR with Route 2 with length:2.700km								
Index	Percentage of Choice 2	Total Travel Time	Speed	Speed	Vehicle Emission	Vehicle Emission Exposure	Early '+'/ Delay '-'	Early Earnings/ Delay Cost
(n)	(p)	(T)	(u)	(U)	(V)	(VE)	(E/D)	(EE/DC)
(No)	(%)	(min)	(km/hr)	(m/s)	(g/min)	(g)	(min)	(Rs.)
(1)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	1-10	20	8.1	2.25	1.172	23.44	10	100
2	11-20	25	6.48	1.8	1.4064	35.16	5	50
3	21-30	25	6.48	1.8	1.5236	38.09	5	50
4	**31-40**	**30**	**5.4**	**1.5**	**1.6408**	**49.22**	**0**	**0**
5	41-50	45	3.6	1	1.758	79.11	-15	-150
6	51-60	45	3.6	1	1.8752	84.38	-15	-150
7	61-70	45	3.6	1	1.9924	89.66	-15	-150
8	71-80	60	2.7	0.75	2.1096	126.6	-30	-300
9	81-90	60	2.7	0.75	2.2268	133.6	-30	-300
10	91-100	90	1.8	0.5	2.344	211	-60	-600

Choice 3 - BUS with Route 2 with length:2.700km								
Index	Percentage of Choice 3	Total Travel Time	Speed	Speed	Vehicle Emission	Vehicle Emission Exposure	Early '+'/ Delay '-'	Early Earnings/ Delay Cost
(n)	(p)	(T)	(u)	(U)	(V)	(VE)	(E/D)	(EE/DC)
(No)	(%)	(min)	(km/hr)	(m/s)	(g/min)	(g)	(min)	(Rs.)
(1)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1-10	**1-100**	**No Mechanism – No earnings and No cost**						

2.5 Transport game – Structure

The transport game is structured under three scenario. Based on this, three games are played with players, with given three choices. The first game is played under no traffic rules or measures as base case scenario, where there is no restriction on given choices and players are allowed to select any choice to reach their office. The second game is played under the introduction of traffic rule and traffic measure in to the game, where there is a restriction on the choices to players. In the first two games, communication between the players are strictly not encouraged. The third game is played same as second game except involving players in to decision making of rules, by allowing them to communicate. Each of these three games is played with six rounds, accounting from monday through saturday in office. Based on this, all players would receive a daily wage salary of Rs.500 (8,50 € approx) for each round. The total earnings of the each player at the end of the each game is the sum of Rs.3000 (i.e. 6*Rs.500) and the early earnings (EE) or delay cost (DC) due to delay or early in travel time. Based on the selection of choices, the investment cost namely vehicle operating cost and ticket price for all the players are same in all six rounds of three games. The procedure and choice details of each game are discussed in the following section.

2.5.1 Baseline Treatment - Game 1

On the start of the round, each player in the game is asked to fill their preferred choice privately, in the given sheet (Annexure1). Then it is collected and evaluated by the game organiser by the use of choice mechanism excel sheet. The organiser announces the earnings or the cost gained or incurred by the player based on his/her choice. After the evaluation, the sheets are returned to the players and are asked to fill their preferred choice for next round. This continues until the game reaches sixth round. In this game, there is no interference of any traffic rules or measures. The choice details for the game 1 is shown in Table 3

Hence the total earnings of the each player by the end of the this game = (Daily wage Rs.500 * 6 rounds) - total investment (VOC or ticket price) for all the six rounds +/- total early earnings (EE) or total delay cost (DC) due to travel time.

2.5.2 Traffic rule - Traffic Management scheme scenario – Game 2

The game procedure is followed same as game 1 except it highlights the interference of rules and management schemes in the given choices to the players.There are three rules in the game which are built on each traffic management measure. They are odd-even car number plate scheme in primary road, odd-even car number plate scheme in both primary and secondary roads, public transport subsidy. The car registration number in the game is the player number. Each rule are explained to all players used in the game and they are asked to vote their preferred rule and they are as follows:

Rule a) - Odd-even car number plate scheme in primary road

The rule is that based on the day, the odd or even players are allowed to select only choice 1.

- On day1 (Monday), only odd players are allowed to select choice 1
- On day2 (Tuesday), only even drivers are allowed to select choice 1 and so on..
- Choice 2 and 3 is open to all players, both odd and even drivers on all days

Rule b) - Odd-even car number plate scheme in both primary and secondary roads

The rule is that based on the day, the odd or even players are allowed to select Choice 1 or Choice 2

- On day 1, only odd players are allowed to select choice 1 or 2
- On day 2, only even players are allowed to select choice 1 or 2 and so on..
- Choice 3 is open to all on all days

Rule c) - Public transport subsidy

The rule is that Government subsidizes Public transport and hence traveling by bus is free, where there is no ticket cost

In this rule, the Government must raise taxes to support subsidies, so Rs.10 would be deducted as road tax from all vehicle users (here all car users)

- All car users must pay the road tax, irrespective of their choices 1 or 2. If driver choose Choice 1 or 2, he/she has to pay fuel cost Rs. 30 plus the road tax Rs.10.
- Bus users are exempted from both ticket cost and road tax
- Choices 1 and 2 are open to all on all day

The selected rule is implemented in the game, based on the maximum number of votes prefered by the players. They are also given an option to violate the rule, by selecting the choice, which is not normally allowed to them. This is controlled by the organiser during evaluation, who act as traffic police in this game and he rolls the dice in every round, where there is 3/6 chance for him to perform checks. In case, when the

violators (players) are caught during his check, then they have to pay Rs.300 as penalty from their salary.
The investement details (Table 4) for all the choices under rule a and b in this game is same as game 1 but in rule c, the players who choose choice 1 or 2 have to pay additional road tax, in order to support government for subsidising public transport (choice 3) and the players who choose choice 3 are exempted from paying ticket price. The violation is allowed for all players only in the traffic rule and not in their investment.
Hence the total earnings of the each player by the end of the this game = (Daily wage Rs.500 * 6 rounds) - total investment (VOC or ticket price or road tax) for all the six rounds +/- total early earnings (EE) or total delay cost (DC) due to travel time – penalty (if so the player violated and caught by police)

2.4.3 Traffic rule - Traffic Management scheme scenario with public participation – Game 3

In this game, the public participation in decision making of rules is encouraged. This is ensured by allowing players to communicate each other in the alternate rounds of the game (1^{st},3^{rd} and 5^{th} round) and to come up with their own proposed rules to regulate traffic, which may be the modifications of existing rules or completely new rules and they are not allowed to do modifications in the choice mechanism. The procedure of this game is same as Game 2 (sec. 2.5.2).
The game based on this structure was experimented with 20 bachelor students from Jawarhalal Nehru Fine Art and Planning University in Hyderabad, India. The results of the game are displayed and discussed in the next section

2.5 Results and discussions

2.6.1 Socio-economic background of the groups

The group consist of 80% of male and 20% of female players. The players are native of Hyderabad city India. The average age of group is 20 years. All players in the group know car driving. The game was first played in Hyderabad, India. The results of the game played under each scenario for the the groups are discussed in the following sections.

2.6.2 Choice decision of group

Scenario 1- Baseline treatment -No rule

From Fig.5, it is observed that out of twenty players, nine players select majority of their preferred choice as choice1 in all six rounds, six players as majority preferred choice as choice 3, two players as choice 2, two players has given equal importance to all the three choices and remaining two players are completely biased towards a single choice namely choice 1 and 3.
It is also obvious that choice 1 is the preferred choice by most of the players in the group. This may reflect the rational behaviour of vehicle drivers in Hyderabad. The short route with no traffic rules might influence them to use, inorder to save their travel time. Two players in the group select choice 1 in all rounds, who indicates the purely rational individuals.
However choice 3 is also mostly preferred by some players in the group. This also reflect the behaviour of bus passengers, who do not want to take risk of congestion or accident, by using the private vehicles. This also indicates that they are not always rational.It is also observed that Player 3 has selected choice 3 in all rounds. This may indicate either that he/she is irrational or they might not understand the game. Choice 2 seems to be less attractive option except for few players in the group. The impact of the implementation of rules on decsion of choices by the players is discussed in the following section.

Scenario2- Traffic rule - Traffic Management scheme

The traffic rules plays a main role in this game. All the players are asked to vote their preferred rule and it is then implemented in the game. The result of the vote by the players is shown in Table 5. It is observed that rule c) Public transport subsidy is the most preferred rules by the players. The result of selection of choices after the implementation of the rule c) in Game 2 are discussed below:
From Fig.6, it is obvious that the rule c) has brought many positive changes in the decision of choices among players. Three different type of decisions towards choice 3 could be oberved from players namely choice shift, most preferred and completely biased could be observed . Four players have shifted their choice from choice 1 to choice 3 and totally nine players have mostly preferred choice 3. Out of nine, four players are completely biased towards choice 3 in all six rounds. Only five players have selected choice 1 and remaining players.

Scenario3- Traffic rule – Public participation

The players are allowed to communicate in every alternate rounds namely Monday, Wednesday and Saturday. In an overall, it is observed from the mutual communication between players that they want to try the other two rules namely rule a) and rule b). Hence,

Table 3 Choice details for No rule base case scenario

Choice	Max. Capacity (%)	Length of route (km)	Initial Investment (Rs.)	Profit (Rs.)	Loss (Rs.)
1	50%	1.8	30 (for all rounds)	Each earlier 1 min, (+)10	Each delay 1 min, (-)10
2	40%	2.7	30 (for all rounds)	Each earlier 1 min, (+)10	Each delay 1 min, (-)10
3	No limit	2.7	10 (for all rounds)	No profit	No loss

Table4. Percentage of preferred rule

	% of preferred rules
Rule a	30
Rule b	20
Rule c	50

they played with rule a) on Monday, Tuesday and Saturday and with rule b) on Wednesday, Thursday and Friday. As a result of the implementation of rule a) and b), it is observed from Fig.7, that again choice 1 and 2, predominated in their decision of players in game 3.

In general, scenario 1 (with out rule) and scenario 3 (with rule a and rule b) have same effects in the decision of their choice among players, mostly towards choice 1 and choice 2 and scenario 2 (with rule c) has major effect towards choice 3.

The outcome of the decision of the choices of players are actually shown as the effect of controlling transport parameters namely monetary earning, vehicle emission exposure and travel time delay/no delay, which are discussed in the following section.

2.6 Effect of transport parameters

The effect of transport parameters namely monetary earnings, vehicle emission exposure and travel time savings due to decision of choice made by players compared with all days (rounds) under all games are explained as follows:

From the Fig.11 and 12, in general, the Game 2 has an average travel time saving of 94.2 minutes and corresponding monetary earnings of Rs.942, which is highest of all the games. Game1 and game 3 has average travel time delay of 136.6 and 104.1 minutes and corresponding negative monetary earnings of Rs.1366 and Rs.1041. The selection of choice also has an effect of vehicle emission exposure, which is shown in Fig.13. It is observed that Game 3 has an average vehicle emission exposure of 1075g, which is higher than Game 1 with 971g and Game 2 with 344g.

The contrasting difference in travel time and their corresponding earnings and vehicle emission exposure between the games might be due to the problem of rivalry in the form of traffic congestion resulting in travel time delay in Game 1 and Game 3. It is also observed that due to effect of rule c (public transport subsidy), the result of Game 2 reflects the social optimum situation when compared to Game 1 and Game 3.

2.7 Further improvement of the transport game

The transport game has to address the following factors for further improvement.

1. The vehicle emission and average vehicle speed for secondary road have to be linked with real estimated value
2. The Social optimum and Nash equilibrium condition of the game has to be determined for the accuracy of the game.
3. The implemantation of traffic rules with driving behaviour has to be analysed further to know about their impacts
4. The choice and rule sets need to be simplified further

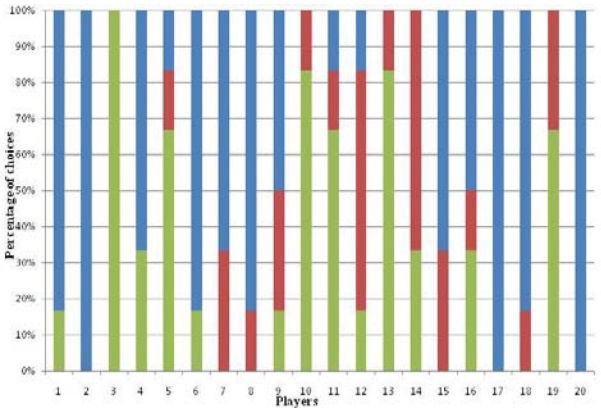


Fig.5 Overall % of choices in game 1

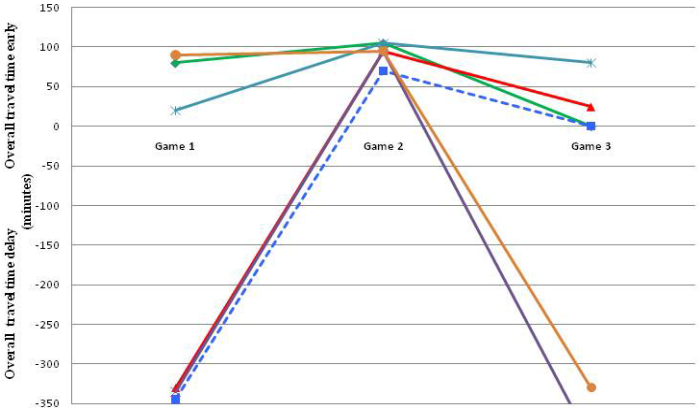


Fig.11 Overall travel time delay-early

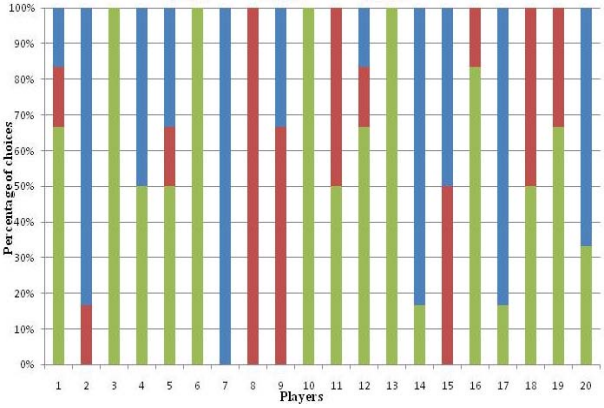


Fig.6 Overall % of choices in game 2

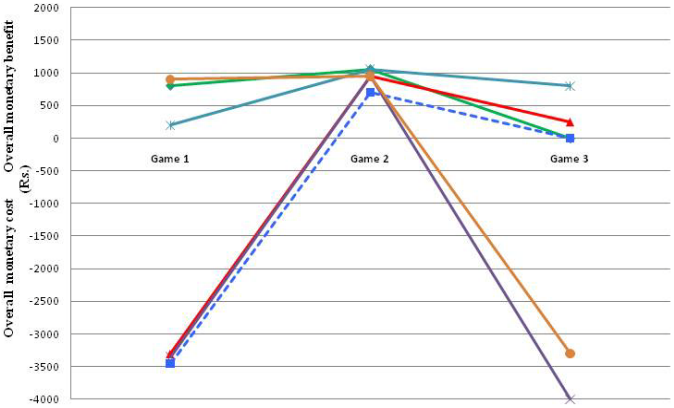


Fig.12 Overall monetary earnings

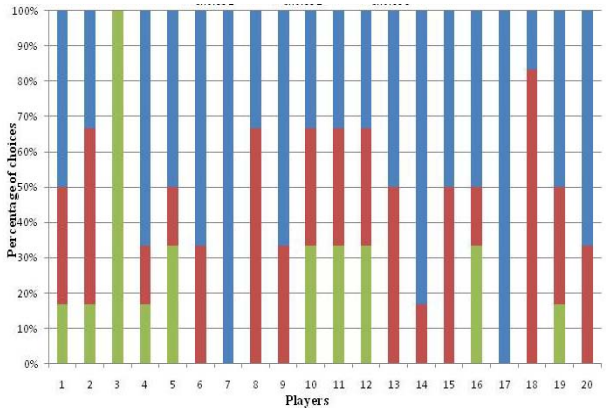


Fig.7 Overall % of choices in game 3

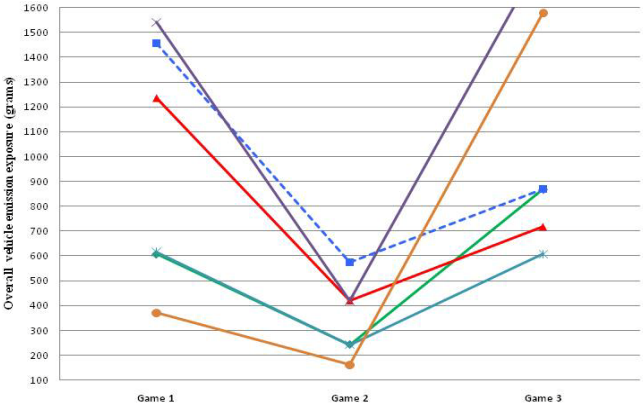
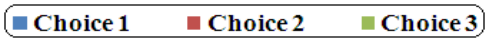
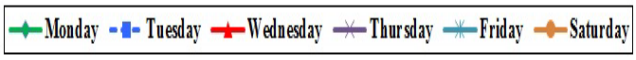


Fig.13 Overall vehicle emission exposure





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Annexure - 1

TRANSPORT GAME 1 Player No._____ Player Name_____						
Rounds	**Daily Salary Rs.** (A) (+)	**My Choice 1/2/3** (B)	**Investment- IF Choice 1 or 2 - Avg. fuel, maintenance, parking cost :Rs.30 only in all rounds or If Choice 3 - Ticket Cost:Rs.10 in all rounds** (C) (-)	**Travel time**		**Total Earnings (Rs.)** (F) = (A)-(C)+(D)-(E)
				Credits Rs. (D) (+)	**Debits Rs.** (E) (-)	
Trial 1	1000					
Trial 2	1000					
TOTAL						
1-Mon	1000					
2-Tues	1000					
3-Wed	1000					
4-Thurs	1000					
5-Fri	1000					
6-Sat	1000					
TOTAL						