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# PROBABILITIES OF POLICY SHIFT TO PUBLIC TRANSPORT
# Case study: Tripoli - Libya

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***Abstract*— Private cars are important for most household activities in Libyan societies. They give comfort and convenience to the users to go to different destinations without affecting other users. However, the total number of private car and private transport namely taxi and micro buses on the road increases and causes many problems such as traffic congestion, accidents, air and noise pollution. This study aims to identify the factors to support private car drivers shifting to public transport system (PT) and to develop model shift from private car to public transport in order to formulate policies to achieve this. The study has been carried out in Tripoli city authority areas among private car users who live in the areas with lack of private transport and no public transport (PT) services. A questionnaire survey was carried out to study the potential reduction of private cars on road through optimal use of suitable public transportation system in order to reduce traffic problems. The probability of policy car drivers shifting to public transport was examined based on scenario several options such as reduce and improve in public transport travel time, travel cost and car parking. This study has recommended shift level of level 113 (it means that parking cost will be increased by Libyan Dinar (LYD) 0.5 as level 1 (low level), travel time to be improved by 10% as level 1 (low level) and travel cost to be reduced by at least 50% as level 3 (middle level)) to be implemented if the targeted PT shift around 60% to be achieved. The result has shown a logical implementation to both of the travellers and operators. Statistical Package for Social Science (SPSS) and Excel 2007 software were used to descriptive and analysis the questionnaire in this study.**

***Keywords— private car, public transport, travel time, travel cost, parking cost, Probability and policy shift.***

## I. INTRODUCTION

Tripoli is Libya's largest city and port, and is the country's capital. Meeting-place of the People's Congress, it is known in Arabic as Tarabalus Al-Gharb, or Tripoli of the West. Tripoli population is exceeding about 1,682,000 people with covered area of 400 square kilometers and population density 2207.32 people / sq km [7]. Private car is one of the important modes of personal transport in Libya cities, mainly because it is cheap and more reliable than the current transport modes available namely (taxi and micro buses) [3]. Every Libyan adult person almost owns one car or more cars. He and she can travel from place to place in safe way. Also, it is provided with comfortable mechanisms such as a cover to protect him from the heat and rain. The other transport type available in Libya is Taxi [4]. This paper is a part of the study that focused on policy of model shift initiatives. These initiatives focused on shifting private car users to safer modes of public transport in order to increase road safety and enhance the environment with improve travel time [1].

## II. STUDY PROBLEM

Understanding travel time, cost, parking cost and the reasons for choosing one transport mode over another is an essential issue. However, travel time is more complex. For each trip, travellers have the choice between different modes of transportation. Each mode has specific characteristics, such as advantages and disadvantages associated with travel time, travel cost and parking cost. Travellers in Tripoli used private transport namely microbuses, private taxies and private cars to their works, study and shopping activities. Private transport can be owned and operated by individuals or private company. The uncontrolled usage of these transport modes has caused traffic congestion problems, which has increased travel time, road accident and air pollution to the city environment [9].

However, private cars users have become more popular and dominant than other modes of transport in Tripoli city due to their availability, flexibility and convenient for travel when required. Private cars also represent high status, comfort and safety. Due to the complex scenarios happening here a study has been carried out to understand the traffic congestion and try to establish suitable models system to reasonably described travelers attitude and perception in Tripoli city.

## III. METHODOLOGY

The survey was done using questionnaires to get relevant data. The questionnaires were distributed to the private vehicle users who do not use other modes of transportation. The respondents were selected randomly. 900 questionnaires were collected in 5 months from (25 July to 23 December 2015). There are several questions that correspond with respondents' views, recommendation and opinions. These questions provide the opportunity for the respondents to give their opinion. The questions are formulated in such as way that could help the respondent answer the questionnaire easily and quickly. Brief questionnaires were formed to ensure for user's comprehension and they are in the form of open and close ended questions. The selected respondents were based on private transportation vehicle and private car users who use their private vehicles as their mode of transportation to go to his/ her trips. The study employs mostly primary data obtained from samples of private vehicle travellers at Tripoli

city. Analyses about relation between factors such as travel time, travel cost and parking cost have been made to answer study questions. Statistical Package for Social Science (SPSS) and Excel 2007 software were used to analysis the questionnaire in this study.

## IV. DESCRIPTIVE AND ANALYSIS RESULTS OF STUDY FACTORS

### A. *Parking cost*

Figure (1) shows the cumulative percentage of the parking cost increase, such as a 0.5 Libyan Dinar (LYD) per hour will encourage 5.2% of respondents to shift to PT. When parking cost is increased by 1 LYD per hour, it will motivate 24.5% of respondents to shift. When parking cost is increased by 3 LYD per hour 54.5% of respondents will be encouraged to shift. Also when the parking cost is increased by 5 LYD per hour 100% of respondents will be encouraged to shift.

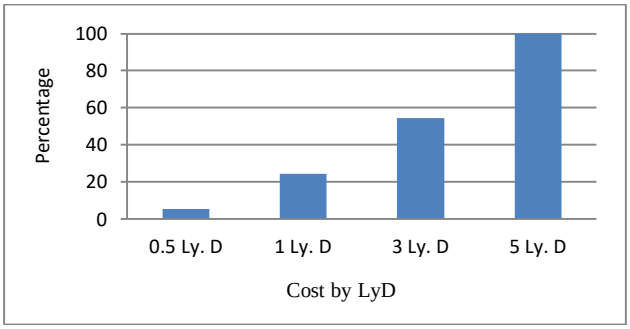


Fig. 1. Parking cost increase

### B. *Estimation of Travel Time Reduction by Public Transport*

The respondents were asked about the estimated percentage travel time reduction, that would make them shift to PT. Improving the travel time for public transport by the reduction of time percentage, can be a way to encourage the public transport use. According to Figure (2), it shows the cumulative reduced travel time percentage likely to motivate the respondents to shift into public transport, 10% reduction of travel time will encourage 7.2% of respondents to shift, the 30% reduction of travel time will encourage 13.6% of respondents to shift, the 50% reduction of travel time will encourage 48% of respondents to shift, the 70% reduction of travel time will encourage 84.3% of respondents to shift and the 90% reduction of travel time will encourage 100% of respondents to shift.

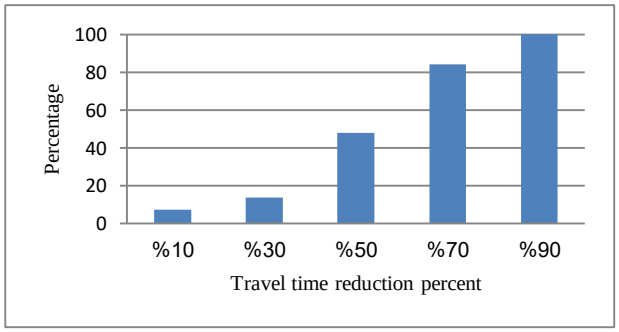


Fig. 2. Reduction cumulative travel time

### C. *Estimation of Travel Cost Reduction by Public Transport*

The respondents were asked about the estimated percentage travel cost reduction, that will make them shift to PT. Improving the travel cost for public transport by reduction cost percent, will serve as an intention to encourage the public transport use. According to Figure (3), it shows the cumulative reduced travel cost percentage likely to encourage the respondents to shift into public transport, 10% reduction on travel cost will encourage 8.3% of respondents to shift, the 30% reduction on travel cost will encourage 25.7% of respondents to shift, the 50% reduction on travel cost will encourage 60.4% of respondents to shift, the 70% reduction on travel cost will encourage 88.5% of respondents to shift and the 90% reduction on travel cost will encourage 100% of respondents to shift, altogether depending on question 41 in the questionnaire.

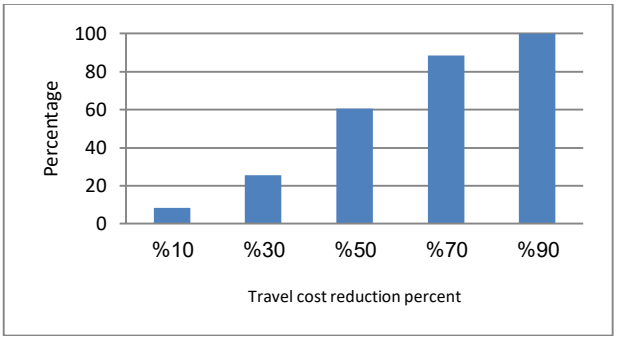


Fig. 3. Reduction cumulative travel cost percent

### D. *Combination of the three deciding factors*

The development of mathematical probabilities function for policy shift to public transport was explored extensively in this study. The three deciding factors namely reduced travel time, reduced travel cost and increased parking fee were used in the development and they were analyzed together as suggested by Neuman. W. I [9].The optimum probability was derived by finding the best combination of the three deciding factors above using a recently developed simulation model for heterogeneous traffic flow.

This section aims to shed light on strategies that may be implemented in decision maker policy to further boost the transport mode shift. Also, the section aims to estimate the optimum combination policy of public transport travel time, travel cost and parking cost per hour of private car to actually maximize the transport shift from private car to public transport. Thus, the objective of this study is to optimize the response, for instance the travel transport shift, which is influenced by several independent factors specifically travel time reduction, travel cost reduction and increasing parking cost per hour[1]. The study has three independent factors at different levels, four levels for parking cost, five levels for travel time and travel cost reduction. Table (1) below shows data which are obtained from above figures as (1) parking cost, (2) concerning reduced travel time and (3) reduced the travel cost to show the probability and cumulative probability of shifting into public transport by various levels of factors for 750

questionnaires. Based on Table (1), the most effective level for parking cost increment happened at 5 Libyan Dinar (LYD), while 70% improvement for travel time and 50% reduction in travel cost.

TABLE 1. THE MAIN SHIFT FACTORS

| Factors | Category | Level | Prob. (%) | Cum. Prob.% |
|---|---|---|---|---|
| Parking cost | 1 | 0.5 LYD | 5.2 | 5.2 |
| | 2 | 1 LYD | 19.3 | 24.5 |
| | 3 | 3 LYD | 30 | 54.5 |
| | 4 | 5 LYD | 45.5* | 100 |
| Travel time | 1 | 10% | 7.2 | 7.2 |
| | 2 | 30% | 6.4 | 13.6 |
| | 3 | 50% | 34.4 | 48 |
| | 4 | 70% | 36.3* | 84.3 |
| | 5 | 90% | 15.7 | 100 |
| Travel cost | 1 | 10% | 8.3 | 8.3 |
| | 2 | 30% | 17.5 | 25.7 |
| | 3 | 50% | 34.7* | 60.4 |
| | 4 | 70% | 28.1 | 88.5 |
| | 5 | 90% | 11.5 | 100 |

* Highest probability for effective levels

If the Libyan decision maker plans to boost the transport mode shift at the fastest pace, then the parking cost increment by 5 LYD, travel time improvement by 70% as well as travel call reduction 50% have to be implemented. However, this Table 1 only presents the information of transport mode shift if action were to be taken only on a factor. A better solution can actually be achieved by the combination of three factors. Table (2) below has demonstrated the transport mode shift probability for the combination of factors at different levels. Policy can be made based on the percentage of users' shift into public transport, which the decision maker wishes to achieve.

For each combination of levels, the probability of shift was calculated using SPSS as shown in Table (2). Table (2) shows, that in this paper study needs to find the levels of parking cost increment (X), level of travel time reduction by public transport (Y) and level of travel cost reduction (Z) that maximize the response (shift) of respondents from private car to public transport. The public transport shift is a function of levels of reduction in travel time, travel cost and increasing parking cost [9], as follows:

$$\textit{Shift level } XYZ = f(X, Y, Z) + \varepsilon \quad (1)$$

Where: X = level of parking cost increment, Y = level of travel time improvement, Z = level of travel cost reduction, ε represents the error observed in the response (shift) and f represents the function of Public transport shift level of reduction in travel time, travel cost and parking cost.

For example when we compute shift level 111 = parking cost <= 1 OR Improved travel time by public transport to shift <= 1 OR Reduce travel cost of public transport to shift to public mode <= 1. Shift level 111 that means, parking cost (X) or level (1) is represented by 0.5 LYD per hour, improved travel time (Y) or level (1) is represented by 10% reduced travel time and reduced travel cost (Z) or level (1) is represented by 10% reduced travel cost. Through this section, a set of combined main factors (reduced travel time, reduced travel cost and increasing parking cost per hour) differentiates the shift behavior of private car users to public transport by increasing the service level of Tripoli city road network. It can be inferred from the modal shift probability in Table (2), that by several shifts in the levels of policy scenarios, with reducing low shift level of travel time as 10% are 63.1% by shift level 113, 63.9% by shift level 123, 69.2% by shift level 133, 89.2% by shift level 143, and when increased the travel time reducing percentage by 30% the level shifting start increased to 71.6% by shift level 213.

Based on Table (2), if the probability to make the shift was set at 60%, few practical solutions were detected such as for Shift level 113, it means that the parking cost will be increased by 0.5 LYD as level 1 (low level), travel time to be improved by 10% as level 1 (low level) and travel cost to be reduced by at least 50% as level 3 (middle level)) with probability shift is (63.1%). For shift level 123, it means that the parking cost will be increased by 0.5 LYD as level 1 (low level), travel time to be improved by 30% as level 2 (low level) and travel cost to be reduced by at least 50% as level 3 (middle level) with the probability shift (63.9%). As for shift level 311, it means that the parking cost will be increased by 3 LYD as level 3 (middle level), travel time to be improved by 10% as level 1 (low level) and travel cost to be reduced by at least 10% as level 1 (middle level) with probability shift is (61.1%). Shift level 312, it means that parking cost will be increased by 3 LYD as level 3 (middle level), travel time to be improved by 10% as level 1 (low level) and travel cost to be reduced by at least 30% as level 2 (middle level) with the probability shift (65.9%). Next, for shift level 321, it means that the parking cost will be increased by 3 LYD as level 3 (middle level), travel time to be improved by 30% as level 2 (middle level) and travel cost to be reduced by at least 10% as level 1 (low level) with the probability shift being (62.8%). Also, for shift level 322, it means that the parking cost will be increased by 3 LYD as level 3 (middle level), travel time to be improved by 30% as level 2 (middle level) and travel cost to be reduced by at least 30% as level 2 (middle level) with probability shift of (67.1%). This study however recommends Shift level 113 to be implemented if the target of public transport shift was around 60%, as it yielded comparable results, given the ease of implementation (low level of parking cost does not burden the citizens and low level of travel time is achievable with little effort).

With shift 113, it means that the parking cost will be increased by 0.5 LYD, travel time to be improved by 10% and travel cost to be reduced by 50%.

TABLE 2. THE LOWEST AND HIGHEST PROBABILITIES PERCENTAGE OF SHIFT TO PUBLIC TRANSPORT (n=750)

| Level | N | Prob. | Level | N | Prob. | Level | N | Prob. | Level | N | Prob. | Level | N | Prob. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Shift 111 | 117 | 15.6 | Shift 121 | 147 | 19.6 | Shift 131 | 392 | 52.3 | Shift 141 | 651 | 86.8 | Shift 151 | 750 | 100 |
| Shift 112 | 222 | 29.6 | Shift 122 | 240 | 32 | Shift 132 | 421 | 56.1 | Shift 142 | 653 | 87.1 | Shift 152 | 750 | 100 |
| Shift 113 | 473 | 63.1 | Shift 123 | 479 | 63.9 | Shift 133 | 519 | 69.2 | Shift 143 | 669 | 89.2 | Shift 153 | 750 | 100 |
| Shift 114 | 676 | 90.1 | Shift 124 | 678 | 90.4 | Shift 134 | 686 | 91.5 | Shift 144 | 701 | 93.5 | Shift 154 | 750 | 100 |
| Shift 115 | 750 | 100 | Shift 125 | 750 | 100 | Shift 135 | 750 | 100 | Shift 145 | 750 | 100 | Shift 155 | 750 | 100 |
| Shift 211 | 250 | 33.3 | Shift 221 | 276 | 36.8 | Shift 231 | 469 | 62.5 | Shift 241 | 675 | 90 | Shift 251 | 750 | 100 |
| Shift 212 | 333 | 44.4 | Shift 222 | 349 | 46.5 | Shift 232 | 491 | 65.5 | Shift 242 | 677 | 90.3 | Shift 252 | 750 | 100 |
| Shift 213 | 537 | 71.6 | Shift 223 | 543 | 72.4 | Shift 233 | 572 | 76.3 | Shift 243 | 690 | 92 | Shift 253 | 750 | 100 |
| Shift 214 | 693 | 92.4 | Shift 224 | 695 | 92.7 | Shift 234 | 702 | 93.6 | Shift 244 | 713 | 95.1 | Shift 254 | 750 | 100 |
| Shift 215 | 750 | 100 | Shift 225 | 750 | 100 | Shift 235 | 750 | 100 | Shift 245 | 750 | 100 | Shift 255 | 750 | 100 |
| Shift 311 | 458 | 61.1 | Shift 321 | 471 | 62.8 | Shift 331 | 584 | 77.9 | Shift 341 | 705 | 94 | Shift 351 | 750 | 100 |
| Shift 312 | 494 | 65.9 | Shift 322 | 503 | 67.1 | Shift 332 | 593 | 79.1 | Shift 342 | 706 | 94.1 | Shift 352 | 750 | 100 |
| Shift 313 | 613 | 81.7 | Shift 323 | 618 | 82.4 | Shift 333 | 636 | 84.8 | Shift 343 | 715 | 95.3 | Shift 353 | 750 | 100 |
| Shift 314 | 720 | 96 | Shift 324 | 721 | 96.1 | Shift 334 | 724 | 96.5 | Shift 344 | 731 | 97.5 | Shift 354 | 750 | 100 |
| Shift 315 | 750 | 100 | Shift 325 | 750 | 100 | Shift 335 | 750 | 100 | Shift 345 | 750 | 100 | Shift 355 | 750 | 100 |
| Shift 411 | 750 | 100 | Shift 421 | 750 | 100 | Shift 431 | 750 | 100 | Shift 441 | 750 | 100 | Shift 451 | 750 | 100 |
| Shift 412 | 750 | 100 | Shift 422 | 750 | 100 | Shift 432 | 750 | 100 | Shift 442 | 750 | 100 | Shift 452 | 750 | 100 |
| Shift 413 | 750 | 100 | Shift 423 | 750 | 100 | Shift 433 | 750 | 100 | Shift 443 | 750 | 100 | Shift 453 | 750 | 100 |
| Shift 414 | 750 | 100 | Shift 424 | 750 | 100 | Shift 434 | 750 | 100 | Shift 444 | 750 | 100 | Shift 454 | 750 | 100 |
| Shift 415 | 750 | 100 | Shift 425 | 750 | 100 | Shift 435 | 750 | 100 | Shift 445 | 750 | 100 | Shift 455 | 750 | 100 |

Shift XYZ, where X = level of parking cost increment, Y = level of travel time improvement and Z = level of travel cost reduction

If the proportion of respondents' transport mode shift was to be set at 70%, two practical solutions have been found, which are firstly, Shift level 213 , where this means that the parking cost will be increased by 1 LYD, travel time to be improved by 10% and travel cost to be reduced by 50%, with shift probability (71.6%) and secondly shift level 223, where it means that the parking cost will be increased by 1 LYD, travel time to be improved by 30% and travel cost to be reduced by 50%, with shift probability of (72.4%). Nevertheless, this study suggests Shift 213 to be taken by improving the travel time from 10% to 30%, and the likelihood to shift only increase by 1%. Therefore, Shift 213 is deemed to be more suitable as reducing travel time by 10% is more practical to 30% reduction, while both solutions yielded comparable results.

In light of the above discussions, the probabilities prediction policy is proposed to re-establish and develop public transport services and control private car ownership simultaneously has become necessary for solving the problems. The objectives of this study are to develop mode shift models to expressing private car and public transport users behavior and investigate their response to scenario of a reduction in public transport travel time and travel cost with increased car park fee by introduce public bus rapid transit (BRT) with exclusive lane. The reduction in travel time and travel cost of public transport modes emerges as the most important elements in a program aimed at attracting private car users towards public transport and away from their usual private car dependency.

Reduced travel time by 10% to 30% especially at rush hour on major roads of Tripoli city will most likely render higher probability of public transport shift, according to data and results for instance between Al-Gabis entrance and Tripoli city center, the trip travel time may be reduced by 30% from 40 minutes to 28 minutes in the morning peak hours, and from 45 minutes to 31.5 minutes in the afternoon peak hours. Also, the separation from traffic congestion will result in predictable, reliable services [2] & [11]. The "reduce travel time, travel cost and increases car parking fee and build exclusive public transport lanes" between Tripoli city and main Entrances provide traffic services as following:

- Improve the average speed and reliability of travel, making travel a more attractive activity for those people who are now driving, and who are able to leave their private cars at home;
- Encourage the provision of improved travel services to Tripoli and the employment areas in the city boundary.
- Support the objectives of reducing people's dependence on the private car during rush hours and reducing traffic congestion.

Accordingly, the level of travel time improvement should be set at lower level (10 to 30%) so that the decision made will be to be more practical in the context of implementation later on. On the other hand, travel cost and parking cost are easier to adopt compared to travel time, although some limitations may be applied to these two aspects. For the parking cost increment, it is proposed that the government should avoid from making increment at a level that will give extra burden to private car users. Lastly, for the travel cost reduction, it can be done easily with the government support or subsidy. Ultimately, the target of parking cost increment as well as travel time improvement at lower level should only be taken into consideration, to avoid excessive burden to the citizens as well as in terms of the policy's practicality. There is no absolute solution in achieving the desired transport shift (%); however it should be based on the capability of the government in taking such action. Viewing from the angle of implementation's difficulty, reducing travel time must be the most complicated action compared to reducing the parking cost and travel cost. Travel time can be explained as a long term strategy which involves the improvement of the traffic system in terms of having wider land, exclusive lanes for public transport, and etc.

## V. DISCUSSION:

The probability prediction of policy shift shows a wide range of respondents' opinions and their probability of choosing the better travel services. Nurdden et al, have identified the factors that prevent private car users from using public transport so that rational policies could be expressed to encourage greater use of public transport [10]. Mackett R. I, identifies different policy actions to reduce private car use for different types of trips and the actions that are required to meet the travel needs that the car currently fulfills [8]. The most important factors, found likely to encourage the use of public transport, were reduced travel time, travel cost and increased car park fee by different percentages and the provision of separated lanes for public transport modes for example bus rapid transit (BRT) [5]. The results show the if proportion of respondents' transport mode shift was to be fixed at 60%, with two practical solutions found, which are Shift 113 (63.1%), 123 (63.9%), also 70%, where two practical solutions are found, which are Shift 213 (71.6%) and 223 (72.4%). The results of these would contribute to less traffic congestion on the Tripoli network roads and subsequently giving less pollution and high level of service and safety. The factors that avoid private transport users from using public transport must be identified, so that rational policies could be formulated to encourage greater use of public transport, [10].

## XII CONCLUSION

The significant increase in the level of service of the public transport system is due to the reduction of travel time and cost and increased private car parking fee with the introduction of exclusive bus lanes determined using a recently developed simulation model for heterogeneous traffic flow. A better solution can actually be achieved by the combination of three factors. Policy can be made based on the percentage of users' shift to the public transport, which decision maker seeks to achieve.

This study has recommended shift level of level 113 (it means that parking cost will be increased by LYD 0.5 as level 1 (low level), travel time to be improved by 10% as level 1 (low level) and travel cost to be reduced by at least

50% as level 3 (middle level)) to be implemented if the targeted PT shift around 60% to be achieved. The result has shown a logical implementation to both of the travellers and operators. Consequently, charging a low level of parking fees may not be a burden to the travellers, whereas, providing a low level of travel time and middle level of travel cost are also achievable by the PT operators.

Finally, this study proposes some initiatives to encourage the usage of the public transport system with separated lanes in Tripoli's network roads to improve travel time with suitable travel costs and car park fees.

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