

## Elasticity of Intercity Buses in the West Bank

معدل مرونة ركاب الباصات بين المدن في الضفة الغربية

Khaled Al-Sahili\*, Abdel Majid Sadeq\*\*

\*Department of Civil Engineering, Faculty of Engineering, An-Najah National University, Nablus, \*\*Al-Qararah Municipality, Khan Younis, Gaza, Palestine

E-Mail: [alsahili@yahoo.com](mailto:alsahili@yahoo.com)

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### Abstract

In the Palestinian territories, as the country is developing, there is a need to study public transport characteristics. This study is concerned with transportation planning in Palestine. The objective of the study is to collect and analyze information about public transportation ridership behavior by using two different questionnaires for bus riders and shared-taxi riders. The study area was the Northern and Central Governorates of the West Bank. Five hundred and eighty six forms were distributed for intercity bus and shared-taxi riders, which accounted for 5 percent of riders. Questions were about riders' characteristics, trip itself, and changing mode preference for a change in bus fare or waiting time. Results showed that ridership demand elasticity towards the change in bus fare was -1.83 for bus riders and 1.34 for shared-taxi riders. Employees and students who make frequent trips were the most sensitive to mode change based on fare change, reducing waiting time, and availability of express bus services. It is recommended for future research to extend such efforts for the rest of the West Bank governorates and Gaza Strip.

**Keywords:** Intercity, Pubic Transportation, Elasticity, Ridership, West Bank

### ملخص

تعنى هذه الدراسة بتخطيط المواصلات في فلسطين، فهناك حاجة لدراسة خصائص المواصلات العامة في المناطق الفلسطينية، حيث إن المنطقة تتطور وتتمو. وتهدف هذه الدراسة إلى تجميع معلومات وتحليلها بواسطة استبانات تم توزيعها على ركاب الحافلات، وسيارات النقل المشترك بين المدن. ومنطقة الدراسة هي المحافظات الشمالية والوسطى في الضفة الغربية. تم توزيع ٥٨٦ استبانة على ركاب النقل العام بين المدن، وهذا العدد يشكل ما يقارب ٥% من مجموع ركاب النقل العام لمنطقة الدراسة. وتحتوي الاستبانات على أسئلة عن خصائص الركاب، والرحلة، ومدى قابلية الركاب لتغيير وسيلة النقل العام نتيجة لتغير أجرة الركوب، وزمن الانتظار. وأظهرت النتائج أن معدل المرونة في الطلب، نتيجة تغير أجرة الركوب، هي -١,٨٣ لركاب

الحافلات، و ١,٣٤ لركاب سيارات النقل المشترك. وتبين كذلك أن الموظفين والطلبة هم الأكثر تأثراً بتغير أجرة الركوب وزمن الانتظار، وذلك لكونهم يقومون برحلات شبه يومية، وهم أيضاً معنيون بالوصول إلى غاياتهم في وقت محدد. وتوصي الدراسة، لمن سيقوم بأبحاث مستقبلية، في هذا الموضوع، تناول باقي محافظات الضفة الغربية وقطاع غزة في مثل هذا النوع من الدراسة.

## Introduction

Transportation planners around the world direct their research and studies toward the development of public transportation using different technologies. Research efforts focus on increasing efficiency of the existing public transportation system using different strategies to achieve objectives. These strategies include providing incentives to increase patronage by different methods such as improving bus services. Another strategy deals with the analysis of modeling demand for travel. The combination of these two strategies has been growing steadily in recent years.

Upon launching the peace process between the Palestinian Liberation Organization and Israel in 1993, the Palestinian National Authority (PNA) gradually resumed control over some parts of the West Bank and Gaza Strip. After 1995, the PNA started several transportation development projects. However, there was no fund assigned to the development of public transportation facilities except by the private sector. Therefore, there is a need to evaluate the existing public transportation in the Palestinian territories to meet the expected automobile growth on Palestinian roads.

The main objective of this research is to evaluate some factors that have impact on the elasticity of the passenger demand for the patronage of bus and shared-taxi services. The study also aims at identifying public transport riders' characteristics and the reasons as well as the problems of riding the bus. The significance of this study is being the first public transport elasticity study in the Palestinian territories.

Travel demand elasticity is a major tool that measures the rider's sensitivity to any change of one or more service-related variables. This means that a rider may change his/her preferable transportation mode,

route, and trip itself because of such changes<sup>(7)</sup>. The percent change in ridership demand relative to the original demand in comparison to the percent change in the independent variable/s relevant to the original value/s is called “elasticity”. Elasticity may have either positive or negative values.

The study area for this research was the Northern and the Central Governorates of the West Bank, which includes the Governorates of Nablus, Tulkarm, Jenin, Qalqilia, Salfit, and Ramallah. The core of the study was Nablus City, which is one of the most populated and the largest commercial city; centrally located in the West Bank. It also has the largest university in the West Bank. Figure 1 shows the location of the main cities studied in this research.

Two modes of intercity public transport are common in the West Bank: the shared-taxi and the bus. For all study routes, both modes are available and riders can choose between either mode. Shared-taxi is considered a para-transit service. It is privately owned and operated. The standard intercity shared-taxi seating capacity is seven passengers. Services may deviate from routes and/or fixed schedule, and may pick up and drop off passengers at other than regular stops. Shared-taxi is normally faster and more expensive than bus service. The majority of passengers ride at the origin terminal and drop off at the end point; therefore, it is similar to an express service.

Intercity bus service is the public transportation mode that connects cities. Intercity bus offers fixed-fare services weekdays on a fixed route and somewhat fixed schedule. Intercity bus service is currently provided by private companies, which operate at a profit, with little or no support from the government. Trip travel time is normally longer and trip fare is cheaper than shared-taxi for the same service.



Figure (1): Main Cities of Study Area

### **Literature Review**

Researchers found out that a major component of public transport planning decisions was investigating how passengers react to changes in transit either imposed by the operator, such as alterations in fares and the level of service offered, or brought about by changing circumstances affecting, for example, income levels, car ownership, and land-use patterns<sup>(9)</sup>.

The elasticity concept is a measure frequently used to summarize the responsiveness of demand to changes in the factors determining the level of demand. The following equation was set for price elasticity:

$$E = \{(Y - Y_0) / Y_0\} / \{(X - X_0) / X_0\} \quad (1)$$

Where

- E = elasticity of the ridership demand
- $Y - Y_0$  =  $\Delta Y$  change in ridership demand
- $Y_0$  = original ridership demand
- $X - X_0$  =  $\Delta X$  change in transit fare
- $X_0$  = original transit fare

Hughes<sup>(5)</sup> studied the elasticity of demand for suburban rail travel using British Rail's National Passenger Accounting and Analysis System. The analyzed data was used to determine the elasticity of rail travel demand with respect to the main types of fare. The model was applied to a sample of sixty-two flows with origins outside Greater London and with destinations at one of the main London terminals. The obtained elasticity was nearly -1.0 for reduced-fare tickets, -0.7 for full-fare tickets, and -0.2 to -0.4 for season tickets.

Urquhart and Buchanan<sup>(10)</sup> discussed the substantial changes in bus fares and service levels which were introduced in Telford, Shropshire, England. The study found evidence that shopping trips by bus had been redistributed between the various shopping centers in Telford in response to changes in relative fares and service levels. When a method of estimating elasticity, which eliminated redistribution effects, was used, fare elasticity for shopping trips ranged from -0.58 to -0.80. The authors

found that shopping trips seemed to be fairly insensitive to changes in service frequency, but elasticity with respect to a weighted combination of walking, waiting, and in-vehicle time ranged from -0.55 to -0.71. For non-shopping trips, fare elasticity ranged from -0.32 to -0.46 while service frequency elasticity (buses per hour) was between 0.29 and 0.37.

Hensher <sup>(4)</sup> predicted market response to specific fare classes; knowledge of how various market segments would respond to both the choice of ticket type within a public transport mode and the choice between modes. The resulting matrix of direct and cross elasticities reflected the market environment on which concession and non-concession travelers made choice. Hensher stated that the better understanding of market sensitivity to class of tickets was promoted as part of the improvement in management practices designed to improve fare yield. The elasticities from the study indicated the level of switching between ticket types and between the car and bus modes for any given change in fare levels or types.

Kain and Liu <sup>(6)</sup> studied transit ridership systems of Houston, Texas and San Diego, California. The study developed two models: Model (I) was based on Houston ridership equation and employed a fare elasticity of -0.23, and Model (II) replaced the estimated Houston fare elasticity with industry consensus estimate of - 0.33.

### **Research Methodology**

The elasticity equation measures the proportion by which the additional bus rider or service taxi rider demand increase, decrease, or remain unchanged because of a fare change, for example. The elasticity of ridership demand in this research was measured for a change in bus fare and bus waiting time. Changing the internal variables such as bus fare, service level, and travel time were not easy to apply during this study. Decision makers for such changes are not awarded to execute such policy at the current time. Thus, the approach to measure the elasticity of bus ridership demand depending on existing data could not be used. Therefore, a public transportation questionnaire was carefully prepared to investigate the required riders' input regarding these changes.

A survey was conducted at bus stations, shared-taxi main stations, and on-board buses. The sample survey was conducted during normal conditions, at different times of the day, and during typical weekdays to obtain a reliable and representative sample. The main purpose of the survey was to define the ridership elasticity towards the change in bus fare and the reduction in bus travel time.

### **Sampling and Distribution**

It is recommended in similar sampling surveys that the sample size be a percentage of the population to achieve acceptable results. These recommended percentages are 20 percent of the population of about few hundreds; 10 percent of the population of about few thousands; or 5 percent of the population of more than 10 thousands<sup>(2)</sup>. The approximate number of public transport riders for the study regions was more than 10 thousands. Therefore, the minimum required sample size is 5 percent of the population.

The average daily intercity public transport riders were about 11,500<sup>(8)</sup>. Therefore, the minimum sample size should be  $11,500 \times 5\% = 575$ .

A pilot survey provides an opportunity to field test the questionnaire to detect and correct any serious irregularities or inadequacies. A pilot survey can also provide information or suggestions that improve both the sampling methods and sampling size. A small-scale survey (35 forms) was tested and as a result, few questions were modified. Some of the required information was also obtained through meetings with bus companies' managers.

A total of 430 and 175 forms were distributed for bus and shared-taxi riders, respectively. The distribution of the questionnaires was proportional to the number of riders for each city pair for bus and shared-taxi services. After survey forms were collected, it was found out that the number of valid bus riders' forms was 410, while the valid shared-taxi riders' forms were 158. The total valid sample size was 568. Based on Bernoulli Theorem, this sample size provides a 95% confidence level and 7.5% standard error<sup>(3)</sup>.

The non-valid forms were rejected for one of the following reasons: (a) they were not completed, (b) there was more than one answer for one question, or (c) some answers were not clear. It was noticed that the non-valid forms for shared-taxi riders were more than that for bus riders, which was mainly because some taxi riders had not completed their answers before the taxi took off.

### **Data Collection Procedure**

All city pairs that have bus services within the study area were included. These were Nablus, Jenin, Ramallah, Tulkarm, Qalqilia, and Salfit, as shown in Figure 1. These cities represent the core of commercial, educational, and institutional activities in their respective governorates.

The intercity public transportation questionnaire was carried out using two forms; one for bus riders and the other for shared-taxi riders. The first questionnaire contained 16 questions, which were sequenced from general information to specific questions of this study. The main questions related to this study were about the main reason for riding the bus and the bus rider's willingness to continue riding a bus when fare increases. The second questionnaire (for shared-taxi riders) contained questions to examine the main reason for not riding a bus and shared-taxi riders' willingness to convert to a bus if shared-taxi fare increases, bus waiting time at the origin station decreases, or bus stops are eliminated.

### **Analysis and Results**

Riders' answers to the questionnaire reflected their opinions and feelings. These answers reflected their willingness to switch mode for possible changes in certain variables. This may not be an accurate measure for switching modes since riders' answers depend on their perception and responses to specific questions at the time of the survey. However, this was the first study of its kind in the Palestinian territories and other supportive data was not available at the time of this study. Furthermore, this technique is widely used worldwide.

**Overall Results**

Most riders were commuting students (62% and 66% of bus riders and shared-taxi riders, respectively). Most trip purposes were educational (60% and 62%, respectively) and the least number of trip purposes was for shopping. Most riders hold a bachelor degree or study at a university (81% and 77%, respectively).

The problems that intercity bus riders mostly face while riding the bus were: the number of bus stops and waiting time (approximately 30%). The main three reasons why shared-taxi riders do not ride a bus were bus waiting time (28%), slowness (26%), and the number of bus stops (22%). Summary of the results are shown in Table 1.

**Table (1):** Bus Riders' Problems with Buses and Shared-Taxi Riders Reasons for Not Using a Bus

<b>Reason</b>	<b>%Bus Riders</b>	<b>%Shared-Taxi Riders</b>
Slow	14	26
Discomfort	8	4
Waiting Time	29	29
Walking Distance	10	5
# of Bus Stops	30	22
Others	9	14
<b>Total</b>	<b>100</b>	<b>100</b>

The main reasons why intercity bus riders preferred using a bus were: low cost (46%) and safety & comfort (29%). The main reasons why shared-taxi riders preferred riding shared-taxis were: speed (37%) and comfort (24%), see Table 2.

**Bus Ridership Demand Elasticity**

Rider’s response towards price change (trip fare) was the basis for price elasticity in this research. A total of 188 riders out of 410 bus riders (46%) expressed their preference of a bus because of its cost while others had other reasons.

**Table (2):** Main Reason for Riding a Bus or Shared-Taxis

Bus Riders		Shared-Taxi Riders	
Reason	%	Reason	%
Low Cost	46	Speed	37
Safety and Comfort	29	Comfort	24
Only Mode	9	Only Mode	17
Trip Route	9	Trip Route	15
Other Reasons	7	Other Reasons	7
<b>Total</b>	<b>100</b>	<b>Total</b>	<b>100</b>

The 188 riders were asked if they will go on riding the bus if the bus fare increases by 25 percent of the original fare. As a result, riders who were willing to continue riding buses, ride shared-taxis, private cars, and other modes were 42, 51, 3, and 4 percent, respectively. When asked about a bus fare increase by 50 percent, those who were willing to continue riding buses, ride shared-taxis, private cars, or other modes were 13, 79, 2, and 6 percent, respectively. The unexpected decrease in preference for private cars from 4 to 2 percent could not be explained; however, this decrease was marginal. Table 3 shows the possible shift in bus mode because of a bus fare increase by 25 percent and 50 percent.

**Table (3):** Bus Riders Preference of Transportation Mode for Bus Fare Increase

	Original Fare	25 % Increase	50 % Increase
Private car	1	3	2
Bus	70	43	13
Shared taxi	27	51	79
Others	2	3	6
<b>Total</b>	<b>100</b>	<b>100</b>	<b>100</b>

Based on these results, the elasticity can be calculated as:

$$E = (\Delta Y / \Delta X) * (X_0 / Y_0) = -1.828 \quad (2)$$

This means that the intercity bus riders fare elasticity is  $-1.828$ . For example, a 25 percent increase in bus fare would result in a decrease in bus ridership demand by 45.7 percent ( $-1.828 \times 0.25 = -0.457$ ). This elasticity was relatively high compared to other international studies.

Intercity bus riders would more likely shift to shared-taxis, as survey results showed. Shared-taxis are available and accessible, faster, more reliable, and thus more convenient. In addition, shared-taxi fares are more expensive than bus fares by 25 to 85 percent <sup>(8)</sup>. Therefore, an increase in bus fare by 25 to 50 percent will make shared-taxis more attractive to the majority of intercity riders.

**Shared-Taxi Ridership Elasticity**

The 158 shared-taxi riders were asked about their willingness to continue using shared-taxis if a bus fare decreases by 25 percent compared to the original fare. The riders who were willing to ride a bus, shared-taxi, and other modes were 51, 38, and 11 percent, respectively. If the bus fare decreased by 50 percent, these numbers would be 63, 25, and 12 percent, respectively (see Table 4). The shared-taxi riders' fare elasticity can be calculated as:

$$E = (\Delta Y / \Delta X) * (X_0 / Y_0) = 1.34 \tag{3}$$

**Table (4):** Shared-Taxi Riders Preference of Transportation Mode for Bus Fare Decrease

	<b>Original Fare</b>	<b>25 % Increase</b>	<b>50 % Increase</b>
Private car	11	8	7
Bus	26	51	63
Shared taxi	63	37	25
Others	0	4	5
<b>Total</b>	<b>100</b>	<b>100</b>	<b>100</b>

Therefore, the intercity shared-taxi riders fare elasticity was 1.34. For example, a 25 percent decrease in bus fare would result in a 33.5 percent of shared-taxi riders switching to a bus (1.34 x 0.25 = 0.335). This elasticity value is relatively high because a reduction of bus fare by 25 percent makes shared-taxi fare twice the bus fare for most intercity routes.

### **Other Elasticities**

Shared-taxi and intercity bus riders demand elasticity for a change in bus waiting time at the origin station as well as for eliminating bus stops were also studied in this research. However, results were inconclusive because the elasticity curve (line) was based on less than 3-data points. Nonetheless, results showed that there was relatively a high number of shared-taxi riders who would switch to a bus mode (ranged between 17 and 63%) if bus travel time was reduced.

### **Discussion of Elasticity Results**

Students and regular employees formed 59 and 30 percent of the total bus riders, respectively. The highest percentage of the trip purpose groups who would switch mode if a bus fare increases was for daily commuters trips (64%) because these groups are expected to be highly sensitive to price change since they make daily trips.

Riders' income group of less than 200 Jordanian Dinars (JD) per month (relatively low income) was the highest (63%) among shared-taxi riders' income groups who would switch to riding a bus if bus fare decreases. Low-income riders are normally sensitive to price change. Shared-taxi riders who make four or more weekly trips were the most sensitive to fare change (64%) because they make frequent trips. Therefore, they will be highly affected by this price change.

Shared-taxi ridership demand was also sensitive towards decreasing bus-waiting time at the origin station. The main reason why some people did not ride the bus was the long waiting time. Therefore, when bus-waiting time is reduced, some shared-taxi riders will divert to riding intercity buses.

Employees were the highest shared-taxi riders' group who would switch mode to express bus services. Employees always want to arrive at their job on time. Therefore, they are expected to be highly sensitive to express bus service. Some shared-taxi riders (22%) did not prefer riding the bus because of the frequent number of bus stops. Therefore, as expected, some of these riders would switch for the intercity bus if the total trip time is reduced by providing express bus services.

**Comparison between Ridership Demand Modeling and Elasticity**

A simple ridership demand model for the same intercity bus services was developed <sup>(1)</sup>. The developed demand model had the following form ( $R^2 = 0.82$ ):

$$D = f(X_i) - 813 F \tag{4}$$

The weekly intercity bus ridership (D) was expressed in terms of bus fare (F) in New Israeli Sheqel (NIS) and a function  $f(X_i)$ , which is a linear combination of origin city population, destination city population, percentage of origin city students attending high school or university, and percentage of origin city people who are employed.

For example, the impact of 25 percent bus fare increase on ridership demand can be calculated using the developed demand model and elasticity value ( $E = -1.828$ ). The computed results are presented in Table 5. The reduction in ridership demand based on the demand model was less than the reduction based on elasticity to all destination cities (except for Salfit).

**Table (5):** Comparison between Bus Ridership Modeling and Elasticity

Origin City	Destination City	Actual Weekly Ridership	Original Fare (NIS)	Fare+ 25% Increase	Ridership Reduction (Demand Model)	Ridership Reduction (Elasticity)
Nablus	Ramallah	6900	6.00	7.50	1220	3153
	Jenin	7614	5.00	6.25	1016	3480
	Tulkarm	6263	4.00	5.00	813	2862
	Qalqilia	3330	5.00	6.25	1016	1522
	Salfit	1008	3.50	4.38	711	461

This difference can be attributed to the fact that the ridership model was a simple linear equation derived based on the aggregate characteristics of riders and cities. However, the derived elasticity was based on riders' willingness to switch mode for price change.

The elasticity result is a constant percentage for all routes while the percent change in ridership for each route varies when the demand model is used. The demand model reflects the characteristic of each city pair.

The two forms can be used as measures to determine riders' mode change for bus fare increase (or decrease). The nature of the available data would sometimes necessitate applying one of the two forms.

### **Conclusions and Recommendations**

Based on the study results, the conclusions were:

1. Bus long waiting time, frequent stops, and being uncomfortable were the most frequent reasons for not riding the bus. The number one reason why riders preferred using the bus was its relatively low fare.
2. Employees and students who make frequent work and school trips were the most sensitive to reducing travel time or fare; and thus would change mode accordingly.
3. Price elasticity of bus riders was calculated to be -1.828, while the elasticity for shared-taxi riders was 1.34.
4. Bus ridership can be increased by reducing waiting time, operating on schedule, reducing the number of bus stops, providing comfortable buses, or reducing bus fare.

This type of research cannot be feasible nor worthy by itself without coordination with relevant authorities and decision-makers in considering results and recommendations.

For bus companies, it is recommended to improve the frequency of intercity bus services by providing more frequent travel service on existing routes. This is expected to attract more riders. Bus companies should also explore providing an intercity express bus service during peak periods to attract more riders such as employees who would like to arrive at their work on time. However, the economic feasibility of any of these improvements should be investigated first.

Public transport planners should coordinate with bus companies and investigate offering pricing policies to increase intercity public transportation riders, especially daily commuters.

Future researchers should be aware of that this study was conducted with limited data and financial resources. Therefore, future studies should include database with more detailed information about trips of other transportation modes (shared-taxi and private cars).

The study questionnaires were carried out for buses and shared-taxis only. It is recommended that private car riders be included in future studies. It is believed that interviews with the public in the study area (household survey) and their expectations regarding the need for public transportation services would enhance the quality of such studies. It is also recommended that future research should include Gaza Strip and the Southern Districts of the West Bank.

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