# TRANSPORTATION MARKETING------

## A Study of Attitude And Preference of Saudi Families Towards School Transport In Saudi Arabia:

*A Case Study of Dammam City*


**BY**

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## In the name of Allah the most Gracious and the most Merciful

All thanks and praise goes to Allah the Creator of the universe. I pray that He may forgive me if I have wronged, and that He may reward me in the hereafter if I have done useful work.

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May Allah bless all of us and keep us in the straight path. (Ameen).

# DISSERTATION ABSTRACT

**Name: Khodran Ali AlGafai Al-Zahrani**

**Title of Study:**

**TRANSPORTATION MARKETING-----**

**A Study of Attitude And Preference Of Saudi Families**

**Towards School Transport In Saudi Arabia:**

***A Case Study of Dammam City***

Education is an important factor in the development and growth of a country. It is essential to have school transport to facilitate the transport of male and female students to school so that the families will be persuaded to send their children to schools, and the children are encouraged to continue education. The school transport modes are of different kinds: students can walk to the schools; families may own private cars; transport may be rented or may be provided by the government, such as school buses.

The focus of this research is to identify the modes which are used to transport the students to and from schools, problems associated with such modes of transport, and the modes preferred by the Saudi households. The research also concentrates on identifying the constraints preventing the selection of preferred modes, and investigates the relation between the socio-cultural factors and the selection of the modes in order to develop a Modal Split Model.

A review of previous studies reveals that comfortability, convenience, time, safety, and costs, are the factors that play important roles in the selection of the transport modes. In the light of these factors, the school transport modes in the city of Dammam, Saudi Arabia are evaluated.

Data were collected from a sample of 1081 male and 1084 female students, as well as from their guardians. An analysis of the data shows that students use the following modes for school transport at varying rates depending on the educational level: Walking, Private Car, Carpool, Limousine/Taxi, Government School Bus, and Public Bus, while the preferred modes are: Walking, Private Car, Government School Bus, and Rented (Public) Bus.

Eleven modal split models for school trips have been chosen from 161 models as the best models for predicting school trips in terms of rho-squared ($\rho^2$).

As a result of the descriptive analysis and the modal split models, market demand and market share of the school transport modes are analyzed, and applications of how to use the models are shown in the benefit of the Saudi' households and the private companies.

# خلاصة الرسالة

**اســـم الطالب : خضران علي محمد القفعي الزهراني**
**عنوان الرسالة : تسويق النقل المدرسي ، تأثير المتغيرات الحسية في سلوك العوائل السعودية عند إختيار وسيلة النقل المدرسي**

حيث أن التعليم من الأهمية بمكان في تطور الدول ونموها ولما للنقل المدرسي من أهمية في تسهيل وصول الطلاب والطالبات إلى مدارسهم مما يشجع الأسر على إرسال أبنائهم إلى المدارس ويشجع الأبناء على مواصلة تعليمهم وبما أن وسائل النقل تعددت فمنها ما يملكه الطالب والطالبة كالمشي ، ومنها ما تملكه الأسرة مثل السيارة الخاصة وتأجير السيارات لأداء هذه المهمة ، وما تقوم الدولة من توفير حافلات النقل المدرسي . لذا فإن هذا البحث يركز على معرفة الوسائل المستخدمة حالياً لنقل أبناء العائلة من وإلى مدارسهم والمشاكل الموجودة من جراء تلك الوسائل ومعرفة رغبات وتوجهات العائلة السعودية بغرض التعرف على أولويات تفضيلهم لوسيلة / وسائل النقل المفضلة لأداء مهمة النقل المدرسي مع معرفة العوائق التي تحول دون اختيار تلك الوسيلة / الوسائل وكذلك تقصي العلاقة بين الخصائص الاجتماعية ( الديموغرافية ) واختيار الوسيلة والعوائق التي تحول دون اختيار الوسيلة / الوسائل المفضلة .

وعلى ضوء الدراسات السابقة ذات العلاقة تم تحديد العوامل المؤثرة في اختيار الوسيلة مثل الراحة – الملائمة – الوقت الإجمالي – السلامة ، والتكلفة والتي على ضوئها تم تقييم جميع وسائل النقل المدرسي في مدينة الدمام بالمملكة العربية السعودية .

كان الاستبيان وسيلة جمع المعلومات حيث تمت صياغته ليفي بمتطلبات البحث . وبناءاً على ذلك تم توزيع الاستبيان لجميع مراحل التعليم بنين وبنات وذلك عن طريق الجهات الحكومية ذات العلاقة حيث تم الحصول على المعلومات من 1081 طالب 1084 طالبة ، ثم تم تجميعها وفرزها وتم تحليلها عن طريق برنامج الكمبيوتر BLOGIT والذي تم عن طريقه معرفة الوسائل المفضلة لأداء لدى العوائل السعودية من بين وسائل النقل المختلفة : المشي السيارة الخاصة ، النقل التعاوني ، اليموزين والتاكسي ، النقل المدرسي ، والنقل الجماعي . وقد كانت الوسائل المفضلة لأداء مهمة النقل المدرسي ثلاث وسائل فقط هي : ( 1 ) المشي ، ( 2 ) السيارة الخاصة ( 3 ) حافلة النقل المدرسي الحكومي ( 4 ) النقل الجماعي . كما تم اختيار احدى عشر نموذجا (Models ) لوسائل النقل المدرسي للمستويات التعليمية المختلفة وذلك من بين مائة وواحد وستين نموذج تم تكوينها للنقل المدرسي . وبناءاً على ذلك تم تحليل الاحتياج التسويقي ( Market Demand ) والمشاركة التسويقية (Market Share ) لوسائل النقل الأربعة ، كما تم عمل التطبيقات العلمية ( Applications) للاستفادة من نتائج هذا البحث بما يرجع بالفائدة للطلاب والطالبات والعوائل السعودية ووسائل النقل المختلفة .

**درجة الدكتوراة في الفلسفة**
**جامعة نيوكاسل**
**نيوكاسل بريطانيا**

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# 1 *INTRODUCTION*


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# 1. INTRODUCTION

## 1.1 Background

Education is a fundamental element of government plans and policies to produce a literate and educated society, and also a skilled workforce. This, with the aim of providing equality of opportunity to all, is seen as requiring universal education at the primary and secondary school level. The objective of providing education for all invariably involves government provision of free education at an elementary, intermediate and secondary school level for those unable or unwilling to send their children to private schools.

One element of equality of access and opportunity in education is concerned with school transport. The lack of school transport, and the cost to households of transporting their children to school, can inhibit households' pursuance of education for their children. A number of studies have shown that the demand and supply of public services declines with increasing inaccessibility of the service (see Taylor *et al* 1978; Russell et al , 1978; Carmicheal and Taylor, 1980; Tussing and Wojtowycz, 1986).

School transport is considered a factor in the motivation of students' guardians to send their children to school, and as an encouragement for

students to pursue their education. School transport is a means of making education available to children who cannot easily reach school on foot (Linn and Henry, 1956) or whose parents lack their own transport and time to take their children to school. School transport is important particularly to those students who reside in remote areas where accessibility to schools is more difficult.

This thesis analyses a particular aspect of school transport: namely the factors determining parents' and guardians' choice school transport for their children. This is a complex problem in Saudi Arabia in that religious and cultural norms dictate that non-family male and female children must travel in separate vehicles, whilst adult male members of a household can drive the children to school. This complicates the choice for parents and guardians of which mode of transport their children should use in their journey to school.

Due to the fact that Saudi Arabia is a vast country of about 2.24 million square kilometers, with low population densities of a little over 18 million inhabitants and dispersed settlements, the Five Year National Plans have always emphasized the necessity to develop student transport so that education would be provided to all members of the society. For example, the Fourth Development Plan specifically outlined the desire to decrease the number of

young persons who fail to attend school due to remoteness of their houses by providing school transport to them via specialized Saudi Companies (Ministry of Planning 1988).

The total number of students enrolled in all educational institutions of the country increased from 474,000 in 1969-70 to about 3.416 million in 1994-95 as shown in Table 1.1. In 1994-95, around 176,000 more students enrolled as compared to the previous year.

## 1.2 PROBLEM STATEMENTS

The number of students receiving elementary education rose from 397,000 in 1969-70 to 2.154 million in 1994-95.The number of students receiving intermediate and secondary education expanded from 77,000 to 1.262 million over the same period.

## Table 1.1

## Male & Female Students in Saudi Arabia.

| Number of Students (Thousand) | | | | |
|---|---|---|---|---|
| **Year** | **Elementary Education** | **Intermediate education** | **Secondary Education** | **Total** |
| 1969/70 | 397 | 61 | 16 | 474 |
| 1974/75 | 634 | 137 | 42 | 813 |
| 1979/80 | 862 | 245 | 93 | 1,200 |
| 1984/85 | 1,242 | 373 | 158 | 1,773 |
| 1985/86 | 1,317 | 388 | 172 | 1,877 |
| 1986/87 | 1,460 | 432 | 199 | 2,091 |
| 1987/88 | 1,579 | 466 | 218 | 2,263 |
| 1988/89 | 1,694 | 494 | 243 | 2,431 |
| 1989/90 | 1,762 | 514 | 252 | 2,528 |
| 1990/91 | 1,876 | 574 | 291 | 2,741 |
| 1991/92 | 1,909 | 613 | 313 | 2,835 |
| 1992/93 | 1,980 | 685 | 347 | 3,012 |
| 1993/94 | 2,111 | 769 | 384 | 3,264 |
| 1994/95 | 2,154 | 815 | 447 | 3,416 |

Source: Ministry of Education, Ministry of Higher Education, and General Presidency for Girls Education.

Existing school transport services in the Kingdom include governmental as well as public and private services. The total number of students, male and female was 3.416 million in 1994-5. For government services, the Ministry of Education (1988), provides school transport for only 12.3% of the total, or about 0.223 million male students, as shown in Table 1.2; and the General Presidency of Girls Education provides school transport

for only 21%, or about 0.337 million female students, as mentioned by the School Transport Seminar (1988), and shown in Table 1.3.

**Table 1.2**

**Male students.**

| Number of Students (Thousand) | | | | |
|---|---|---|---|---|
| **Year** | **Elementary Education** | **Intermediate education** | **Secondary Education** | **Total** |
| 1969/70 | 277 | 56 | 14 | 347 |
| 1974/75 | 411 | 99 | 32 | 542 |
| 1979/80 | 537 | 165 | 64 | 766 |
| 1984/85 | 720 | 232 | 93 | 1,045 |
| 1985/86 | 762 | 240 | 100 | 1,102 |
| 1986/87 | 811 | 267 | 114 | 1,192 |
| 1987/88 | 868 | 279 | 124 | 1,271 |
| 1988/89 | 924 | 292 | 137 | 1,353 |
| 1989/90 | 961 | 304 | 142 | 1,407 |
| 1990/91 | 1,015 | 327 | 159 | 1,501 |
| 1991/92 | 1,016 | 344 | 169 | 1,529 |
| 1992/93 | 1,050 | 385 | 184 | 1,619 |
| 1993/94 | 1,114 | 432 | 210 | 1,756 |
| 1994/95 | 1,121 | 443 | 245 | 1,809 |

Source: Ministry of Education, Ministry of Higher Education

**Table 1.3**

**Female students.**

| Number of Students (Thousand) | | | | |
|---|---|---|---|---|
| **Year** | **Elementary Education** | **Intermediate education** | **Secondary Education** | **Total** |
| 1969/70 | 120 | 5 | 2 | 127 |
| 1974/75 | 223 | 38 | 10 | 271 |
| 1979/80 | 325 | 80 | 29 | 434 |
| 1984/85 | 522 | 141 | 65 | 728 |
| 1985/86 | 555 | 148 | 72 | 775 |
| 1986/87 | 649 | 165 | 85 | 899 |
| 1987/88 | 711 | 187 | 94 | 992 |
| 1988/89 | 770 | 202 | 106 | 1,078 |
| 1989/90 | 801 | 210 | 110 | 1,121 |
| 1990/91 | 861 | 247 | 132 | 1,240 |
| 1991/92 | 893 | 269 | 144 | 1,306 |
| 1992/93 | 930 | 300 | 163 | 1,393 |
| 1993/94 | 997 | 337 | 174 | 1,508 |
| 1994/95 | 1,033 | 372 | 202 | 1,607 |

Source: General Presidency for Girls Education and
Ministry of Higher Education

The remaining majority of male and female students travel to school at their own cost by either private or public services. This imposes significant private and public expenditure in terms of societal costs of congestion, pollution, road accidents and escort time. The private modes of transport include walking and private vehicles.

The public services include mainly various para-transit public modes, such as limousine, taxi, or transport by arrangements (car pool, van pool etc.) As a matter of fact, the existing school transport services are fragmented and far from being specialized. Also, the major public transport company in Saudi Arabia (SAPTCO) is not utilized in the school transport services.

Recognizing the importance of school transport, and the desire to improve the existing services, some concerned governmental agencies (Ministries of Planning, Communication and Education, the General Presidency of Girls Education, and other government units, such as the traffic headquarters) organized a special symposium (1988) dealing with school transport issues. Studies were presented by some of the Kingdom's universities, such as King Abdul Aziz and King Saud Universities as well as King Fahad University of Petroleum and Minerals. Another study was also presented by the representative of public transport in the Kingdom.

Moreover, a special symposium was held on the subject of school transport in Riyadh in 1988. All these studies tackled the current problems of school transport and put forward the recommendations required to solve those problems. The problems mentioned can be classified as follows:

### *1.2.1 The problems of school transport for male and female students.*

There are problems for the non-school transport student. These are: the requirements of organizing the students while riding in and out of the present transport; the children are also exposed to traffic accidents due to the fact that the vehicle may be driven by an unqualified person; the non-availability of guides to help the students of the preliminary and intermediate schools when crossing the streets, especially important given that the statistics in some countries show that the percentage of children up to the age of fourteen killed in traffic accidents on the way to school is higher than those killed in traffic accidents on other trips. Due to these problems and the shortage of government school transport, Saudi society tends to look for other ways to transport their children, for example by using the family sponsor, one of the family members, hiring a vehicle, such as limousine, taxi, etc. or recruiting a private driver. Use of private modes creates problem for the students, such problems as stated by Jones (1999) "There are also concerns that children who are ferried everywhere by car have less opportunity for exercise as part of their daily routine, and are not developing the road skills they need as pedestrians and cyclists".

Even for families trying to solve their problems by these means, there may still be negative effects and problems created by the existing school transport for the families, for educational departments and for the government.

### *1.2.2 The problems faced by the students' guardians.*

The problems faced by guardians are due to the deficiencies in the school transport system and the burden imposed on their income by spending on the vehicle's fuel and maintenance, employing drivers, and being confronted by traffic congestion during the morning and afternoon when transporting their children to schools and thus being exposed to traffic hazards throughout those periods.

### *1.2.3 The problems of educational departments.*

The problems of educational departments supervising the school transport are worthy of attention and need to be solved. These problems include the difficulty of providing the service, the educational concerned parties being busy by activities outside their primary function, and the administrative and technical problems which confront the educational department rendering the service.

### *1.2.4 The government's problems.*

The government, likewise, faces problems with the present school transport system in a number of respects. The commitment to transport a great number of students involves enormous financial cost, including the commitment to render expensive road services due to the pressure on those roads caused by thousands of vehicles transporting the students to and from their schools. There are also negative effects on the environment due to the

abundance of vehicles involved in school transport; these negatives also described by Jones (1999) as "The concerns about the increasing numbers of children travelling to/from school by car, and the contribution that this makes to traffic growth and congestion." School transport is one of the factors affecting the punctuality of employees at work, whereby a part of their actual working hours is deducted and their productivity eventually affected. The Civil Service Bureau considered school transport as one of the factors affecting the punctuality of the employees.

### *1.2.5 The problems of the present means of transport.*

In addition to those problems, the problems of the present transport itself outweigh the problems mentioned previously. The problems with present school transport include non-availability of a unified system for the present school transport, and non-availability of a specialization for these services, the present service being rendered in diverse and inappropriate forms.

The buses designated for the school transport are insufficient in number to transport all the students. There is insufficient coordination between the parties concerned in the school transport and the public transport in towns. Deterioration has occurred in the service level of the students' transport in terms of vehicle quality and absence of convenience: the vehicles and drivers do not meet the specifications required. In addition, monitoring is only conducted weekly by some of the education departments in respect of school

transport processes; and these processes are only occasionally reviewed. Several transport processes are not willing to apply the transport rules; this situation causes suffering and takes the time and effort of the concerned parties.

Lack of a minimum level of safety requirements for the different forms of transport, including the current school transport, is not the ideal situation required to meet the satisfaction of the responsible citizens.

All the studies not only presented the current school transport problems but also proposed recommendations which could help in solving the problems. A number of recommendations were made, as follows.

One recommendation was to encourage the use of carpools by neighbours. Also there is the question of establishing a specialized concerned party in the transport field to render this service in a unified form. The importance of the private sector's participation in solving the national problems was also discussed, although the private sector attitudes towards this problem would have to change. Generally, this attitude conceives the government as being solely responsible for rendering all convenient means of transport. The service of school transport provision must involve payment of part of the service expenses.

Another issue raised was assigning the execution of the school transport projects to private national companies, either by establishing a new company or forming an independent company within the public transport company; as well as investigating the possibility of forming more than one company to provide services in different places throughout the Kingdom.

Motivating and encouraging the private sector to play a pioneer role in activating the national economy, attracting a greater number of students to use the school transport, and abandoning the use of private transport means where possible were also discussed. Providing sufficient and appropriate school buses to meet the demand at different levels of education, together with providing transport between houses and school in safety and with convenience, were seen as crucial issues in marketing a successful school transport network.

Decreasing the problems of traffic congestion inside cities and around schools, particularly during the peak hours, which would ultimately lower the percentage of traffic accidents, pollution and noise, was perceived to be a primary concern. These concerens are also stated by Cervero and Kockelman (1997), that the three common transport objectives of shaping travel demand are: (1) reduce the number of motorized trips: what has been called trip degeneration; (2) of trips that are produced, increase the share that are non-motorized (i.e. by foot or bicycle); and (3) of the motorized trips that are produced, reduce travel distances and increase vehicle occupancy levels (i.e.

encourage shorter trips and more travel by transit, paratransit, ride sharing). An expected outcome of degenerating trips and weaning people from their cars, proponents hope, will be a lessening of the negative consequences of an automobile-oriented society - namely, reductions in air pollution, fossil fuel consumption, and class and social segregation (Banister and Lichfield, 1995; Ditmar, 1995).

Other issues were concerned with eliminating the phenomenon of employing foreign drivers to transport students to schools; studying the ways and means of linking the school transport sector with the general transport sector; coordinating each to realize the maximum utility from the general transport in the fields of maintenance, operation and management; paying attention to the attitudes and preferences of the transport users and conducting periodical studies to identify whether they are benefiting from the service; receiving proposals that the Saudi company for Public Transport should take over the responsibility for the school transport.

In general, recommendations set forth in the symposium were to improve existing school transport with emphasis on organization, privatization, coordination, and efficient utilization of existing facilities, as well as citizen participation. Actually, these recommendations should be translated into planning, designing and operation of school transport services.

Taking into account the diversity of public transport services in the Kingdom, (SAPTCO and other Para-transit modes), the wide variation in school travel demand among Saudi households (separately for male and female, and separately at different levels) along with the socioeconomic and special features of Saudi population and settlements, it is probably better to utilize a marketing approach in the planning, designing, and operation of public school transport services. The marketing approach seeks to change the role of urban transportation planner from that of a facility designer to that of transportation needs and services manager. The marketing approach recognizes that each form of public transportation is featured with certain characteristics (e.g. travel time, cost, accessibility, and comfort) which determine its competitiveness with other modes, and render it more suitable for certain types of trips. Also the marketing approach recognizes that the preference for the use of one particular mode of a certain type of trip, such as a school trip, depends on the characteristics of the person making the journey (e.g. car ownership, income, social status) as described by Consumer Oriented Transportation Service Group (1977).

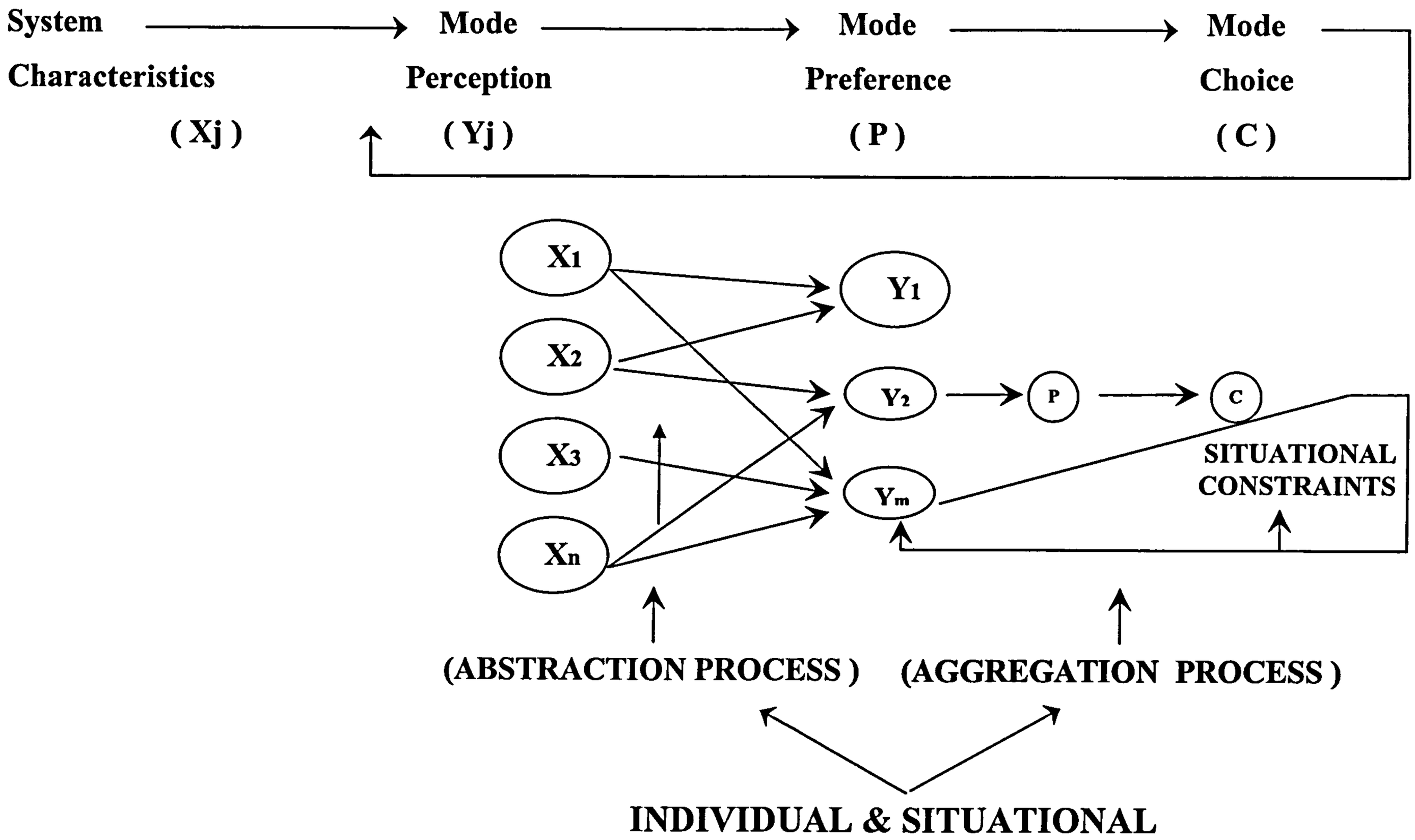
Finally, Koppelmann and Pas (1980) mention that the marketing approach involves market segmentation of potential users and their needs, which depends on the planner's understanding of consumer travel choice behavior, which is based on the attitudes (perceptions and feelings) toward different public transport modes .

Because travel behavior is partially culture-bound, this research is expected to contribute to the marketing approach by exploring school travel behaviour in the Kingdom of Saudi Arabia. It will examine the relationship between Saudi households' sociodemographic characteristics, their attitudes towards school transport modes, and their preference for, and choices of, such school transportation services and modes.

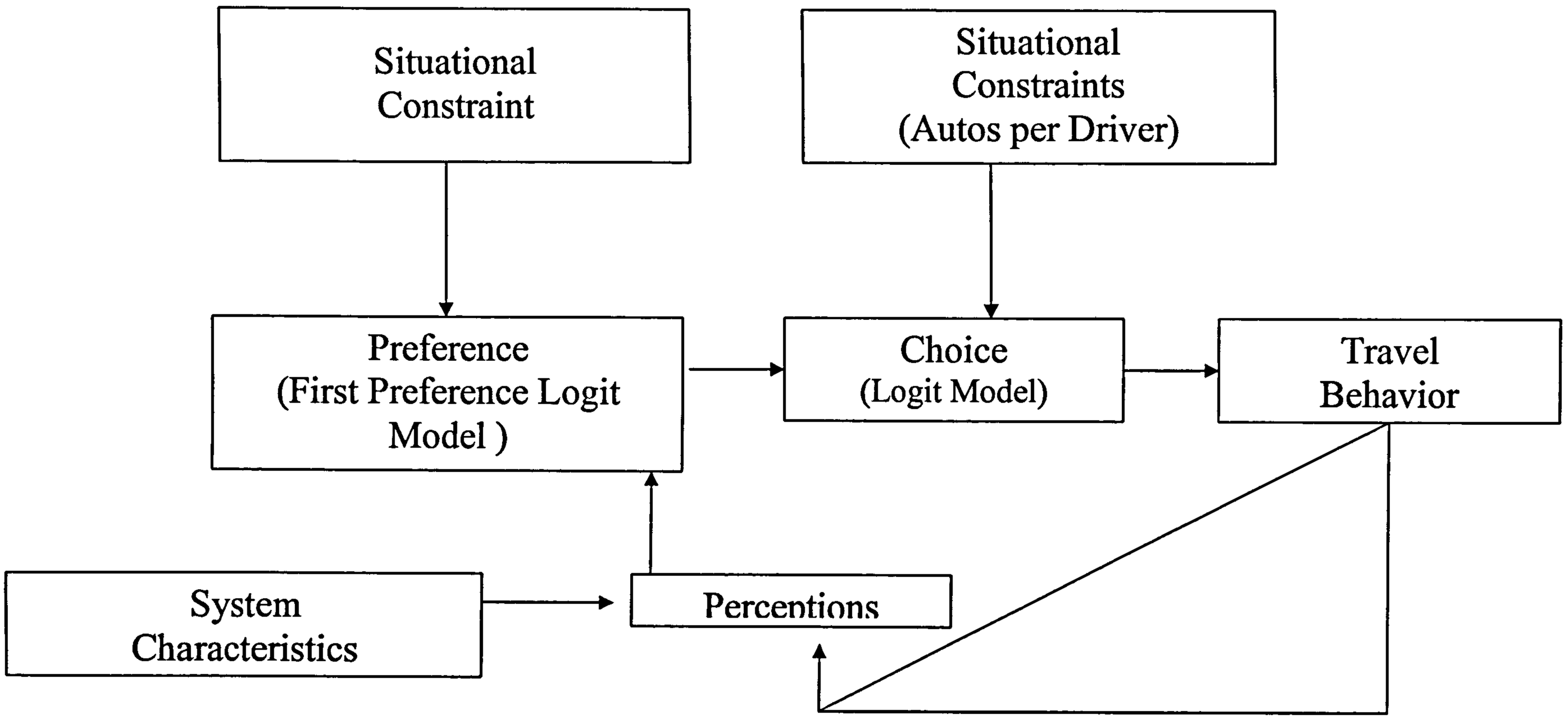
Koppelmann and Pas (1980), Brunskwick (1952), Hartgen (1974), Hanser and Koppelmann (1977), and the Consumer Oriented Transportation Service Group (1977), have verified that attitudes towards transport modes are correlated with traveller behaviour and their sociodemographic characteristics. Measures of traveller attitudes include perceptions of service attributes and personal feelings towards different services. These relationships are explained by the following transportation decision-making paradigms (Figure 1.1).

## *Figure 1.1*
## Decision Making Paradigms

**A . Model Of Consumer Transportation Behavior**



## B. Model Components



In this paradigm, system characteristics (Xi) serve as causes in the formation of consumer perceptions of service characteristics (Yi). Each system characteristic is a partial indicator of one or more perceptions and feelings. Once perceptions and feelings are formed, they are aggregated to determine preference. Preferences are modified by situational constraints determining choice, such as mode availability. Finally, the experience gained by choice and behavior may feed back to modify perceptions.

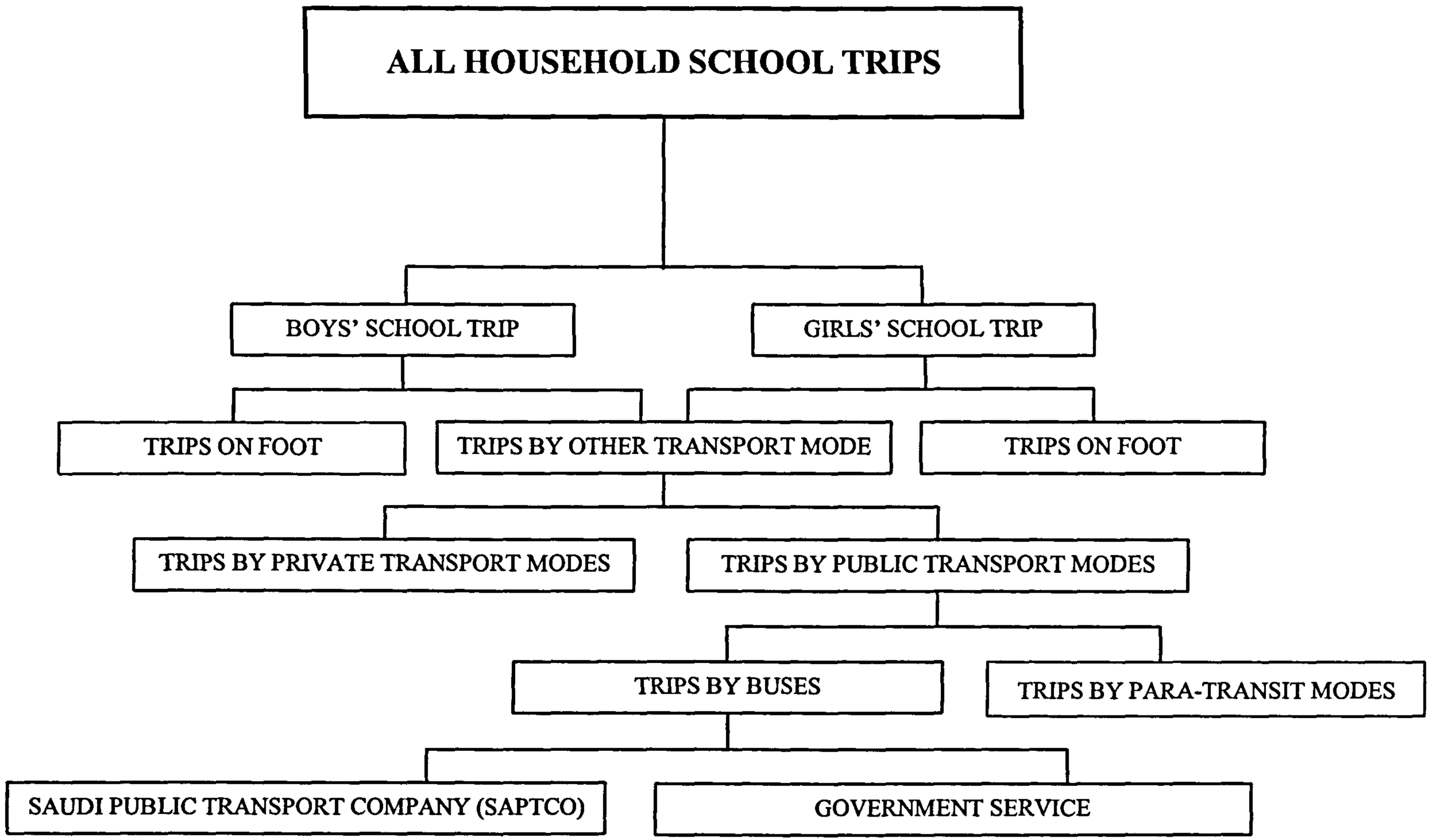
This research is expected to contribute to the marketing approach by exploring the school travel behavior in the city of Dammam, Saudi Arabia, as stated below.

## 1.3 School Trips

For school trips generated from Saudi households, and according to traveller behaviour mechanisms described previously, it is expected that school trips (Elementary, Intermediate, High School) would split the different modes hierarchically as illustrated in Figure 1.2.

# FIGURE 1.2

## SCHOOL TRIPS



This research will examine the relationship between Saudi households' sociodemographic characteristics, their attitudes towards different school transport modes, and their preference for, and choices of, such school transportation services and modes. Transportation planners and managers may benefit from this research through its diagnostic information, such as modal split models, and through the analysis of the school travel behaviour of Saudi households. This information could be used to modify available services to meet school travel needs, or as a guide to formulate strategies which influence school travel behaviour.

## 1.4 RESEARCH OBJECTIVES

These research objectives are pursued by undertaking a review of the existing literature on modal choice in transport with reference to school transport. The preferences of Saudi households for school transport modes are identified through the following:

(1) To study attitudes (perceptions and feelings) of Saudi households towards different modes of school transport.

(2) To identify preferences of Saudi households for school transport modes.

(3) To identify constraints which impede Saudi households from choosing their preferred modes.

(4) To examine potential relationships between attitudes and sociodemographic characteristics, with mode preference and mode choice.

(5) To develop potential modal split models.

(6) To assess policy implications of the findings

## 1.5 SUMMARY

From the introduction, it is clear that there are many problems associated with the existing school transport, that the majority of students, 88% male and 79% female, which is equivalent to more than 3 million students, are left without government school transport, and travel to school at their own cost by different private and public services, causing problems to the male and the female students, to the student's guardians, to the educational departments, and to the private and public sectors.

Due to the diversity of school transport services in Saudi Arabia, public transport and other Para-transit modes, the wide variation in school travel demand of male and female and at different educational levels, elementary,

intermediate, and secondary, the marketing approach is utilized. Market approach involves market segmentation of potential users and their needs. This research will examine the relationship between Saudi households' sociodemographic characteristics, their attitudes towards different school transport modes, and their preference for, and choices of, such school transportation services and modes. Next chapter is a review of literature on model choice with reference to school transport, attitudes and preferences of Saudi households, which are the main objective of the research.

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# 2 REVIEW OF EXISTING LITERATURE


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# 2. REVIEW OF EXISTING LITERATURE ON MODAL CHOICE IN TRANSPORT

The choice between available transport modes, known as modal choice or modal split, involves complex decisions related to the characteristics of the available modes, characteristics of the travellers, and type of trip. This literature review is concerned with identifying modal attributes with relation to traveller attitudes towards different transportation modes and their effect on modal choice. At the same time, it investigates potential relationships between sociodemographic factors and social constraints as emphasized by different researchers, such as : Dobson and Tischer (1976), Nicolaidis (1975), Spear (1976), Ostrom (1969), Fishbein (1972), Schwartz and Tessler (1972), Nicolaidis, Waches and Golob (1979), Frank, Massy and Wind (1972), and Black and Black (1982).

## 2.1 Modal Attributes And Traveller Attitudes.

Attitudes towards different modes of transport are formulated as a result of the development of feelings towards, and perceptions of, certain modal attributes. Since the 2nd National Development Plan (1975-1980) for the Kingdom of Saudi Arabia, the government has emphasized the necessity of developing pupil transportation to school. Adams (1959) mentioned that, in the U.S.A., pupil transportation started as early as 1840, based on private expenditure. Ben-Akiva and Lerman (1985) described the way that in 1869

school children in Massachusetts were brought to school through the expenditure of school funds. In other states, such as Pennsylvania, the school truck started in 1909 for the purpose of pupil transportation, according to the Transportation Research Board (1982).

A number of studies have been conducted to build mode-choice models in Saudi Arabia. Al-Ahmadi (1989) developed mode-choice models for two major corridors in the Kingdom, namely, Dhahran-Riyadh and Riyadh-Jeddah. Al-Ahmadi, Ergun, Al-Senan and Ratrout (1993) developed a national intercity mode-choice model for Saudi Arabia for various trip purposes. They found that distance of travel, travel cost and perception of privacy influenced mode choices.

In 1994, Al-Sughaiyer carried out a study investigating the effect of incorporating perceptual concepts of privacy, comfort, convenience and reliability in intercity mode-choice models for Saudi Arabia. He used these variables along with the traditional travel and socioeconomic variables.

Recently, in 1995, Afroz concluded that, among the various travel and socioeconomic determinants, purpose of trip, trip length, age, occupation, nationality, accompanied family size and education level play a significant role in influencing travellers' decisions for mode-choice.

A review of several studies, such as Recker and Golob (1976), Nicolaidis and Dobson (1975), Nicolaidis and Sheth (1976), reveals that there are many attributes that influence feelings and perceptions. In selecting a mode, the following attributes are used for evaluation purposes:

1. Comfort,
2. Dependability,
3. Availability,
4. Attractiveness of vehicle,
5. Noise in vehicle,
6. Vehicle safety,
7. Smoothness of ride,
8. Privacy,
9. Avoiding exposure to traffic congestion,
10. Minimum exposure to bodily crowding,
11. Out - of - pocket cost,
12. Riding time,
13. Walking time,
14. Waiting time,
15. Opportunity to meet and talk with other people,
16. Opportunity to relax,
17. Opportunity to read,
18. Continuous ride with few stops,

19. Protection from weather on entire trip,

20. Flexible destination - can go anywhere,

21. Year-round temperature comfort in vehicle,

22. Assurance of having a seat,

23. Security from undesirable acts of others, and

24. Low level of pollution.

Other studies on mode attributes in testing travellers' attitudes were conducted by Dobson and Tischer (1979), Gensch and Torres (1980), Haynes, Fox and Williams (1979), and Tarditt (1977). These studies characterized different modes such as walking, private automobile, carpool and bus.

### *2.1.1 Attribute Importance.*

Mode Attributes are not equal in their importance for travellers. Some attributes have priority for determining a mode such as travel time, travel cost, convenience, and comfort in the context of home-to-work, or home-to-school trips. According to Haynes, Fox, and Williams (1979), consumers place greater emphasis on some attributes than on others. In their study, respondents gave high ratings to punctuality, care of passengers, weather protection, route information (especially for mass

transit), accessibility and safety. Also in analyzing attitudes towards transit, they found that people concentrated on definite attributes such as time (waiting and walking):

> " People generally desired a system that ran frequently ( no more than 7 min. waiting ) and came close to their home (no more than 2.25 blocks away)."

However, the length of journey should not subject the child to undue stress or strain, as this would prevent the pupil from benefiting from the education received at school.

In the UK, the National Travel Survey for 1985/6 shows the average length of primary school walking journeys to be 0.6 miles, compared to 0.7 miles for secondary school pupils, with average journeys for motorized modes being longer, particularly for secondary school age pupils in rural areas, as described by Thornthwait (1994).

The study by Gensch (1980) concentrated mainly on time as an important attribute. He indicated 10 attributes for evaluating three types of transportation modes: bus, auto, and carpool. Four of these attributes dealt with time, such as punctuating, travel time, and waiting time in traffic; while the remaining attributes were: costs, safety, convenience, and relaxation. Dumas

and Dobson (1979) revealed the importance of the convenience variable, indicating that it was an extremely important factor affecting traveller behavior.

For school transport, some authors such as Swersey and Ballard (1984), Graham and Nuttle (1986), and Dauler and Nuttle (1987) considered travel time as an important factor, which needed to be solved through bus scheduling and studying of routes, congestion problems, arrival and departure times. Other variables, such as waiting in transit, were studied by Bowman and Tourniquets (1981) in order to improve and minimize the time spent waiting by improving service frequency and reliability for the benefits of consumers.

### *2.1.2 Attitude Measurement*

Attitude measuring instruments vary in terms of the response options they allow. In a highly constrained format, individuals may be asked to state their attitudes by responding to specific questions or statements with only one of two alternatives: "agree or disagree" as described by the The New Encyclopedia Britannica (1974). Alternatively, both Dunne and Nicolaidis and Dobson mention that six-point scales have also been used to measure the degree to which the respondents agreed or disagreed with different attributes. All of these previous studies used semantic differential scales to measure the extent of an individual's indicated agreement or satisfaction with each attribute. Dobson and Tischer used a one-to-seven point scale. Also, Gensch and Torres measured the satisfaction of respondents concerning the modes by a seven-point scale,

where 1 was assigned to very good and 7 assigned to very bad. In the study by Dumas and Dobson (1979), measurement was based on a seven - point scale ranging from completely satisfied to completely dissatisfied.

Osgood and his associates (1972) developed semantic differentials to measure attitudes. In some contexts, the semantic differential consists of a set of bipolar scales, such as good-bad, very important-not important, and so on. Typically, the objectives in a given pair are placed on opposite ends of seven-point scales, and respondents are asked to evaluate the attitude objective by rating it on each scale, as described by Ajzen and Fishbein (1980).

Since the attitude variables are equal in their importance to the useres, it is better to use same number of point scale, thus attitude measurements might be presented as the following evaluative semantic differential :

| | | | | | | |
|---|---|---|---|---|---|---|
| Very Cheap | 1 | 2 | 3 | 4 | 5 | Very Expensive |
| Very Low | 1 | 2 | 3 | 4 | 5 | Very High |
| Very Safe | 1 | 2 | 3 | 4 | 5 | Not Safe At All |
| Very Good | 1 | 2 | 3 | 4 | 5 | Very Bad |

## 2.2 SOCIAL CONSTRAINTS

Traveler characteristics include social constraints which have an effect on modal choice. Many authors, including Nicolaidis, Waches and Golob (1979), Gensch and Torres (1980), Swait and Ben-Akiva (1987), Koppelmann and Pas (1980), Dauler and Nuttle (1987), Bowman and Tourniquets (1981), Graham and Nuttle (1986), Gensch (1980), and Recker and Golob (1976), have discussed one or more individual constraints that get in the customers' way of choosing their preferred mode. Situational constraints emphasize the hindrances that impede people from choosing what they prefer. Koppelmann and Pas (1980) stated that:

> " Because of situational and availability constraints, consumers do not always choose the transportation mode that they most prefer for a particular trip".

Describing the usefulness of market segmentation to analyzing the constraints, Swait and Ben-Akiva (1987), state:

> "Market segmentation, allied with specific choice models, can be a useful tool for expressing the effects of constraints ".

The choice-constraints include variables such as bus access time (waiting plus walking times), bus transfers needed, automobile availability, accessibility to bus service, and the appropriateness of the buses.

Other researchers, such Hartgen (1974), and Recker and Golob (1976), believe that such variables as automobile ownership and the availability of bus service influence travel behavior and responses to marketing more significantly than do demographic differences.

However, Dauler and Nuttle (1987) verified that the ownership or the availability of a car can affect mode choice in two ways:

a) Providing an option for use as the main mode,

b) Giving a means of access to the main mode terminal.

Since there are various constraints and differences at individual levels, individuals face many problems in choosing their preferred mode. These problems are associated with heterogeneity of choice constraints. For that reason the idea of grouping homogeneous populations is justifiable. This idea was found by Nicolaidis, Waches and Golob (1979) to be the strongest in explaining travel behaviour. In their study, many constraints were mentioned,

such as: automobiles availability, lack of buses, accessibility to bus service, inappropriate bus routing and income.

Swait and Ben - Akiva argued that constraint is not only accounted for by income and transport infrastructure, but there are other variables too:

> " The process of constraints identification must not only consider constraints such as income and transport infrastructure, but must also account for informational, psychological, cultural and social restrictions ".

However, an individual's mode choice may be affected by other constraints, which may influence or even constrain an individual's preference, e.g. nonavailability of a driver's licence may lead to the removal of an automobile from mode choice. Gensch (1980) found that some individuals tend to shift from one mode to another, such as to shift from auto to bus mode, but more than half of those respondents in the study do not own a car, and as such they are constrained from their preferred mode.

Travel time is considered by Graham and Nuttle (1986) to be a problem, especially for school buses, and they concentrate on ways of solving it through routing and scheduling. Dauler and Nuttle (1987) hold the same view on analyzing the school bus scheduling for the purposes of reducing the travel time. Bowman and Tourniquets (1981) mention that in order to improve service

quality, the waiting time and in-vehicle time for transit users should be improved to a competitive level with the private auto.

Lewin et al. studied the desirability of undergraduate students, male and female, using carpools for school transportation. The study shows that when the number of riders who are acquainted with each other decreases, the undesirability increases, and the converse is also true. To solve the problem, they suggest an increase in the acquaintances through using a chaining approach in which each rider supplies the name of another rider.

### *2.2.1 The choice constraints' variables can be summarized as follows:*

*2.2.1.1* *Automobile availability*: for those families who have automobiles, it is possible for them to use them for many purposes, whereas those who don't have a car miss this advantage and are forced to use other modes of transport for their school children.

*2.2.1.2* *Inappropriate bus*: if there is no suitable bus which has the full requirements for the different types of users, such as male and female students, and for the different ages of students, such as for small children in primary level and so on, the people will be forced to use the available one, even if it is not appropriate, not according to specification, and not their preferred mode.

*2.2.1.3* *Routing*: Inappropriateness of the routing of buses that were available to respondents forced people to use another mode.

*2.2.1.4* *Poor bus accessibility*: one of the most important constraints is the accessibility of the bus, in the sense that it stops close to the consumers' houses. For example, if a bus-stop for picking up students is far away and increases the walking time, the families will think deeply before allowing their children to use that bus, particularly considering the security and safety circumstances for female students. Some situations are also considered, such as waiting time for the bus and the travel time inside the bus during travel to and from the schools.

*2.2.1.5* *Nonavailability of bus service* for school transportation purposes.

*2.2.1.6* *Income*: an important variable in choice constraint is that low income families cannot choose the preferred transport mode, even if they have a car, because it is used for work. It is very important also to notice that even medium income families who have many male and female school age children at different levels of general education have difficulties in choosing the preferred mode. Even high income families may encounter this problem.

## 2.3 SOCIODEMOGRAPHIC ASPECTS.

The sociodemographic aspect is one of the travelers characteristics, which impacts on individual and household choice of preferred modes. Hence, demographic characteristics are taken into consideration in grouping populations. The underlying assumption is that travel demands and consumer responses to marketing are strongly associated with socioeconomic status or cultural variables. Many studies such as those by Spear (1974), Nicolaidis (1975), Charles River Associates (1972), Ben-Akiva (1973), and Prashker (1977), concentrated on identifying the role of transit on consumers' demographic characteristics. In general, these studies have explored the relationship between usage of transportation modes and the individual's demographic characteristics.

The sociodemographic variables considered are the following: number of people in the household, their sex, age, marital status, level of education, income, employment, and number of automobiles owned by the household. Other characteristics, such as type of dwelling, presence of children under 18, occupation of sponsors (managerial and professional versus clerical and sales versus service and crafts persons), and possession of driver's license, have also been described by different researchers, such as Dobson and Tischer (1976), and Nicolaidis, Waches and Golob (1979).

However, for more explanation of the effect of sociodemographic variables, the following variables are described.

*2.3.1 Income:* High-income families can easily provide a better transportation mode, and they can choose their preferred mode. The opposite is true for low income families.

*2.3.2 Number of people in the household:* When the number of children going to schools increases, it increases the cost in the family expenditure, which affects mode choice.

*2.3.3 Type of dwelling:* Type of dwelling (e.g. villa or apartment) reflects the income of the family and hence is related to mode choice.

*2.3.4 Age:* Of all family members, which is useful for the purpose of testing whether there is a difference in thinking between the different family members and on their views, attitudes and preference for transportation modes.

*2.3.5 Sex: Number of males and females in the family.*

*2.3.6 Marital Status* :Married or Single.

*2.3.7 Education:* of all family members. Educated families have a larger and better range of mode choice.

*2.3.8 Number of vehicles in the household:* if a family has more than one car, it is obvious that they have more choices than those who do not .

*2.3.9 Working status:* Differences in employment situation for the sponsors, either in government or private sectors, lead to differences in income, and this will affect the preference and mode choice due to the effect of the income. Those sponsors working in high status jobs in private business fields are similarly affected. Uncles (1987) states that high income people tend to use private modes, indicating that family income has an effect on mode choice:

> " Working status makes an indirect contribution to family income, which influences the evaluation of time and mode choice ".

Sociodemographic characteristics, such as income, number of automobiles available, number of people in household, and number of driver's licenses in a household, were used by Dumas and Dobson (1979) as background variables for studying the interrelationships of attitudes and behaviour. Said (1992) mentioned that household car ownership increased as income increased. Kuwaiti and non-Kuwaiti households had increasing levels of car ownership in relation to income increases. The number of male and female adults in the household had an impact on car ownership. Arabian household car ownership levels increased as the number of adults per household increased.

Car ownership levels vary with the house type. Kuwaiti households in single family housing (villas and "other housing types") have higher ownership rates than households in apartments (Said, 1992).

Said also mentioned that Kuwaitis do not use public transport and rely completely on private cars for work and other trips. This is not the result of employing any utility maximization decision criterion; it is rather due to their very high income, the perception that public transit users are less socially-situated individuals, and the presence of family drivers in most households, making factors such as the number of family members in the driving age irrelevant to the car ownership decision making process.

Although cost is the main concern of an individual in mode choice, particularly in the lower income group, consumers might choose another mode if the travel cost decreased, such as to switch from private automobile to mass transit. Swait and Ben-Akiva (1987) argued that an individual of low income level has more flexibility in mode choice if the size of choice sets is increased. In measuring automobile availability, Tarditt (1977) used the ratio of the number of automobiles to licensed drivers in the household, and he used the distance from respondents' home to closest bus line to measure bus availability. Golob (1989) found that car ownership had the greatest total influence on car trips, which is stable over time. Substantial total effects on car trips are also directly related to income class, but these effects are temporally less stable. The strongest influence on public transport trips are from car ownership, with an additional negative influence from car travel. The strongest effect from each income class on public transport is through car use: more car trips imply less public transport trips.

## 2.4 Relations Between Different Characteristics

In terms of relations between different characteristics, Dobson and Tischer (1976) found strong associations between attitude and mode choice, indicating that these relations are not influenced by sociodemographics, but when attitudes and sociodemographics are combined they affect the mode

choice. According to that research, the modal split was 18.8% carpool, 25% bus, and 56.2% single-occupant automobile. This modal split was for Central Business District Workers. If it was for school trips, the result might be changed. In addition, the researcher did not consider the worker constraints; only beliefs, sociodemographics and modal choice were investigated. Said (1992) mentioned that car ownership has a clear correlation to household size: the level of car ownership increased steadily as the household size increased, but Kuwaiti and non-Kuwaiti households had different numbers of cars in relation to household size, for reasons previously noted.

Attention has been devoted to the consideration of traveller's attitude. This attention, as mentioned by Gilbert and Foerster (1977), resulted from the need to make travel demand models more sensitive to a wide range of travel modes and service options. Since there is a variety of existing transportation modes, Haynes, Fox and Williams (1979) point out that the marketing approach should encourage travellers to use those modes in ways that minimize the need for new facilities, especially if the cost differs from one mode to another, allowing members of the different income levels to have their own choice. As Swait and Ben-Akiva (1987) found in their studies, a decrease in travel cost for the bus mode leads to an increase in travellers for that mode.

Said (1992) mentions that the analysis also suggests that the variables describing income, household size and number of adults are important quantitative variables for mode choice.

Variation in individual attitudes may exist towards some variables. For example, walking distance to the bus stop may be considered by some to be a reasonable distance, thus making the bus an available mode choice. Others, according to Swait and Ben-Akiva (1987), may consider it to be an unreasonable distance, and this can act as a constraint for individuals. Since individuals may have varying perceptions of what constitutes an acceptable walking distance, it is important to know people's perceptions to assess mode choice. Generally, an individual's choice represents an expression of his preferences among the available options at the time and under the conditions in which the choice is made.

Koppelman and Lerman (1986) described the way that all operational models for predicting an individual's choices are based on the behavioral principle called "utility maximization". According to this principle, there is a mathematical function "U", called a utility function, whose numerical value depends on attributes of the available options and the individuals. The individual chooses the most preferred option, which is the one with the highest utility function value.

The utility function is:

$$U(T, C, Y) = -T - 5C/Y$$

Where:

T=travel Time,

C=travel Cost, and

Y= annual income.

In the U.K., the way in which children travel to school has changed considerably in recent years, as shown in Table 2.1

**Table 2.1**

**Modes used for School Trips in U.K.**

| Modal Choice, Education Journeys, 1975/6 - 1993 | | | | | |
|---|---|---|---|---|---|
| | % of education journeys | | | | |
| | 1975/6 [1] | 1985/6[2] | 1985/6*[3] | 1990 [4] | 1993 [5] |
| Rail | 0.8 | 0.7 | 1.3 | - | 18 |
| Local bus | 11.7 | 12.2 | 13.0 | 20.2 | |
| Other public | 0.2 | 0.7 | 0.6 | | |
| Private hire bus | 8.0 | 7.1 | 6.3 | | |
| Car | 13.6 | 15.7 | 16.8 | 20.0 | 34 |
| Bicycle | 4.0 | 3.5 | 3.6 | 1.3 | - |
| Walk | 64.3 | 59.5 | 58.1 | 58.6 | 48 |
| Other private | 0.4 | 0.6 | 0.3 | - | - |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100 |
| Sample Size (N) | 43,103 | 30,405 | 17,890 | 1,001 | 10,702 |

**Sources :**

1NTS 1975/6 5-15 yrs,

2 NTS 1985/6 5-15 yrs,

3 NTS 1985/6* special tabulation of education journeys 5-19 yrs,

4 Hillman et al 1991,

5 Berkshire C C 1993 survey of schools in 5 areas.

The trend suggests an increasing use of cars, accounting for an extra 1 to 1.5% of journeys each year, with a corresponding reduction in the proportion of pupils walking to and from school.

A survey of 817 schools in Northern Ireland (approximately 75% of all schools) in February 1990 showed that 8.6% of pupils traveled to school by dedicated school buses; 7.8% on service buses, 0.02% by rail; 1.5% by taxi; 40.9% by car; 1.2% by bicycle; and 40% walked. (RoSPA, 1991, p 5).

The modal choice for the school journey has been found by several studies (Bell & Tether, 1983, p.456; Mensink, 1973, p 82; Thomas et al. 1985, p.169; Rigby, 1979; Jones, 1977, p.3) to be largely influenced by the distance travelled to school, with walking predominating on short journeys and motorized modes used for longer journeys, for both primary and secondary school pupils. The surveys also suggest that the proportion of pupils travelling to school by car in the morning is higher than for the afternoon journey due to the use of cars for linked trips. A 1993 survey in Berkshire (Berkshire County Council, 1993) found that 43% of the cars used for the morning school journey were linked to a work journey with the average number of pupils transported in each car being 1.5.

## 2.5 SUMMARY

This review of literature has concentrated mainly on mode attributes and traveller characteristics, such as attitude, choice constraints and sociodemographics and their relation to modal choice. In order to satisfy needs

and desires of populations or individuals, those characteristics divided the population into clusters based on similarity of their attitudes, social constraints and sociodemographic characteristics, as described by Nicolaidis, Waches and Golob (1979), Gensch and Torres (1980), Koppelmann and Pas (1980), Dumas and Dobson (1979), Dobson and Tischer (1979), Gilbert and Foerster (1977), and Recker and Golob (1976).

Consumers' attitudes towards transportation modes depend on the characteristics of the mode, and individuals' evaluations of the modes are based on many attributes. In order to characterize the consumers' feelings towards different modes, many researchers have described numerous attributes. Dobson and Tischer (1976) used 19 attributes; Nicolaidis, Waches and Golob (1979) used 25 attributes, Koppelmann and Pas (1980) used 24 attributes, Haynes, Fox and Williams (1979) used 26 attributes, Recker and Golob (1976) used 25 attributes, Tarditt (1977) used 8 attributes, Gensch and Torres (1980) used 19 attributes, and Gensch (1980) used 10 attributes. The most important of these attributes are:

1 - Comfort, ( COM )

2- Convenience, ( CON )

3 - Safety (personal and vehicular safety), (SAFE)

4 - Travel cost, (COST)

5 - In - vehicle travel time, (IVTT)

6 - Access time (walking time), (AT)

7 - Waiting time (WT).

Semantic differential scales have been used to measure the extent of an individual's agreement or satisfaction with each attribute for each mode. Some researchers used a six - point scale, others a seven - point scale, such as: very important to not important at all, very satisfied to very dissatisfied, very good to very bad, and strongly agree to strongly disagree.

Choice constraints are considered important characteristics which have been found to be the best to explain travel behaviour· These constraints are:

1. Automobile availability,

2. Lack of buses,

3. Inappropriate buses,

4. Accessibility to bus services,

5. Income.

Sociodemographic characteristics have been considered as background characteristics of families and individuals. Sociodemographic characteristics in relation to mode choice were studied by different researchers. Such variables are:

1. Number of people in household

2. Sex

3. Age

4. Level of education

5. Income

6. Number of automobiles in the households

7. Possession of driver's licences, and

8. Employment.

Generally, travel time, income, travel cost, and automobile ownership by a traveller's household are used widely in the disaggregated models.

Automobile ownership is described as the variable known to have the strongest effect on mode choice. Multi-car households are more likely to have higher income than single-car and non-car households. Automobile ownership has an independent effect on mode choice and travel time. An important consideration in the selection of travel cost variables is their interaction with income. Economic theory and everyday experience both suggest that a traveller's sensitivity to changes in travel costs may depend on his income, with high income travellers being less sensitive than low income ones.

An income variable acts as a surrogate for unobserved attributes, such as a preference for schedule flexibility, that tend to make the automobile mode particularly attractive to high - income travelers.

Generally, mode attributes and travellers' characteristics have a strong relationship to modal choice. There is a strong association between attitude and modal choice.Also, attitudes, sociodemographics, and choice constraints have a strong influence on mode choice when combined together.

## 2.6 RESEARCH HYPOTHESES

### *2.6 .1 Attitudes Hypotheses.*

An individual's attitude towards an object is influenced by his or her beliefs about the characteristics of that object.

- The higher the comfort a transportation mode can provide, the greater is the likelihood that this mode will be chosen by individuals and households.

- The lower the travel time involved in a transportation mode, the more favorable that mode will be for individuals and families.

- The more convenient a mode, the more preferable by individuals and households.

- The safest mode will be the most favorable mode for individuals and households.

- Individuals and families tend to choose the lower travel cost mode.

### *2.6.2 Situational Constraint Hypotheses.*

Social constraints are strongly believed to be the primary cause impeding individuals or families from choosing their preferred mode. The literature review indicates that attitude and preference are likely to be influenced by a composite set of constraints. Also, the following situational constraints hypotheses are taken into account.

- The lower the families' income, the lower the chance of choosing their preferred transportation mode.

- The lower the availability of automobiles for households, the greater the chance of their accepting less preferred modes for their children.

- The lower the availability of buses, or appropriate buses, the lower the chance of families choosing their preferred mode.

### *2.6.3 Sociodemographic Hypotheses.*

The socio-demographic characteristics of consumers affect the usage and choice of modes. Along with that, the following hypotheses have to be taken into consideration:

- A household's income has an affect on mode choice, high income families, have more chance to choose their preferred mode than low income famillies.

- The number of students in the families has an affect on mode choice. As the number of students, male and female, increases, so the chance of choosing the preferred mode decreases.

- As the number of vehicles available to the family increases, so the families are less likely to choose other modes.

- Working status makes an indirect contribution to families' income, and this influences the mode choice. The higher the status of the head of the household, the better the chance of choosing a preferred mode for the purpose of school transport.

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# 3 METHODOLOGY


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# 3. METHODOLOGY

As mentioned previously, the purpose of this research is to study the attitudes (perceptions and feelings) of Saudi households towards different modes of school transport, to identify their preference of modes, to identify the constraints that impede Saudi households from choosing their preferred modes, and to examine the relationship between sociodemographic characteristics, attitudes, preferences and choices, as well as to develop potential modal split models. The factors that affect consumer choices are mainly derived from those identified in the previous studies.

This chapter describes the population, sampling, data collection and method of analysis. The study area is the city of Dammam in the Kingdom of Saudi Arabia (as shown on Map 1). Saudi Arabia has a total area of 2.24 million square kilometres and a total population of a little over 18 million inhabitants.

School transport issues in Dammam are typical of those encountered in other cities in KSA, such as Riyadh, Jeddah, etc.

# MAP 1

# SAUDI ARABIA




The total number of students (male and female) in Saudi Arabia is 4,051,370,(1999) and total number of schools is 22,093 for all levels of

education, including Elementary, Intermediate and Secondary. (This table shows the number in Dammam, as in the next paragraph).

Table 3.1

Total Number of Students and Schools in Study Area.

| Level of Education | Number of Schools | | | Number of Students | | |
|---|---|---|---|---|---|---|
| | Male | Female | Total | Male | Female | Total |
| **Elementary** | 71 | 91 | **162** | 24122 | 31506 | **55628** |
| **Intermediate** | 40 | 39 | **79** | 11387 | 13493 | **24880** |
| **Secondary** | 12 | 23 | **35** | 7046 | 10471 | **17517** |
| **Total** | **123** | **153** | **276** | **42555** | **55470** | **98025** |

Source: Male & Female Education Departments in Dammam-1999

## 3.1 Population & Sample

A list of schools and their locations was obtained from two departments, namely the Male Educational Ministry and General Presidency of Girls Education. According to the list, there are a total of 276 schools, and 98,025 students, as shown in Table 3.1.

## 3.2 Sample Size

Sample size determination is an important decision in the planning of any research; the size of the sample must be sufficient to accomplish the purpose. The main advantages of using disaggregate analysis include the better use of data and the improvement of the statistical basis of model building. Samples of 500-1000 are normally sufficient for most disaggregate analyses, (Bates, 1979). Daganzo (1979) reported that it is possible to use just a few hundred data points in order to obtain accurate estimates. Much smaller sample sizes are recommended and used by many other researchers. Inaba and Wallence (1989) developed a joint model/destination MNL choice using a total sample of 183 individuals. Richards and Ben-Akiva (1975) reported that a sample of 200 to 500 per mode is reasonable for mode-choice model calibration using MNL models. In the same reference it is, however, stated that samples as small as 50 to 70 per mode produce reasonable results. Fitzpatrick (1991) considered a sample size of 50 data points as target size. The concern here of mode choice models is for disaggregate models that have substantial practical advantages. Disaggregate models can be developed using data from only 1000 – 3000 households and they can be implemented on microcomputers (Koppelman and Lerman,1986).

Factors determining the sample size are:

1 - The confidence and precision desired.

2 - The variability of the characteristic in the target population, {if unknown one should assume great variability}.

3 - The size of the target population N.

The required formula (Cochran, 1963) is:

$$n_o = t^2 pq / d^2$$

*Where* $n_0$ = first estimate of sample size

$t$ = confidence (for 95% use 1.96)

$d$ = precision 0.05, or 0.10 usually

$p$ = proportion in the target population with the characteristic being measured.

If proportion is known, use

$$p = q = 0.5$$

Then final sample size n, is given by

$$n = \frac{n_o}{1 + n_o / N}$$

To determine $n_o$ consider:

$$t = 1.96,$$

$$p = 0.5,$$

$$q = 0.5, \text{ and}$$

$$d = 0.05$$

$$n_0 = t^2 pq / d^2$$

$$= \frac{(1.96)^2 \ 0.5 X 0.5}{(0.05)^2}$$

$$= 384.16$$

$$\text{Sample size} \quad n = \frac{n_o}{1 + n_o / N}$$

$N$ = The Population

$$\text{Elementary Boys} = \frac{384}{1 + 384 / 24122}$$

$$= 378$$

By applying this formula to the different educational levels: elementary, intermediate and secondary for male students, and elementary, intermediate and secondary for female students, using the population size, number of students male and female in each level of education, the sample size derived is reported in Table 3.2.

**Table 3.2**

**Sample Size Required**

| Level of Education (M & F) | No of Schools | Population (No of Students) |
|---|---|---|
| Elementary Male | 36 | 378 |
| Intermediate Male | 20 | 371 |
| Secondary Male | 12 | 364 |
| Elementary Female | 46 | 379 |
| Intermediate Female | 20 | 374 |
| Secondary Female | 12 | 370 |
| Total | 146 | 2236 |

A two stage sampling design was used in selecting the sample. In the first stage 146 schools (68 male and 78 female) out of the total of the 276 were selected using the simple random sampling technique. In the second stage, students were chosen from the selected schools also by using the simple random sampling technique.

2236 students from the 3 different educational levels were chosen for the sample, to ensure the required sample size. An assumption of a 10% non-response rate was built in to the sampling process. These questionnaires were

considered as homework for the students. Therefore delays were expected. This increased the sample size to 2461 students, as shown in Table 3.3.

**Table 3.3**

**Final Sample Size**

| Level of Education (M & F) | Sample Size Required | Non Respond Questionnaire | Distributed Sample Size |
|---|---|---|---|
| Elementary Male | 378 | 38 | 416 |
| Intermediate Male | 371 | 37 | 408 |
| Secondary Male | 364 | 37 | 401 |
| Elementary Female | 379 | 38 | 417 |
| Intermediate Female | 374 | 38 | 412 |
| Secondary Female | 370 | 37 | 407 |
| Total | 2236 | 225 | 2461 |

## 3.3 DATA COLLECTION

The instrument for data collection was the questionnaire for students and their families. The most important task accomplished during the pre-survey stage of this investigation was the development of the two different types of questionnaires, which are shown in Appendix B. The process of the questionnaire construction design passed through the following stages:

- Gathering items and ideas that were supposedly related to the hypothetical variables of the study.

- Covering all possible statements that could be made about the subject under study, and compiling these statements together in one statement.

- Translating the entire questionnaire into Arabic.

Consideration was given during the designing of the questionnaires to obtaining the data necessary for testing the stated hypotheses in chapter II, and to meet the objectives of this study in chapter I.

The following two components were incorporated in the instrument:

(1) Part I to be answered by the students; and

(2) Part II to be answered by the families as a whole (parents and children).

Both parts consisted of personal behaviour data and personal attitude data.

A personal letter explaining the purpose of the study accompanied each questionnaire. With the help of male and female educational departments in the Kingdom of Saudi Arabia (KSA), lists and locations of all schools of different educational levels were available for all KSA.

Part I was designed to assess the extent of Saudi families' satisfaction with their existing modes of school transportation, and to evaluate different modes in order to choose the preferred mode or modes for their children (male and female). This part of the questionnaire comprised a mixture of dependent and independent measures related to the study of attitudes. Following the review of literature, the construction process of the instrument began by developing the attitude and evaluation system of different modes. A total of 5 attributes were chosen for each mode, which are incorporated in part I of the questionnaire. For measuring attitude, respondents were requested to evaluate modes through these statements, by using five-point scales with 1 for good or safe and 5 for bad or unsafe, etc. Part II dealt with the socio-economic information on Saudi families.

## 3.4 VARIABLES

The review of the relevant literature suggested that the variables that needed to be collected consisted of attitudinal, socio-demographic, and constraint variables (some of which are quantitative, and others are qualitative). Specifically, the questionnaires contained variables that related to the following:

**In part I:**

1. Mode(s) used in school transportation.
2. Households' satisfaction with the mode(s) used.
3. Distance from each student's home, time and cost for the mode(s) used for all six levels of education.
4. Problems due to the existing school transport mode.
5. Evaluation of modes (walking, private car, carpool, limousine or taxi, school bus, and public transport), on the basis of five attributes:

   (a) Comfort (COM)

   (b) Convenience (CON)

   (c) Total Travel Time (Access time, Waiting time, and In-vehicle time) (TTIME)

   (d) Safety (SAFE)

   (e) Expenses (EXPENS)

These are qualitative and attitudinal variables, which are used to explain the behaviour of the students in choosing a mode.

6. Households' attitude, and preference for different transport modes for the purpose of school transport. Also time and cost for these modes.

7. Obstacles preventing use of the preferred modes.

**In part II:**

1. Age of the head of the household (AGE)

2. Head of household's years of education (FEDY)

3. Job field of the head of the household (JHH)

4. Family income (FINC)

5. Number of children in the family (CHN)

6. Number of male students in the household (MST)

7. Number of female students in the household (FST)

8. Educational levels of the children (CHEDL)

9. Number of cars owned by each household (CAR)

The survey was conducted in the months of February and March 1999, during the schools' inter-semester break. The survey was conducted with assistance from the educational departments in Dammam City.

For female students, questionnaires were handed over to each General Girls Education Department in Dammam City, which communicated directly

with the principals of the girls' schools. Questionnaires were then distributed to girls selected in the sample. The female students carried the questionnaires to their families, to get the attitude and preference of the family members. Feedback came through the students, then through the educational department. Full explanation of the purpose of the study and date of submission were clearly explained by the researcher on the front sheet of the questionnaire papers.

Questionnaires for male students were distributed by the researcher directly to the educational departments in the city of Dammam, which in turn distributed them to the male students selected in the sample. The students approached their families. Feedback came through the students to the school, and the questionnaires were then collected by the researcher through the educational departments.

During the collection of the questionnaires from different schools, 67% were returned within the time limit, another 25% were returned one week later, with an 8% non-response rate.

## 3.5 DATA ANALYSIS PROCEDURE

For the first four objectives, simple statistics and graphs were used to present the data and drawn inferences. To achieve the fifth objective, model calibration techniques were employed, using the BLOGIT computer program.

### 3.5.1 *DISCRETE CHOICE MODELLING*

#### 3.5.1.1 *Theoretical Background*

The increasing use of disaggregate analysis in general and logit models in particular has led to a better use of the data, and, indeed, to an improvement in the statistical basis of model building in general, (Daganzo 1979, and Bates, 1979).

Discrete choice models are used to analyse situations in which a decision maker is faced with a finite and exhaustive set of mutually exclusive discrete choices. These models operate at the level of individual decision maker and provide the researcher with the probability with which any particular individual will take a given action (Gene, 1994). Various forms of probabilistic choice functions have been proposed and used in different contexts. However, logit and probit functions have received greater attention (Daganzo, 1987). Specifically, the logit model in its various forms has been used for most individual discrete choice situations (Dickinson and Waterfall, 1984) and (Hewitt, 1983).

Probabilistic choice models are used to estimate the probability, ($P_{ai}$), that alternative (a) is selected by decision maker (i) where, ($P_{ai}$) is function of all factors that influence the choice process (Fischer and Nijkamp 1987). Desirability of choosing an alternative is usually based on the utility offered by that alternative. This utility is commonly expressed as a linear additive function that takes the form (Borgers and Timmermans, 1987, Fischer and Nijkamp, 1987, Gerken, 1991, Horowitz, 1981, Horowitz, 1991, and Wintraud, 1991).

$$U_{ai} = V_{ai} + \varepsilon_{ai}$$

$$V_{ai} = \sum_{k} \beta_k \, X_{aki}$$

where,

$U_{ai}$ : utility of alternative (a) to individual (i);

$V_{ai}$ : systematic (deterministic or representative) component of utility;

$\beta_k$ : weight of the $K^{th}$ attribute;

$X_{aki}$ : value of the $K^{th}$ attribute which affects the choice alternative (a) by individual (i);

$\varepsilon_{ai}$ : random component of utility which constitutes to unobserved attributes, imperfect information, and taste variations.

The model given above is the general form of the Random Utility Model. There are, however, two main approaches or assumptions in specifying Choice Model or in formulating the Utility Function for each alternative (Ben-Akiva and Lerman, 1985, and Manheim, 1979). These assumptions are discussed in the following paragraphs based on Manheim (1979).

***i.Choice or Alternative Independent Utilities:***

In this case, the Utility Function is specified as "Choice Independent" in terms that the Function will be identical for all choices and independent of the choice. In this case the utility function takes the following form:

$$U_a = \sum_i \beta X_i$$

where (a) stands for choice or alternative and $X_i$ stands for the $i^{th}$ attribute which is defined as common for all choices. This means that none of the attributes is defined specific to any of the available choices or alternatives. Instead, each alternative is characterized by the same attributes and the same Utility Function, although the values of attributes and consequently the values of Utilities will be different for each alternative. The idea is that every attribute is given the same weight in two Utility Functions. An example is a binary mode choice model (Bus and Auto modes say) with travel time used as an attribute for both modes. Using the above specification for this example implies that the

unit time (say an hour) has the same marginal effect on the utility whether it is incurred on the Bus mode or on the Auto mode since the coefficient of the Utility Function of that attribute will be the same for both modes.

This hypothesis is usually referred to as "Choice Abstract", and can be invalid for any of several reasons which include, (Manheim, 1979):

**a.** Some attributes are important and cannot be specified common for all of the choices. For example, the availability of an auto is an attribute which is specific to auto mode only in a Binary Choice Model for auto and transit;

**b.** It doesn't allow for different weights to be given by the choice maker to an attribute. For example the choice maker may give time incurred on auto higher weight than time incurred on bus.

The Choice-Independent or "Choice Abstract" Model, however, has some advantages, which include the lower number of coefficients (parameters) to be estimated and the more efficient use of data in case of new similar alternatives (choices). The possible two choices are either to accept or to reject the offered mode.

### *ii. Choice or Alternative Dependent Utilities:*

In this case the Utility Functions for different choices are different in terms that attributes which are particular to a specific alternative of Choice are included in the Utility Function of that choice only and not in the Utility Function of the other. The Utility Function in this case takes the form:

$$U_{ai} = \sum_{i} \beta_{ai} X_{ai}$$

where, (a) stands for choice or alternative and (i) for the attribute.

If all attributes are specified as alternative dependent, the model will be completely choice independent and, if some are specified as alternative-dependent and some as alternative-independent, the model will be partially choice-dependent.

Socioeconomic variables like age and sex basically reflect the differences in preferences for the available alternatives as a function of these variables, (Ben-Akiva and Lerman, 1985). For any given individual (a driver in this case) these variables are constants in effect and it would make no sense to define these variables in both alternatives because all that matters is their effect on the relative utility.

The choice of including these variables as alternatives specific to either of the choices is wholly arbitrary (Ben-Akiva & Lerman, 1985). Only the

sign of the corresponding coefficient will change by changing the choice to which they are specified. The differences in utilities and consequently the choice probabilities will remain unaltered. It should be noted that the above discussion applies for the typical discrete choice cases (like mode choice example) in which each individual has an *a priori* known set of choices to select from. For model calibration in these cases, data for each individual are organized in C rows where C is the number of the available choices or alternatives. In each data row the independent variable is presented by observed choice, while the independent variables are presented by a vector of attributes which affect the choice.

The utility derived from an alternative is used to measure the desirability of a decision maker selecting the alternative. When the mentioned utility is considered random, the model is termed a "random utility model". In such a model, it is assumed that decision makers associate random utility values to alternatives and then choose, as stated by utility theory, so as to maximize utility. Utility is decomposed into a deterministic part ($V_{ai}$ ) and a random part ($\varepsilon_{ai}$) (Ben-Akiva and Lerman, 1985, and Wintraud, 1991). The utility function is not known *a priori* and it has to be specified and calibrated. The specification step consists of determining the form utility function which is usually a linear function including unknown parameter vector $\beta$. The calibration step consists of finding the estimated values in vector $\beta$, i.e. finding the vector $\beta$ using estimation methods like least squares and maximum likelihood (Ben-Akiva and Lerman, 1985, and Daganzo, 1987).

*Assumptions Underlying Discrete Choice Models*

The major assumptions underlying discrete choice models include:

**a.** Each individual decision maker (i) in the population faces a set (C) of mutually exclusive choice options or alternatives (a), (a = 1,……,C) (Fischer and Nijkamp, 1987);

**b.** The population of decision makers is partitioned into population segments (s = 1,……, S) based on the involved attributes (Fischer and Nijkamp, 1987);

**c.** The decision maker, i ε s, assigns to each alternative (a) a utility value ($U_{ai}$) and chooses the alternative which yields the maximum utility; ($U_{ai} > U_{ji}$, V a ≠ j, a = 1,……,C) (Fischer and Nijkamp, 1987);

**d.** Random utility is assumed to represent variations among decision makers within the same segment. All decision makers have completely deterministic preferences but these preferences cannot be fully observed by the analyst because certain choice-relevant attributes are unobserved and because valuation of observed attributes may vary from one decision maker to another (Fischer and Nijkamp, 1987);

e. Random utility models are based on the assumption that an individual's preferences among the available alternatives can be described by utility function. The utility of an alternative depends on attributes of the alternative and characteristics of the individual, (Horowitz, 1991).

f. With only very few exceptions, choice models based on random utility assume that random utility functions are linear in the parameters and additive in the variables, (Fischer and Nijkamp, 1987, and Southworth, 1981).

The assumptions about the distribution of the random component of utility define the form of choice probability. In logit models, it is assumed that error terms are independently and identically Gumbel (or type I extreme value) distributed, (Ben-Akiva and Lerman, 1985, pp. 71 and 104, Fischer and Nijkamp, 1987, and Horowitz, 1991).

A comparison of the observed choices and the predicted choices based on the calibrated models was used to test the validity of the models. Also, the likelihood ratio test for difference between models was used to compare the calibrated models with models that were calibrated using a portion of the collected data other than that used for the model's calibration.

After the questionnaire forms were collected, a coding manual was designed to be used for data entry. The coding manual is shown in Appendix A. The data were entered using numerical codes. Each questionnaire form was represented in two rows of numbers, each row contained a number of columns, and the data were then verified.

### 3.5.2 *Mode-Choice Models Calibration and Comparison.*

This was the second stage in the present study. To calibrate models, the concept of utility theory was used. The basic approach in this theory is that an individual selects an alternative out of the available ones such that his utility is maximised, (Adams, 1959, Ben-Akiva and Lerman, 1985).

Multinomial Logit Analysis that relates the utility of the alternative to the probability of choice was used to calibrate models. Various computer packages for building logit models are available and examples of such packages include BLOGIT, (Crittle, and Jonson, 1989). In this study, the BLOGIT (Basic LOGIT) package was used to calibrate the desired models. This package uses the maximum likelihood technique to calibrate logit models, (Ferreri and Cherwony, 1979).

### *3.5.3 Model Testing*

The BLOGIT program used to calibrate school trips modal choice models in this study gives the individual parameter estimates along with various statistics needed to perform different statistical tests. These tests include the likelihood ratio tests, t-tests and the goodness of fit tests using ?² values and the percent of correctly predicted observations. Other informal tests of the signs and relative values of the model coefficients were also performed.

### *3.5.4 Prediction Success Table*

The prediction success table is a table that presents the number of correct and erroneous cases predicted by the model as compared to the actually observed choices. This table is one of the outputs given by the LIMDEP package. The "percent right" as termed by Ben-Akiva and Lerman (1985) or the "percent correctly predicted" as termed by Stopher (1979) is a measure of the goodness of fit.

In addition to the above-discussed tests, other informal tests including the check for signs and relative values of model coefficients were carried out for the calibrated school trips models.

## 3.6 SUMMARY

Methodology chapter describes the population, sampling, data collection and method of analysis. The total number of students (male and female) in Saudi Arabia is 4,051,370 (1999) and total number of school is 22,093 for all general educational levels.

Dammam city is chosen to be the study area, which is typical of those encountered in other cities in kingdom of Saudi Arabia. There are a total of 276 schools, and 98,025 students in the study area. By applying the formula of Cochran (1963), 2461 students from elementary, intermediate, and secondary levels, for both males and females were chosen for the sample size.

Questionnaire was the instrument for data collection for the students and their families. The questionnaire consisted of attitudinal socio-demographic, and constraint variables. The questionnaires were distributed to the chosen male and female students and collected by the educational departments in the city of Dammam.

After the collection of the questionnaire forms, a coding manual was designed to be used for data entry. In analyzing the data, for the descriptive study, simple statistics and graphs were used to present the data and drawn in references and shown on chapter 4.

Multinomial logit techniques` that relates the utility of the alternative to the probability of choice was used to calibrate mode choice models, as shown on chapter 5.

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# 4 *FINDINGS*


**4. Findings**

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# 4. FINDINGS

## 4.1 Modes Used For School Transport

An analysis of the collected information shows that there are six transport modes that are used by Saudi families for school trips:

1. Walk
2. Private car
3. Carpool
4. Limousine/Taxi
5. Governmental School Bus
6. Public Transport.

It is evident that there are variations in the use patterns of the different modes at different educational levels, depending on socioeconomic and demographic characteristics of the users, as well as the attributes of the modes themselves. These are detailed below.

### 4.1.1 *Elementary School Male Students.*

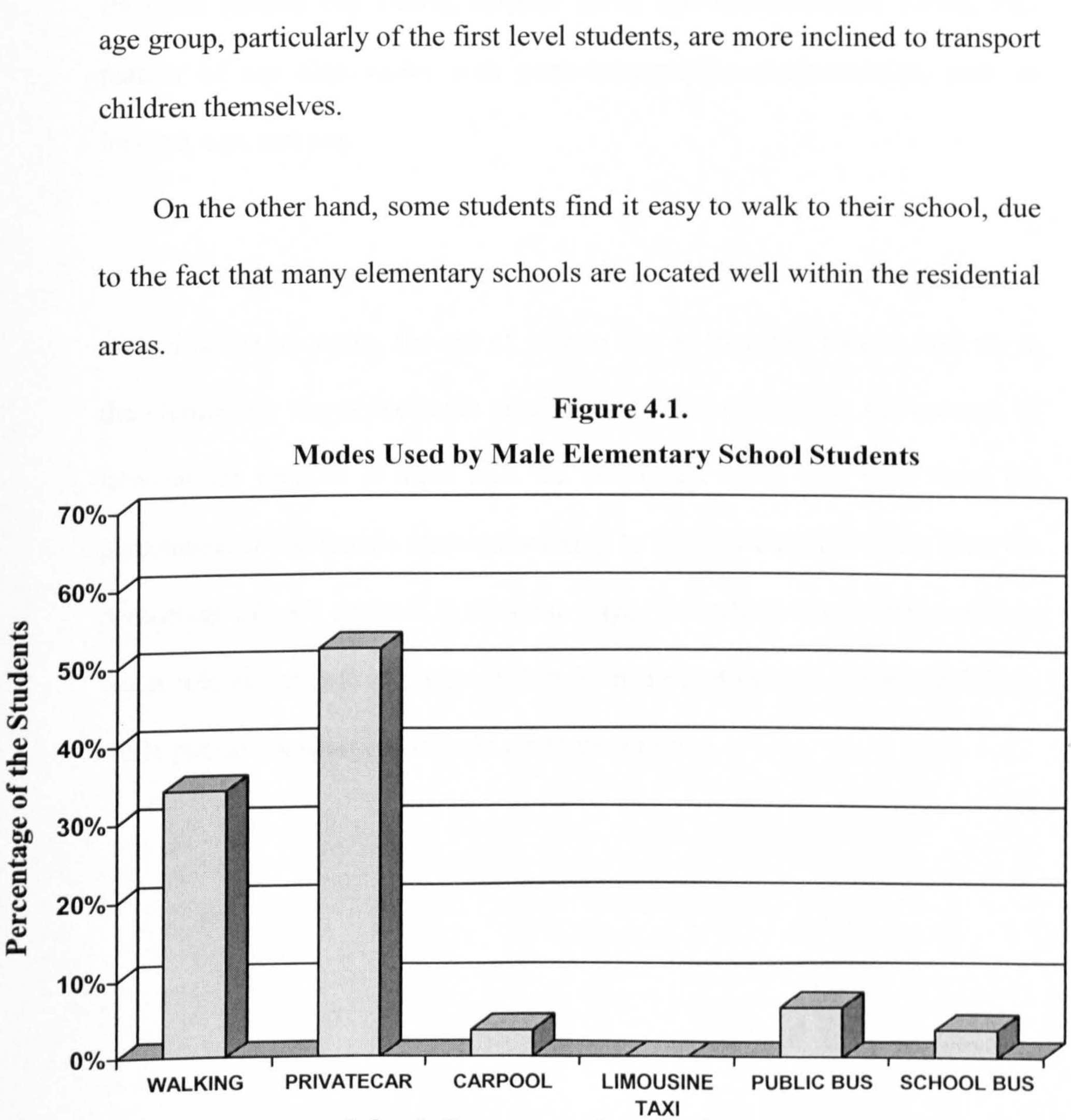
For elementary male students, as shown in Figure 4.1, it was found that 52.4 % of the students were using private cars, while 34.2% went to school on foot. The remaining 13.2% of the students used other modes of transport (carpool 3.5%, public bus 6.4%, and school bus 3.5%). This pattern of use varied with the socioeconomic status and demography of the households.

When income increases, the likelihood that the family will use a private car to transport the students in elementary stages also increases. We know that 90.7% of the families have a private car, as shown in table 4.2. Likewise, if income decreases, the number of students walking to schools increases. At the same time, family members, usually fathers of students of this age group, particularly of the first level students, are more inclined to transport children themselves.

On the other hand, some students find it easy to walk to their school, due to the fact that many elementary schools are located well within the residential areas.

**Figure 4.1.**

**Modes Used by Male Elementary School Students**



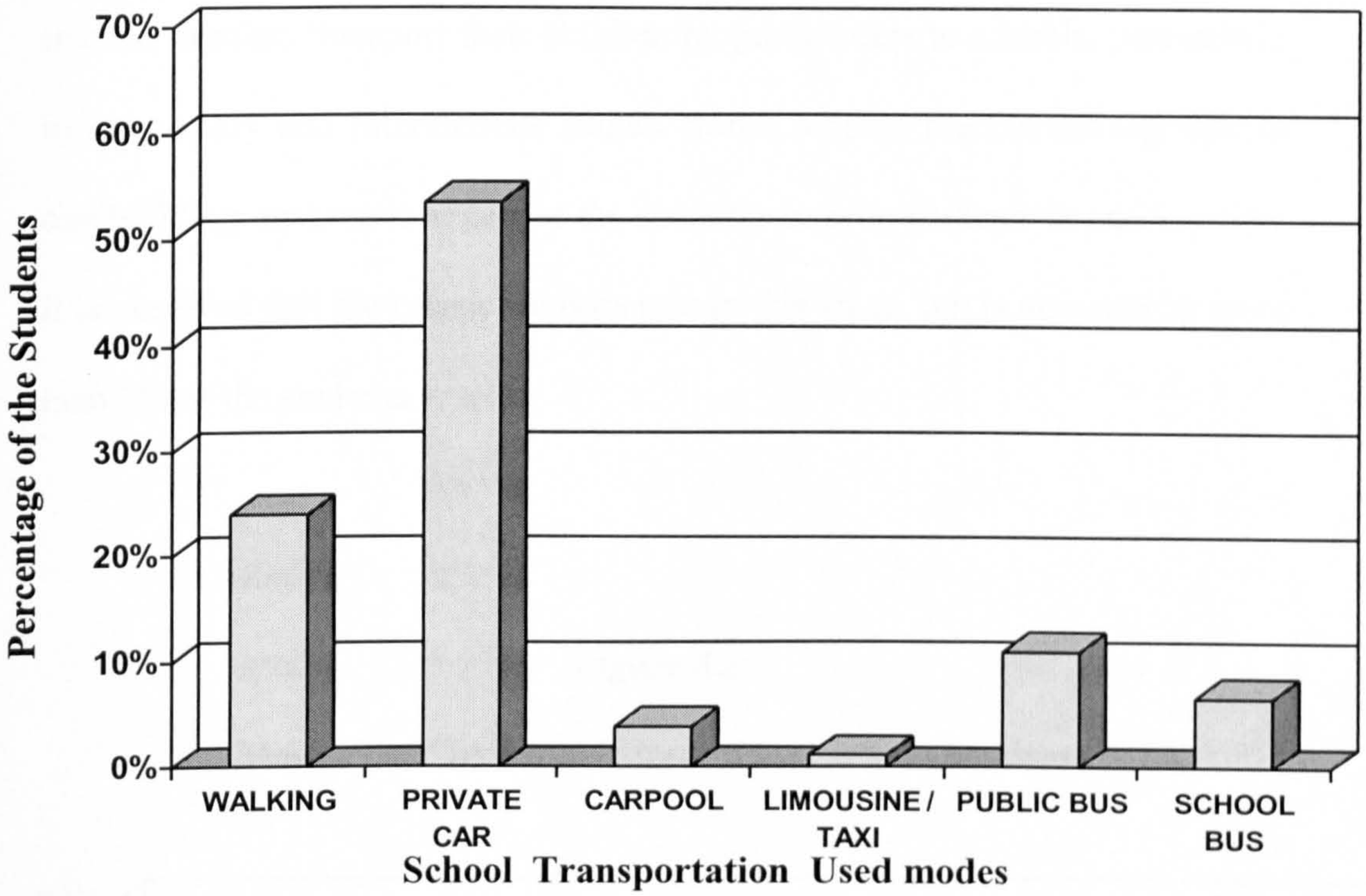
### 4.1.2. *Elementary School Female Students.*

For elementary female students, as shown in Figure 4.2, it was found that 54% of the female students were transported by private cars, and 24% were left to walk to schools. The rest (22%) of the girls used other modes of school transport (school bus 10.9%, carpool 3.8%, and limousine/taxi 3.8%). This pattern of use also varies with sociodemographic characteristics, such as income, age, and sex.

The percentage of private car use is above that of male students. Also, when income increases, the use of private cars to transport female students in the elementary stages increases significantly. This shows that the concern of families for females is more than for the males. Also, it is clear from the percentage of the female students walking to schools that it is lower than the percentage of male students at the same stage. The school bus in this case has a better role as a means of transport than for male students (10.9% versus 3.5%), while public transport has no role worth mentioning.

**Figure 4.2.**

**Modes Used by Female Elementary Students**




### 4.1.3. *Intermediate School Male Students.*

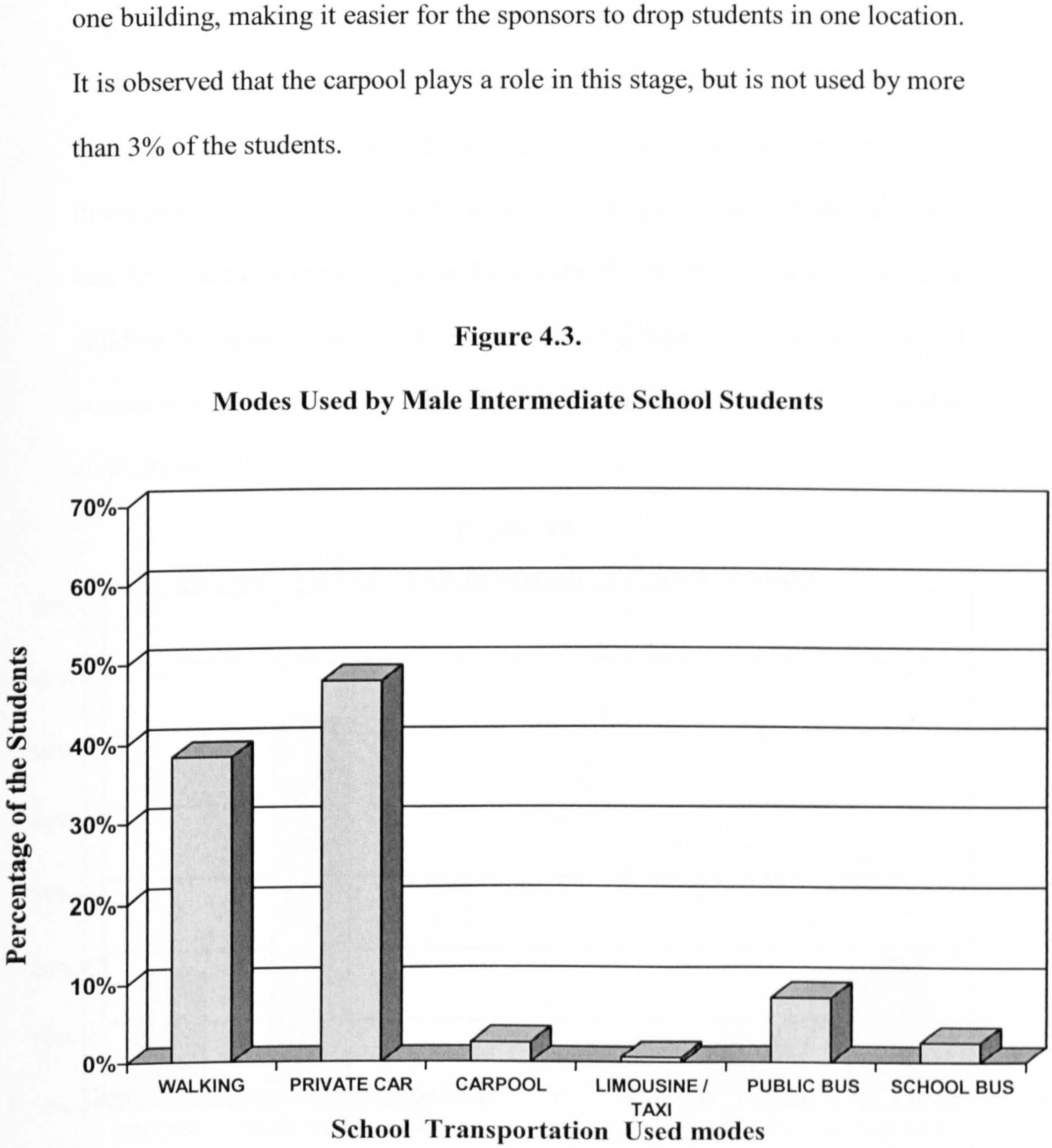
For intermediate male students, as shown in Figure 4.3, it was found that 47.8% of the students were using private cars, and 38.4% of them walked to schools. The remaining 13.8% used the other modes (carpool 4.41%, school bus 8.2%, limousine/taxi 0.6%, and public transport 2.5%).

As before, the pattern of use varies with socoeconomic and demographic characteristics of Saudi households, particularly in terms of income and the number of students in the households. This stage is similar to

the elementary stage with regard to the use of private cars and walking to schools. This stage is a transitional stage after elementary school, and students at this stage receive the same care as those at the elementary stage. So high-income families transport their children by private cars to schools, particularly in elementary and intermediate stages. Some schools are housed together in one building, making it easier for the sponsors to drop students in one location. It is observed that the carpool plays a role in this stage, but is not used by more than 3% of the students.

**Figure 4.3.**

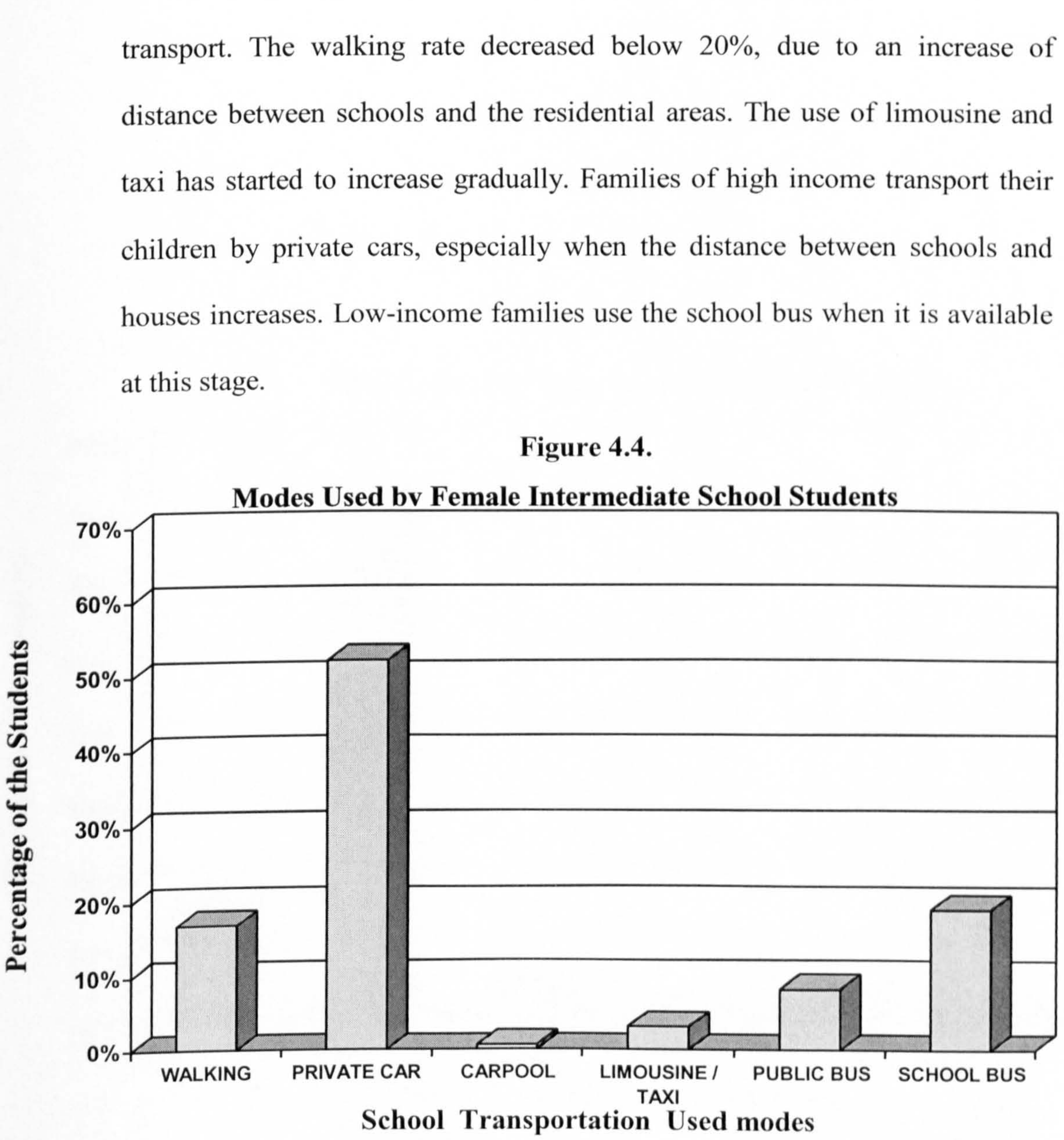
**Modes Used by Male Intermediate School Students**



### 4.1.4. *Intermediate School Female Students.*

For intermediate female students, as shown in Figure 4.4, it was found that private cars transported 52.2% of the female students. This is primarily due to the fact that guardians are more concerned about females than about males when they are outside the home. Also, this stage is different from the previous stage. In this case the school transport bus of the General Presidency for Girls Education is used, and about 18.9% of the female students use this means of transport. The walking rate decreased below 20%, due to an increase of distance between schools and the residential areas. The use of limousine and taxi has started to increase gradually. Families of high income transport their children by private cars, especially when the distance between schools and houses increases. Low-income families use the school bus when it is available at this stage.

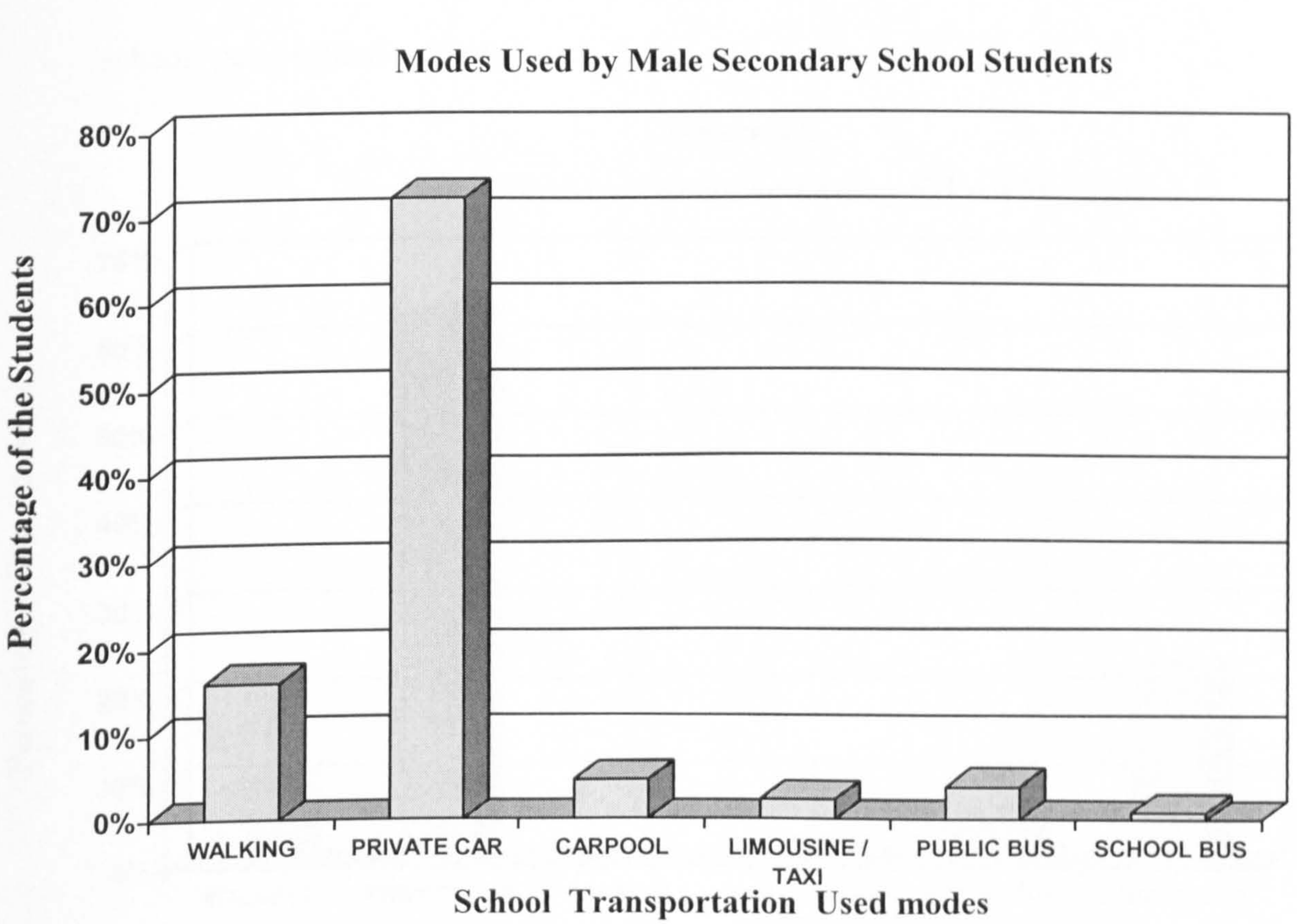
**Figure 4.4.**



### 4.1.5. *Secondary School Male Students*

For secondary school male students, as shown in Figure 4.5, it was found that about 72% of the students used private cars, and 16.2% of the students who were living near the secondary schools went on foot. The other 11.8% of the students used the other modes, according to socioeconomic and demographic characteristics of the households, such as student's age, family's income, number of owned automobiles, and number of driving licenses. The students of second level reach 18 years of age and are eligible to receive driving licenses. This is one of the reasons for the increased use of private car. It is to be noted that 47.7 % of the households own more than one car.

**Figure 4.5.**



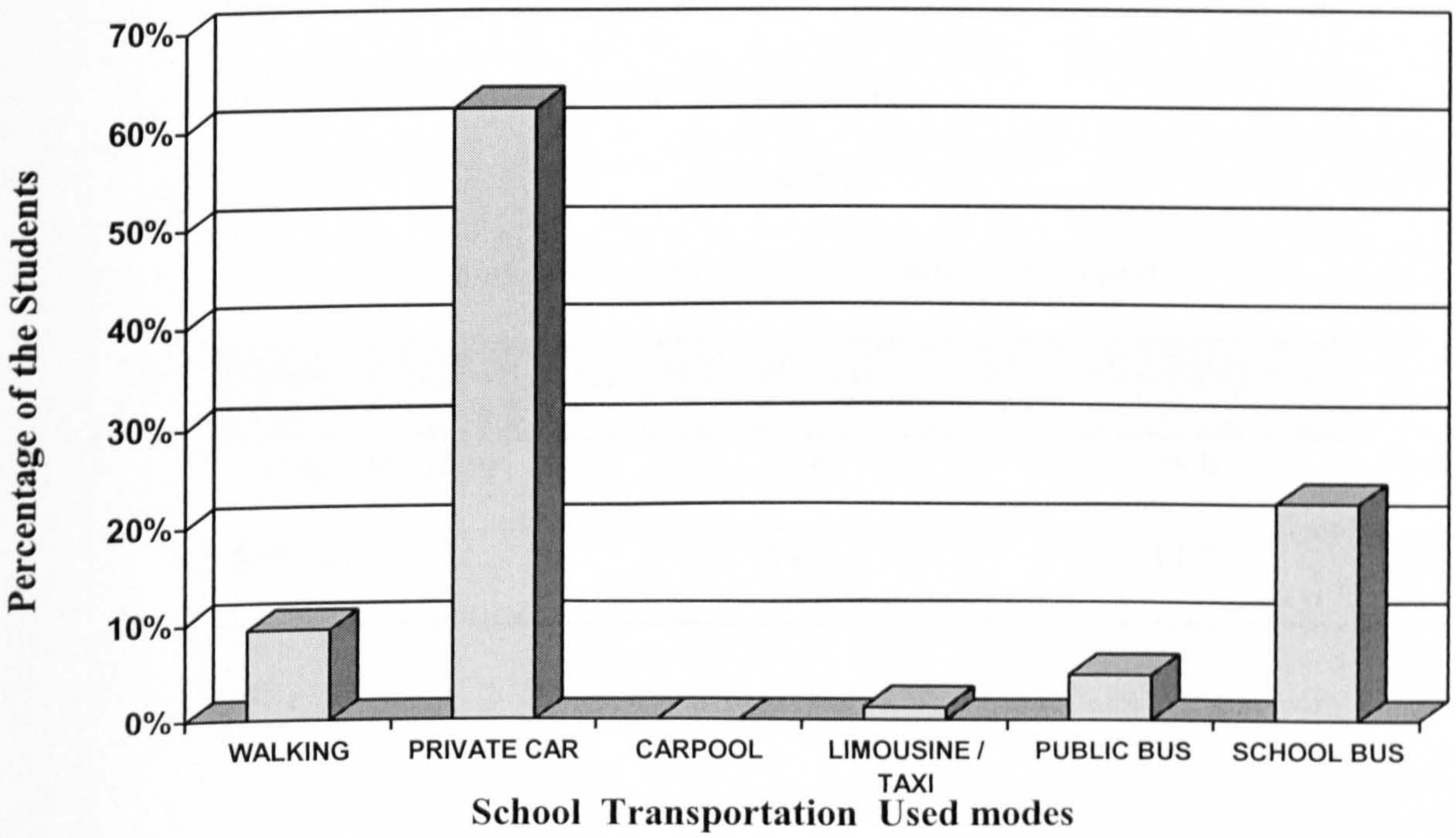
### 4.1.6. *Secondary School Female Students*

For secondary school female students, as shown in Figure 4.6, it was found that 62.6% of the students used private cars, while 22.2% of them used the government school bus, and 9.4% walked to schools. The remaining 6% were transported by the other transportation modes (carpool 1.3%, and public bus 4.7%).

The higher the family income, the higher was the use of the private car. The transportation was made either by a family employee, usually a paid driver, or by one of the family members. On the other hand, low-income families used the government school bus, due to its availability at this stage, while it could be used as an alternative for high-income families. Female students living near the schools go to school on foot.

**Figure 4.6.**

**Modes Used by Female Secondary School Students**



## 4.2 Comparative Analysis of Modes.

For providing a comparative view of the mode used at different educational levels, as shown in Tables 4.1 to 4.4, the following points can be noticed:

- More male students walk to schools than female students.

- The number of students (male or female) who walk to schools decreases with the increase of the level of education.

- In elementary stages, the number of both male and female students transported by private car outnumbers their counterpart in the intermediate stage.

- The number of female students using private cars decreases with upgrading of educational stages. This may be attributed to the proficiency of government school transport.

**Table 4.1**

**Type of drivers transporting students to school.**

| Type of driver | Number | Percentage |
|---|---|---|
| **Family Member** | **861** | **85.8** |
| **Driver** | **143** | **14.2** |

**Table 4.2**

**Distribution of Households by No. of Cars Owned**

| No. of Cars | Frequency | Percentage |
|---|---|---|
| 0 | 93 | 9.3% |
| 1 | 432 | 43.0% |
| 2 | 240 | 24.0% |
| 3 | 152 | 15.1% |
| 4 | 56 | 5.6% |
| 5 | 22 | 2.1% |
| 6 | 3 | 0.3% |
| 7 | 6 | 0.6% |
| Total | 1004 | 100.% |

- Carpool and limousine/taxi modes are used very little by either male or female students. However, the carpool is used more than limousine/taxi.

- Secondary female students use government school buses more that intermediate female students.

- All education levels use the private car. This is due to owning an auto by the families. It is clear from looking at Table 4.2 that 90.7% of

the families have a private car, 47.7% of those families have more than one car.

- Female students use private cars more than government school buses.

- The public transport mode is used by female students more than male students.

**Table 4.3**

**Number of Students Using Each Mode.**

| MODES | ELEMENTARY | | TOTAL | INTERMEDIATE | | TOTAL | SECONDARY | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| | MU | FU | | MU | FU | | MU | FU | |
| WALKING | 69 | 44 | 113 | 61 | 27 | 88 | 21 | 16 | 37 |
| PRIVATE CAR | 106 | 98 | 204 | 76 | 83 | 159 | 94 | 107 | 201 |
| CARPOOL | 7 | 7 | 14 | 4 | 1 | 5 | 6 | 0 | 06 |
| LIMOUSINE / TAXI | 0 | 2 | 02 | 1 | 5 | 6 | 3 | 2 | 05 |
| PUBLIC BUS | 13 | 20 | 33 | 13 | 13 | 29 | 5 | 8 | 13 |
| SCHOOL BUS | 7 | 12 | 19 | 4 | 30 | 34 | 1 | 38 | 39 |
| TOTAL | 202 | 183 | 385 | 159 | 159 | 318 | 130 | 171 | 301 |

## Table 4.4

## Percentage of Students Using Each Mode.

| MODE # | MEL | FEL | MINT | FINT | MSEC | FSEC |
|---|---|---|---|---|---|---|
| WALKING | 34.2 | 24.0 | 38.4 | 17.0 | 16.2 | 9.4 |
| PRIVATE CAR | 52.4 | 53.6 | 47.8 | 52.2 | 72.3 | 62.2 |
| CARPOOL | 3.5 | 3.8 | 2.5 | 0.6 | 4.6 | 0.0 |
| LIMOUSINE /TAXI | 0.0 | 1.1 | 0.6 | 3.1 | 2.3 | 1.3 |
| PUBLIC BUS | 6.4 | 10.9 | 8.2 | 8.2 | 3.8 | 4.7 |
| SCHOOL BUS | 3.5 | 6.6 | 2.5 | 18.9 | 0.8 | 22.2 |
| TOTAL | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

The abbreviations are :

MEL: Male Elementary

FEL: Female Elementary

MINT: Male Intermediate

FINT: Female Intermediate

MSEC: Male Secondary

FSEC: Female Secondary

## 4.3 Problems With The Modes Used

An analysis of the data regarding the school transport modes currently in use shows that only 319 of 1004 families are satisfied with the means they use. These households and students are satisfied because of the closeness of their homes to schools, particularly elementary schools, or they own private cars and they do not have any problems transporting their children to schools, or because they use school buses and they do not have any other choice. The remaining 685 families expressed their dissatisfaction with the modes they use. These are shown in Figure 4.5.

**Table 4.5.**

**Satisfaction with the Modes Used**

| | Frequency | Percent |
|---|---|---|
| **Satisfied** | **319** | **31.8** |
| **Not Satisfied** | **685** | **68.2** |

The reasons for dissatisfaction with some of the modes currently in use can be summarized as follows:

1. High cost
2. Loss of working time when transported by family member
3. Congestion delay
4. Lack of organized school transport
5. Insufficient number of school transport vehicles
6. Crowding of female students inside the school bus.

These were cited as the reasons for dissatisfaction and are presented in the following table.

**Table 4.6**

**Reasons for Dissatisfaction**

| The Mode | The problems * | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| **1. Walk** | 0% | 0% | 0% | 0% | 0% | 0% |
| **2. Private Car** | **20%** | **40%** | **30%** | 0% | 0% | 0% |
| **3. Carpool** | 0% | **20%** | **15%** | 0% | 0% | 0% |
| **4. Limousine/Taxi** | **5%** | 0% | 0% | 0% | 0% | 0% |
| **5. Public Bus** | **45%** | 0% | 0% | 0% | 0% | 0% |
| **6. School Bus** | 0% | 0% | **20%** | **30%** | **15%** | **35%** |

*Percent of Saudi Households dissatisfied with each mode due to each specific problem.

The cost of the mode being used is viewed as a problem for private car, limousine/taxi and public bus. The second problem is the wastage of the employees' time to transport the students by private car and carpool, which leads to loss of financial resources of both the government and private sector due to the loss of productivity, leading to dissatisfaction of employees. In addition, to that, traffic congestion leads to delays and lessening of employees' work hours. Congestion is also problem with the government school buses, even that school buses both causes immediate congestion but also surely alleviate it by taking cars of the road. Delay also another problem with the government school buses, due to using big buses, carrying many students, stopping in many locations to pick up students, causing delays in time for the students themselves, also the congestion problem for private car and carpool.

Organization of bus routes, and bus stop locations are important for the school transport mode. Insufficiency of school vehicles leads to overloading female students, outnumbering the seats available. In this case, many students find themselves compelled to stand inside the bus to and from schools, as no seats are available. This situation pushes the female students to use other means of school transport.

## 4.4 HOUSEHOLDS' MODE EVALUATIONS FOR THE PURPOSE OF SCHOOL TRANSPORT

Perceptions of comfort, convenience, time, safety, and expenses are attitudinal variables used to explain the behaviour of the trip maker in choosing a mode. Those attributes are scaled from 1 to 5 in the questionnaire, where 1 represents a perception of very good, and 5 represents very bad. According to the scale, the lowest total of points is the best, and the highest total is the worst.

### 4.4.1 – *Comfortability*

Comfort is a qualitative and attitudinal variable used to explain the behavior of the tripmaker in choosing a mode. It means:

Protection from weather

Cleanliness of vehicle and station

Fatigue felt when travelling

Control of immediate surroundings

Feeling of personal safety

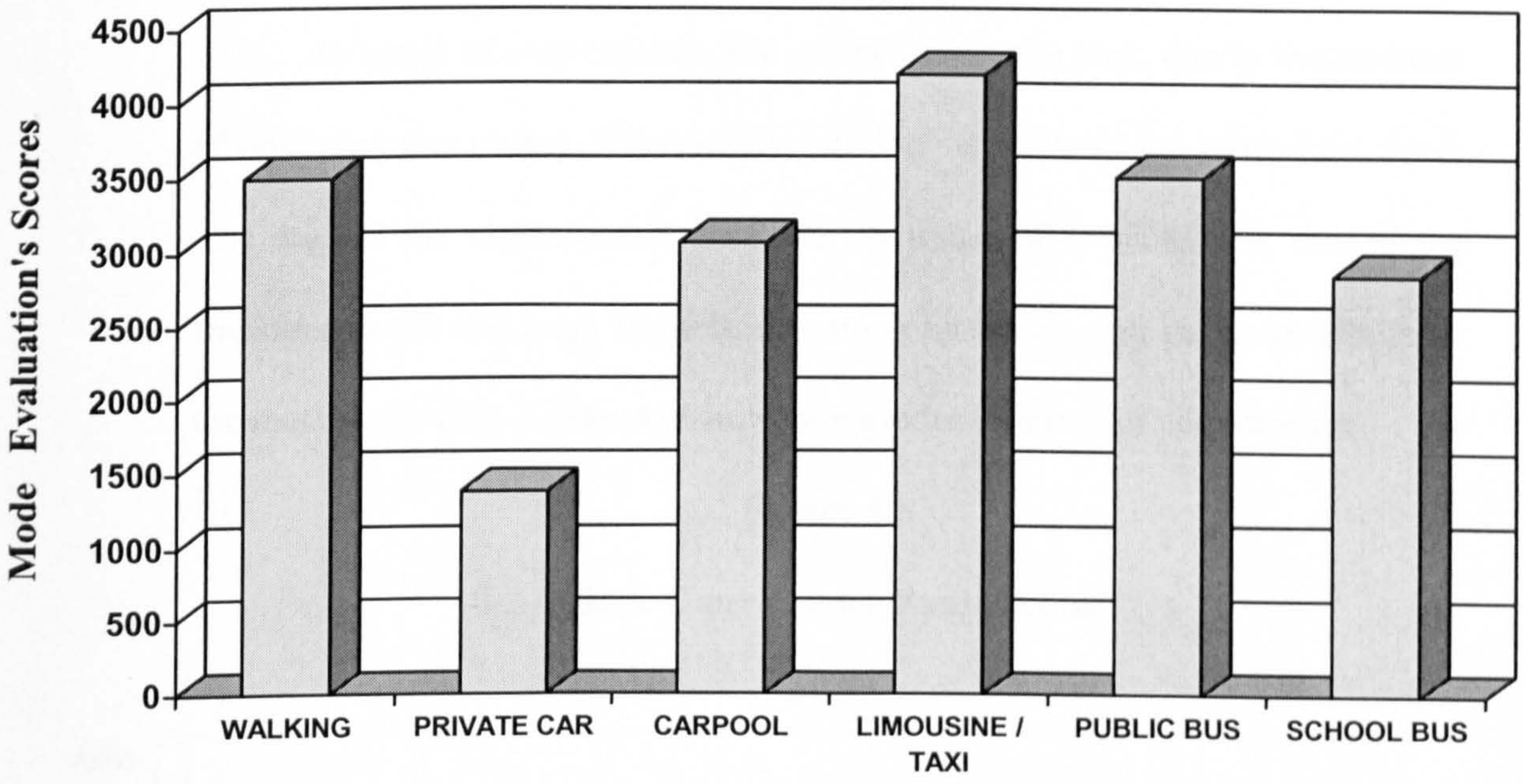
Feeling of privacy

When comparing the various transport modes and evaluating the comfortability factor, it was observed that the private car is the best in terms of comfortability, followed by school bus. The lowest comfortability rating was

for the limousine and taxi mode. Figure 4.7 shows the comfortability for different modes.

**Figure 4.7**

**Mode Comfortability Evaluations**




**School Transportation Modes**

### 4.4.2 – *Convenience*

Convenience is a qualitative and attitudinal variable used to explain the behavior of the tripmaker in choosing a mode. It means:

Ease of use

Reliability

Transfers required

Stops required

Frequency of service

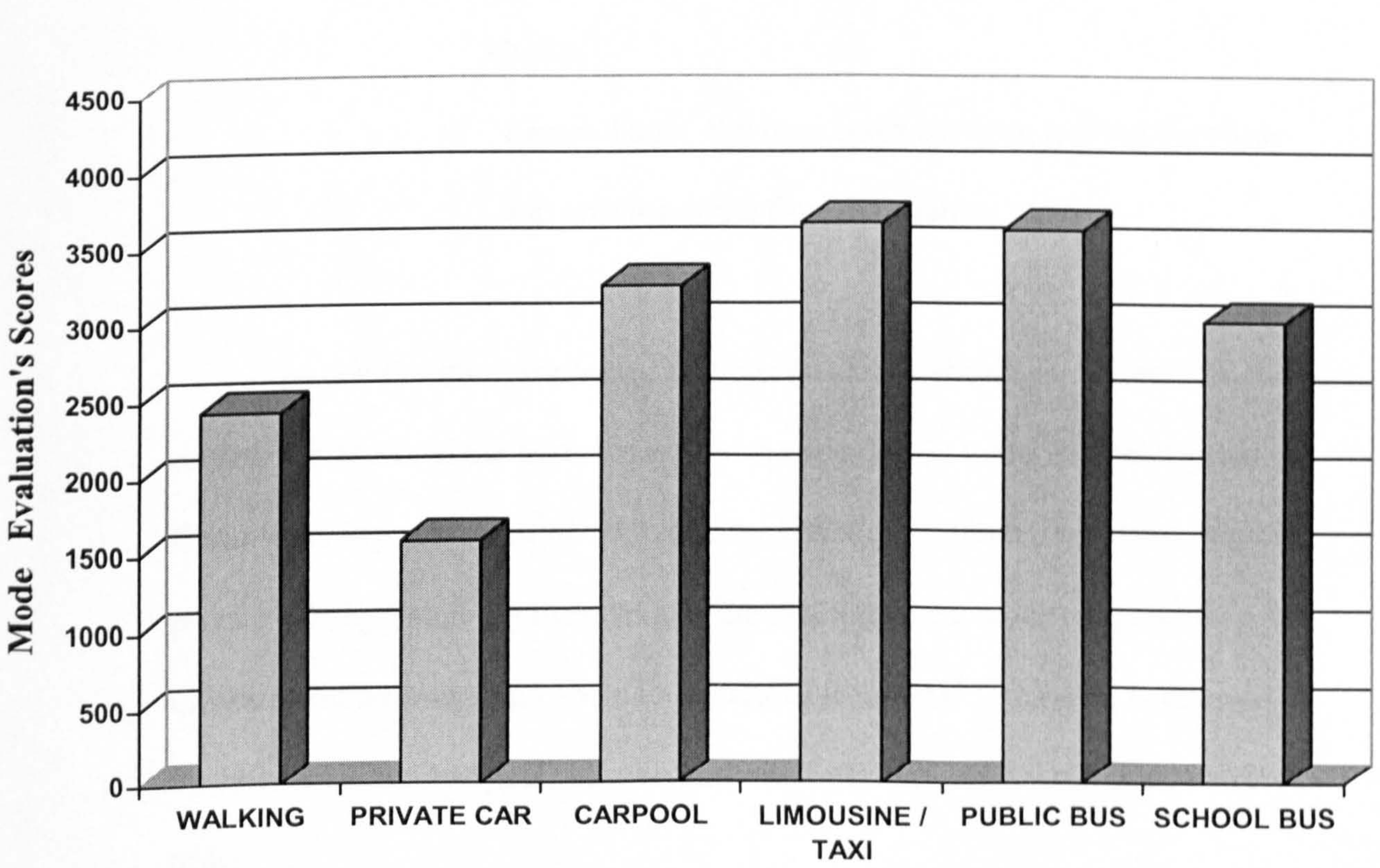
Accessibility to means of travel.

Arrive on time

In terms of convenience, the private car is the best, due to the easiness of obtaining this means, followed by walking. The school bus ranked the third. The rest of the modes rated very low in terms of convenience, due to the transfers to the bus stop, the frequent stops by buses, and the accessibility to the means of travel. Figure 4.8 shows the modes in terms of convenience.

**Figure 4.8**

**Mode Convenience Evaluations**



### 4.4.3 – *Total Trip Time (walking, waiting and travel time)*

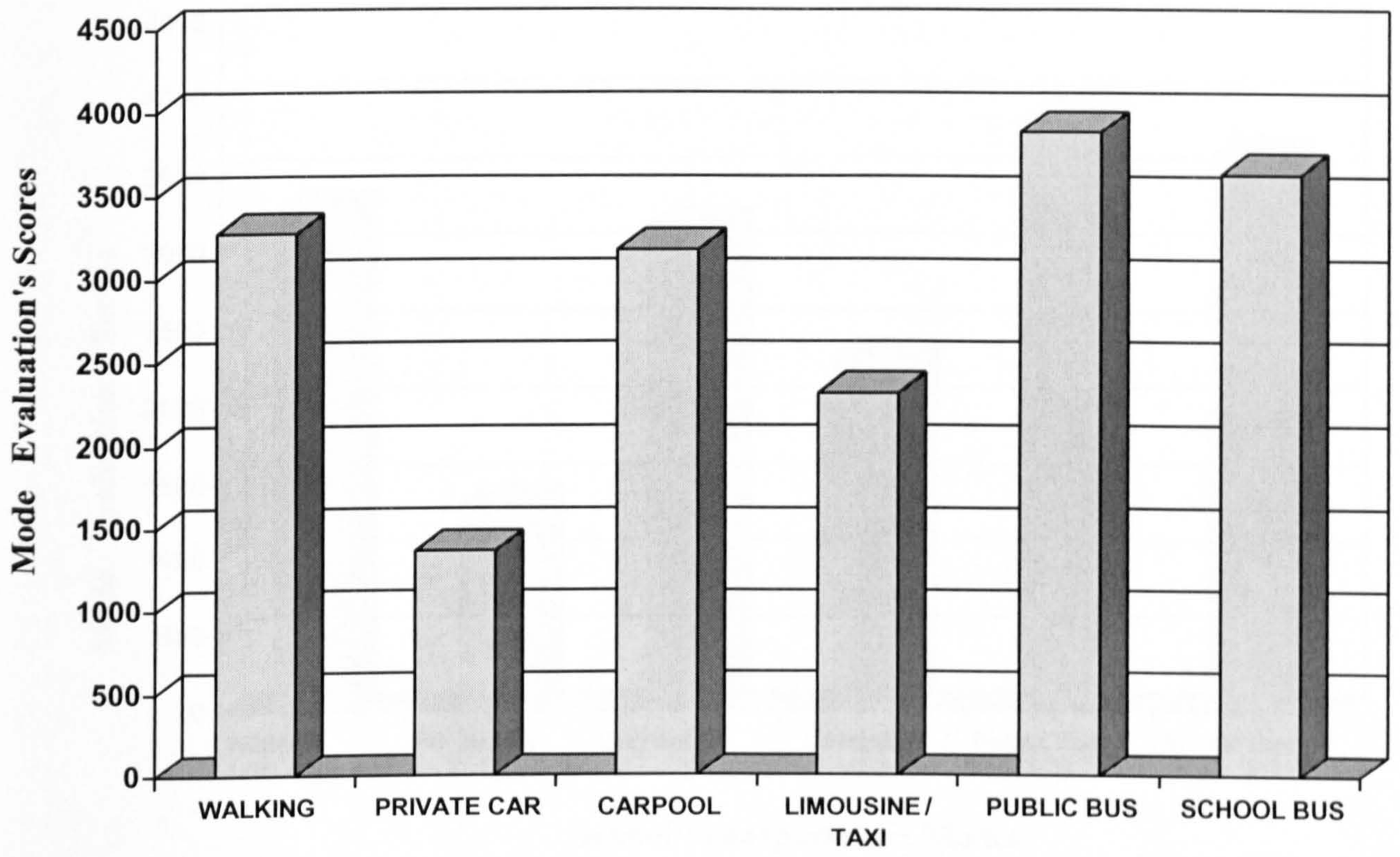
Actual travel time: travel time is one of the traditional variables which is used to build mode choice models. It is the time necessary for an individual to complete his trip starting from his origin and continuing to his final destination. In addition, the total travel time can be broken down into the following components:

- In-Vehicle Travel Time: the time spent in the mode.
- Waiting time: the time spent at the terminal before departure.
- Access Time: the time spent on the way to the mode of choice.
- Egress Time: the time spent between leaving the mode and arriving at the final destination.

As for the third attribute, the time factor, as shown in Figure 4.9, the private car received the best rating from the families in terms of total trip time. Car availability reduces students' walking and waiting time; also ownership of private cars by Saudi families reduces the total trip time, since the private cars, unlike the other means, do not stop at various locations. This mode is followed by limousine/taxi, carpool, school bus, walking and public transport, in that order.

**Figure 4.9**

**Mode Time Evaluations**

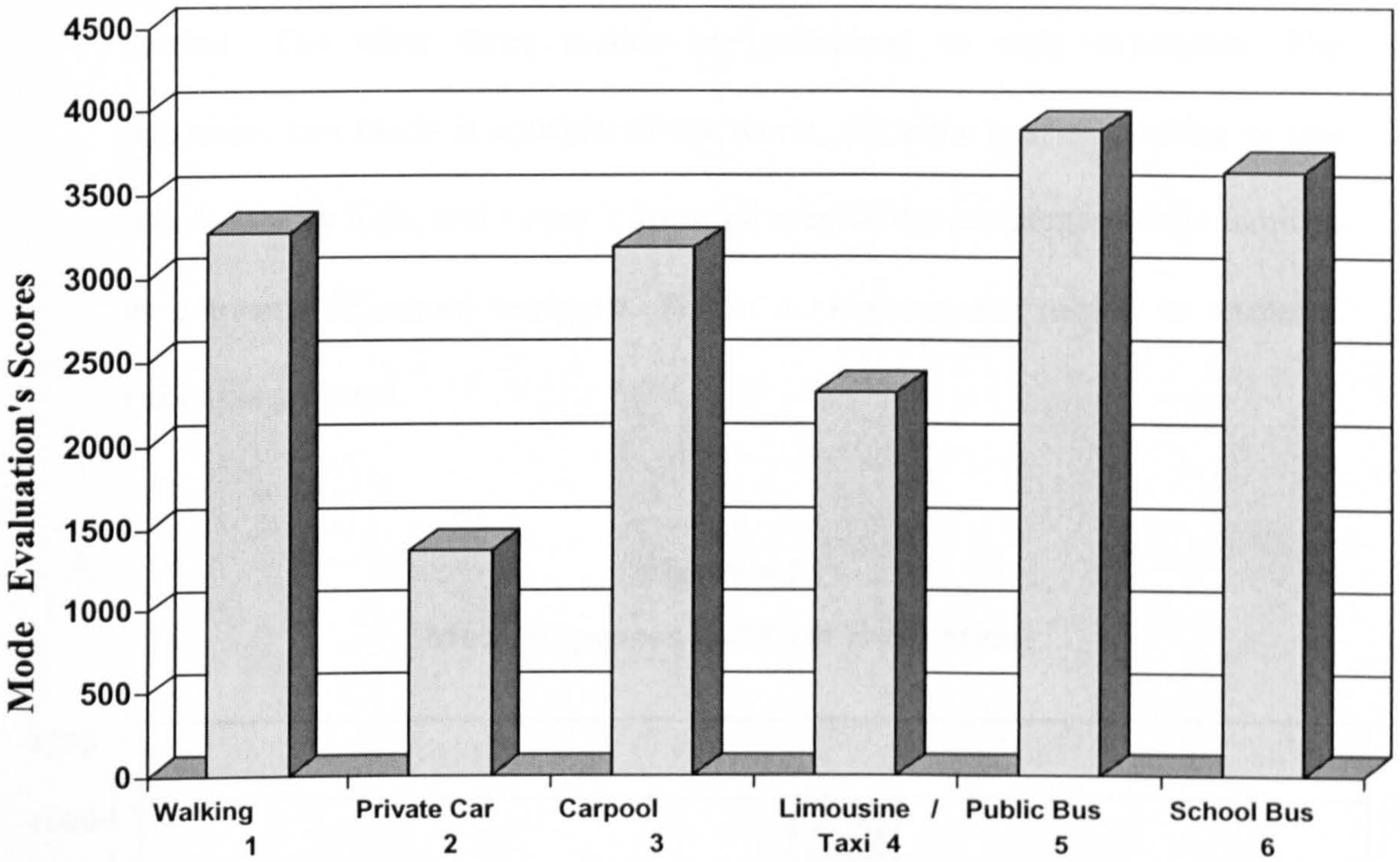



### 4.4.4 – *Security and Safety*

With respect to this factor, and as shown in Figure 4.10, it was found that the private car mode was the best compared with the other means of transport, apparently due to the reason that the private means of transport are owned by the families themselves. Those families who own private cars pay great attention to the security and safety of their children by accompanying them up to the gates of the schools and taking them back to their homes. The limousine/taxi ranked second, then comes carpool followed by walking, school bus and public bus.

**Figure 4.10**

**Mode Security and Safety Evaluations**




**School Transportation Modes**

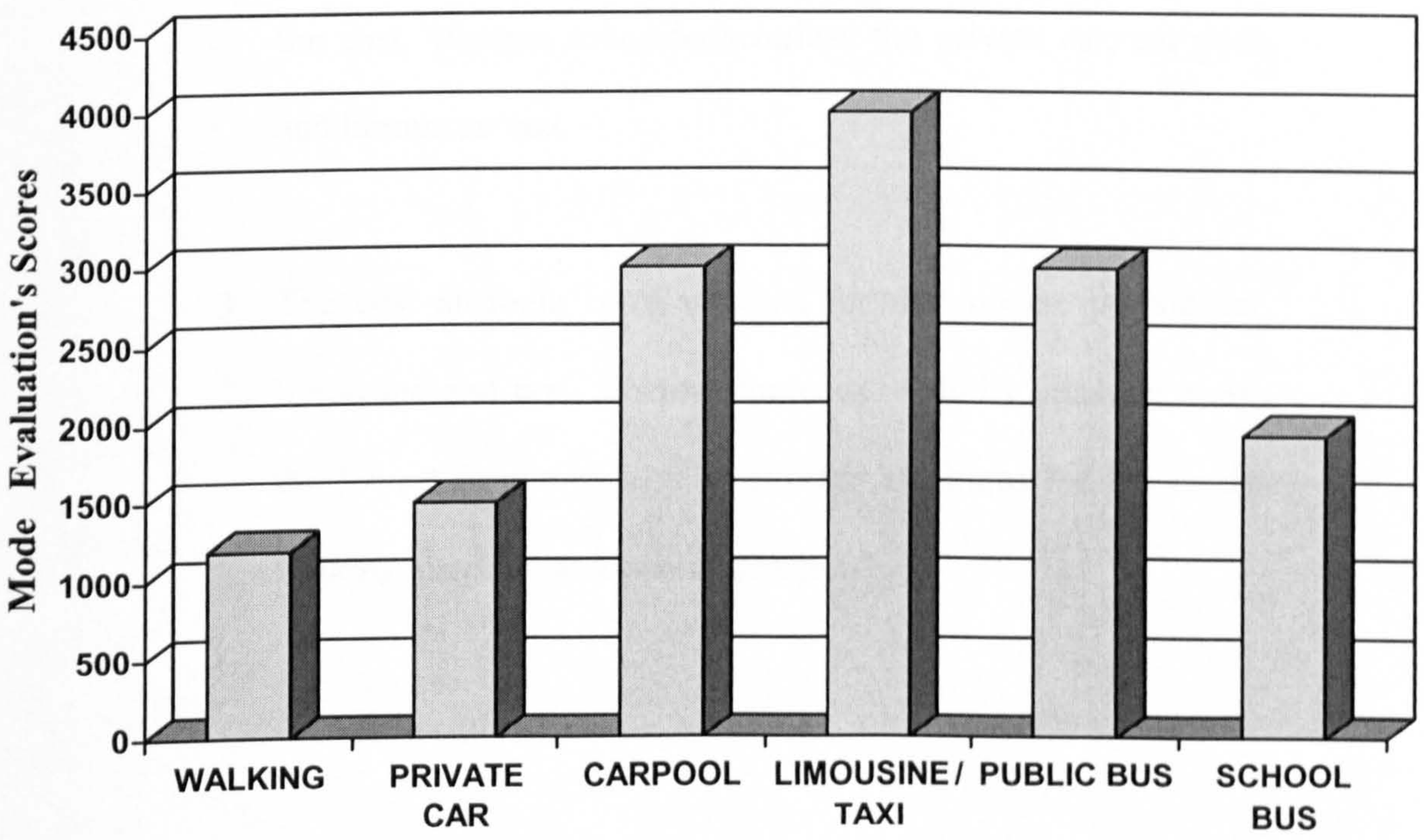
### 4.4.5 – *Expenses and Cost*

It is obvious that no cost is incurred when adopting walking as a means of transport. The private car ranked the second, this maybe as a result of the houshold's income as shown in Table 4.13, that high percentage of population have good income. The school bus received the preference of people because no cost is involved with it, since the education department provides this service, particularly for the female students. These modes received the lowest points, indicating that they are the cheapest means of transport.

The purchasing cost of a car, and in some cases, the driver's regular salary, makes it a real costly means of transport, even though it is ranked the second. The other three modes are perceived as very expensive. The limousine/taxi mode is considered the worst, since the cost of availing of this means is very high, and hence it does not receive the preference of the families as a means of school transport. Figure 4.11 shows the modes in terms of expenses and cost.

**Figure 4.11**

**Mode Expenses and Cost Evaluations**



## 4.5 *Comparative Evaluation of Modes and Attributes*

For comparative evaluation of modes and attributes, Table 4.7 and Figure 4.12 indicate the following:

1. Cost, time, and safety are the attributes characterizing the first preference of Saudi families and their students in choosing a school transport mode.

2. The first attribute characterizing the walking and school bus is the cost, whereas time characterizes the private car, car pool, and limousine/taxi.

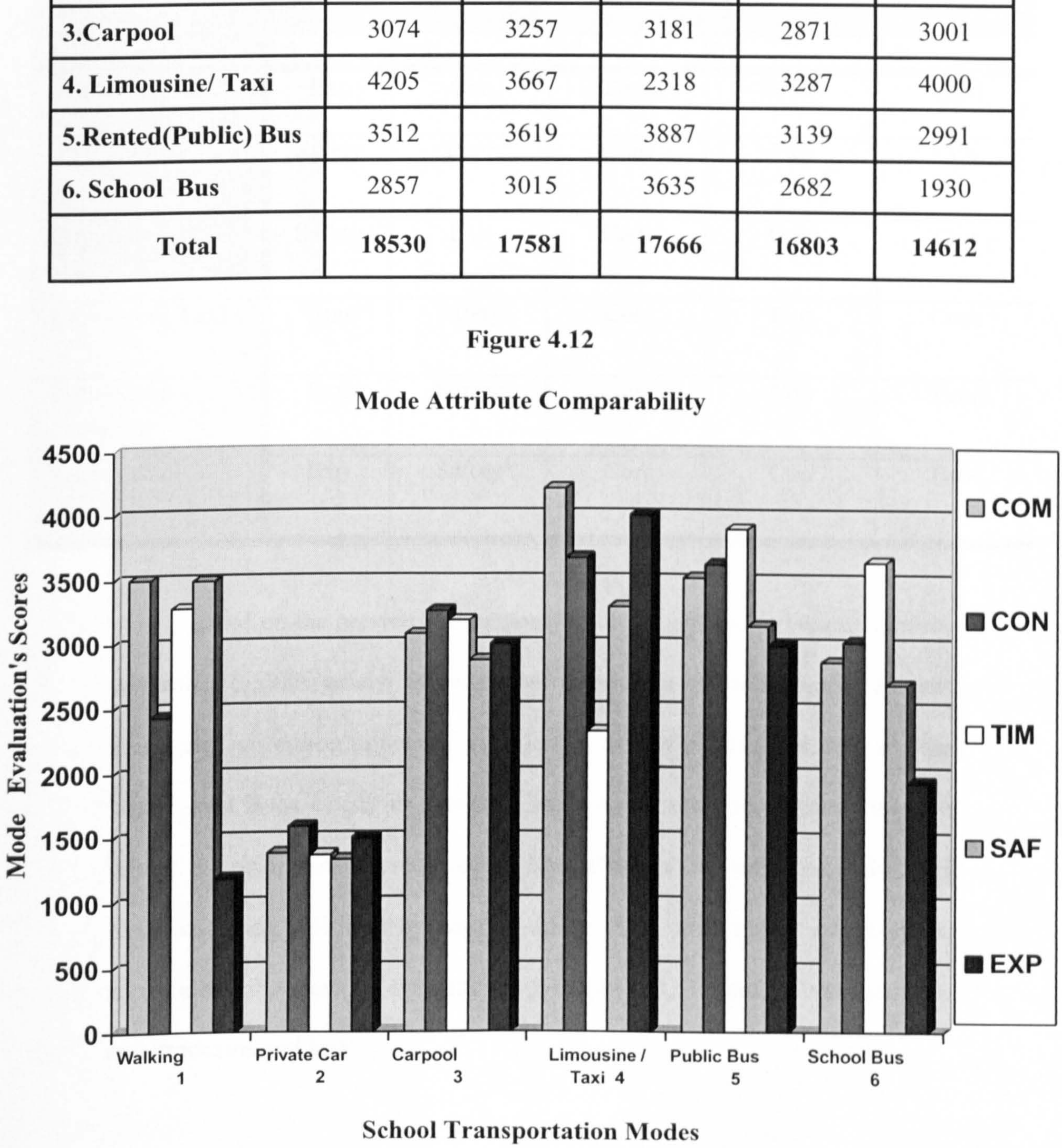
3. The cost attribute is of concern for the modes: private car, limousine and taxi, whereas the comfortability attribute seems the lowest in comparison with other attributes for the modes walking, carpool, and public transport.

**Table 4.7**
**Mode Attribute Comparability**

| Modes | COM | CON | TIM | SAF | EXP |
|---|---|---|---|---|---|
| **1. Walking** | 3502 | 2437 | 3280 | 3493 | 1193 |
| **2. Private Car** | 1380 | 1586 | 1365 | 1331 | 1497 |
| **3.Carpool** | 3074 | 3257 | 3181 | 2871 | 3001 |
| **4. Limousine/ Taxi** | 4205 | 3667 | 2318 | 3287 | 4000 |
| **5.Rented(Public) Bus** | 3512 | 3619 | 3887 | 3139 | 2991 |
| **6. School Bus** | 2857 | 3015 | 3635 | 2682 | 1930 |
| **Total** | **18530** | **17581** | **17666** | **16803** | **14612** |

**Figure 4.12**

**Mode Attribute Comparability**



## Table 4.8

## Attributes Arranged in Sequence According to Importance for Different Modes

| Modes | Attributes | | | | |
|---|---|---|---|---|---|
| | 1st | 2nd | 3rd | 4th | 5th |
| **Walk** | Exp | Con | Time | Safety | Com |
| **Private Car** | Safety | Time | Com | Exp | Con |
| **Carpool** | Safety | Exp | Com | Time | Con |
| **Limousine/Taxi** | Time | Safety | Con | Exp | Com |
| **Public Bus** | Exp | Safety | Con | Con | Time |
| **School Bus** | Exp | Safety | Con | Con | Time |

Based on the previous evaluations of all the generic variables, comfort, convenience, time, safety, and expenses in relation to each school transport mode, and according to the scale, the lowest total of points is the best, and the highest total is the worst, as shown in Table 4.9, it becomes apparent that the private means of transport received the best rating on the evaluation scale of all other attributes, followed by walking mode. The other means of transport, according to the previous evaluation are: school bus, carpool, public transport, and limousine and taxi.

## Table 4.9

## Modes Sequences According To The Household Evaluations

| Mode No. (1) | Mode No. (2) | Mode No. (3) | Mode No. (4) | Mode No. (5) | Mode No. (6) |
|---|---|---|---|---|---|
| Private Car | Walk | School Bus | Carpool | Public Transport | Limousine /Taxi |
| 7159 | 13905 | 14119 | 15384 | 17148 | 17477 |

## 4.6 SCHOOL TRANSPORT MODES PREFERABLE TO THE SAUDI FAMILIES

An individual's choice represents an expression of his preference among the available options at the time and under the conditions in which the choice is made. It is not necessary that the means being used for the school transport be preferred by the male or the female students and the Saudi families. It is possible that some obstacles hinder the selection of the preferred means.

Emphasis has been put here in order to identify preference of the male and female students and their families for the best means, as they perceive, among the various means for school transport. Preference for the means of transport by students and their families at each educational level is analyzed below.

Six means of transport were mentioned in the questionnaire and the respondents were asked to indicate which of the six means they prefer most. These six means, as mentioned before, are

1. Walking
2. Private Car
3. Carpool
4. Limousine / Taxi
5. Public Bus, and
6. School Bus.

An analysis of the data showed that the students of all educational levels, as well as their families, preferred only four out of the six modes.

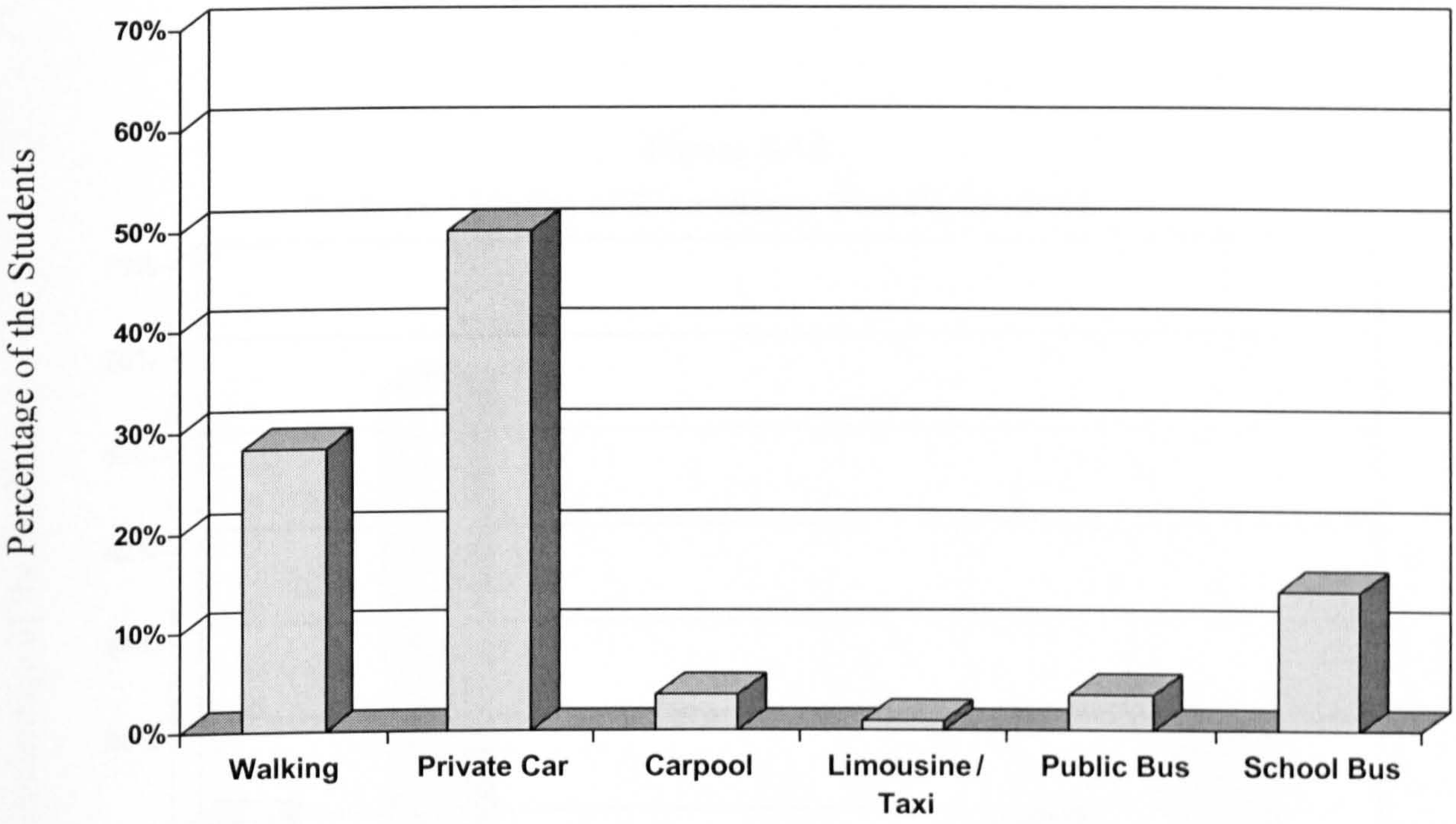
### 4.6.1 *The Preferred Modes of Elementary Male Students*

For elementary male students, as shown in Figure 4.13, it was found that 50% of the students and their families preferred the private car, 13.9% preferred the school bus, and 28.2 % preferred walking. The remaining 8% preferred the other modes (carpool, limousine / taxi, and public transport). This pattern of preference is explained by the perception of many families that private cars are most convenient, secure and reliable. Other families prefer school buses, to avoid wastage of working time in transporting children, and also because school buses are secure and incur no cost. Some families who cannot afford the cost of transport preferred their children to walk to school and most of them choose their residence close to the schools. Those families who can afford to have a car in consideration of its advantages such as time saving, security and safety, convenience and comfortability prefer taking their

children to school by private car. However, there are problems associated with this mode, such as traffic congestion, delays and wastage of employees' time.

**Figure 4.13**

**Preferred Modes of Elementary Male Students**



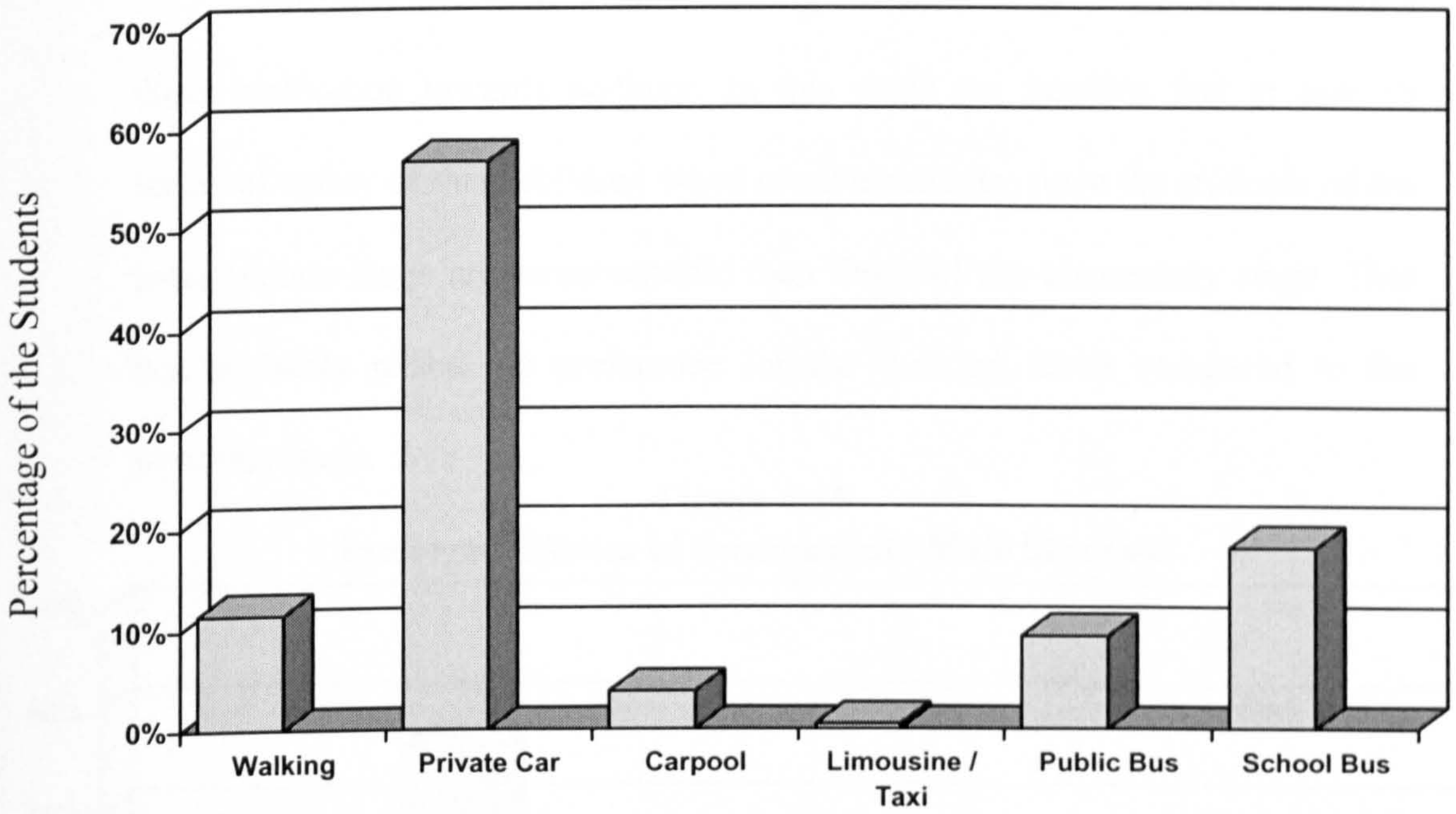

### 4.6.2 *The Preferred Modes of Elementary Female Students*

For elementary Female students, as shown in Figure 4.14, it was found that 56.8 % of the students and their families preferred the private car, 18.0 % preferred the school bus, and 11.5% preferred to walk to schools. The remaining 13.7% of the students preferred other modes (carpool, limousine/taxi, and public transport). This pattern of preference is explained by

the fact that families are concerned to accompany their children to school to ensure security and avoid the risks of the road, particularly for the children who study in first, second, and third classes. Also, there is an obvious desire among the group of Saudi families to use school buses in this stage. However, this mode is not provided for the elementary stage in an organized manner.

**Figure 4.14**

**Preferred Modes of Elementary Female Students**



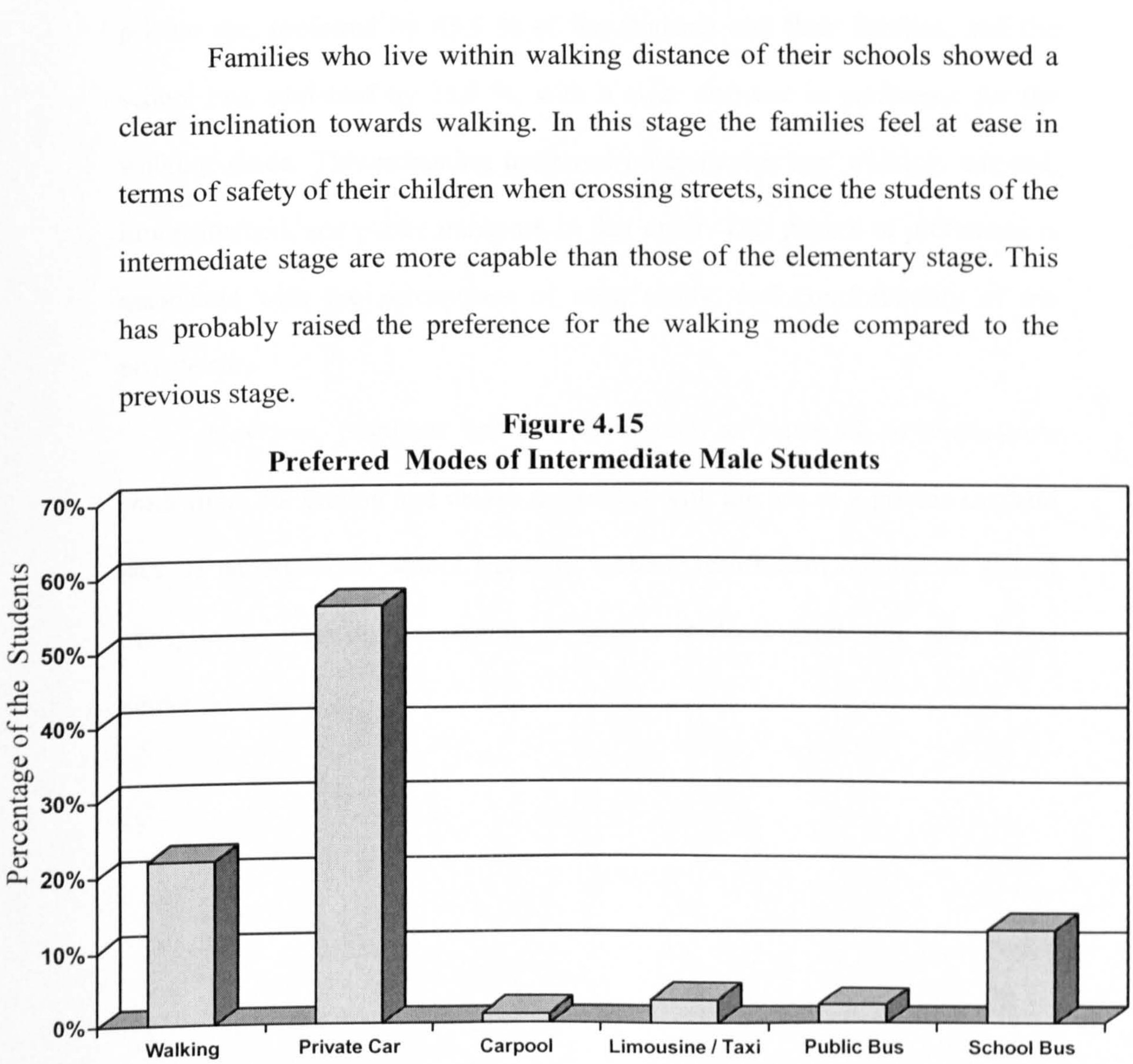

### 4.6.3 *The Preferred Modes of Intermediate Male Students*

For intermediate male students, as shown in Figure 4.15, it was found that 12.6 % of the students and their families preferred the school bus, 56.8 %

preferred the private car, and 22 % preferred walking to school. The remaining 9.6% of the students preferred the other modes (carpool, limousine/taxi, and public transport). This pattern of preference can be explained by the perception of many families that the school bus is secure, safe and not costly. However, this mode is not available for the male students right now.

Families who live within walking distance of their schools showed a clear inclination towards walking. In this stage the families feel at ease in terms of safety of their children when crossing streets, since the students of the intermediate stage are more capable than those of the elementary stage. This has probably raised the preference for the walking mode compared to the previous stage.

**Figure 4.15**
**Preferred Modes of Intermediate Male Students**



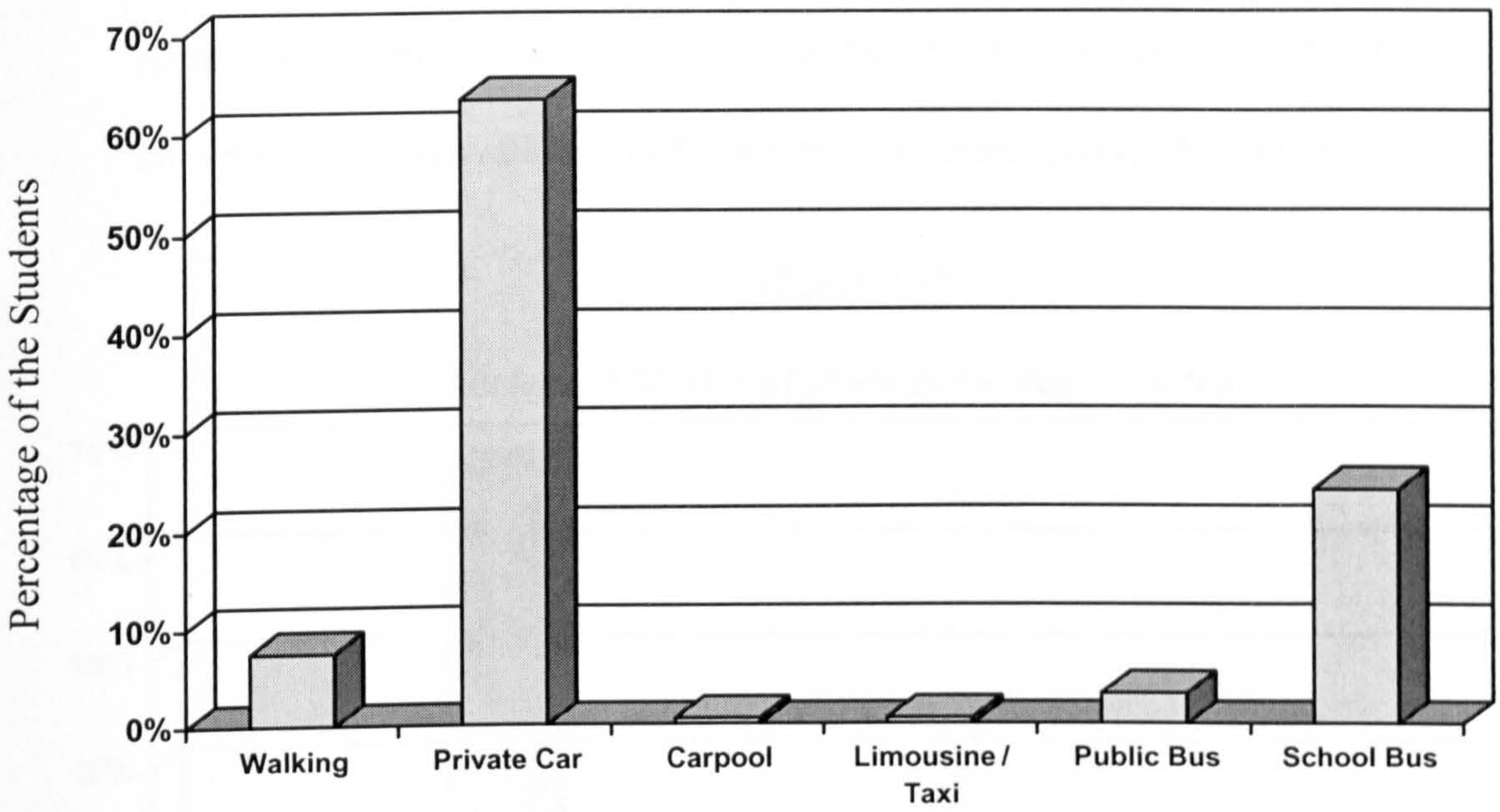
### 4.6.4 *The Preferred Modes of Intermediate Female Students*

The preference of the female students and their families is confined to two means of transport only, unlike the previous stage where three means of transport were preferred. These two modes, as shown in Figure 4.16, are the private car, preferred by 63.5 % of the students and their families, and the school bus, preferred by 23.9 %, with a clear decrease in preference for the walking mode. The remaining preferred other modes are: walking, carpool, limousine/taxi, and public transport, in that order. This pattern of preference is associated with the perceptions of cost, safety, and comfortability of the private car.

However, problems and obstacles, such as waste of an employee's work time, congestion and delays associated with the use of a private car, and lack of an organized school transport system, insufficient number of school transport vehicles, and crowding of female students inside the school bus hinder their uses.

**Figure 4.16**

**Preferred Modes of Intermediate Female Students**



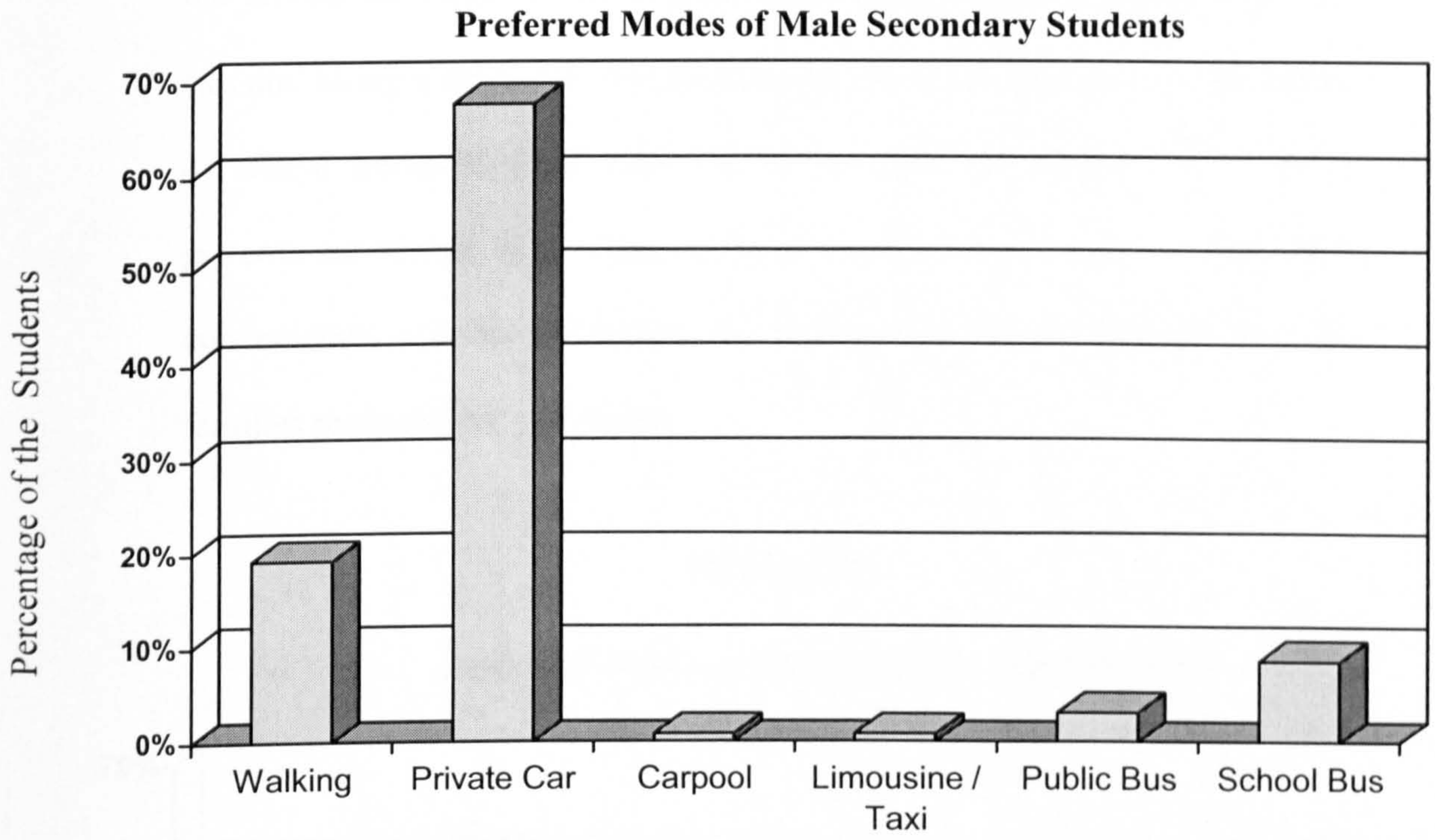

### 4.6.5 *The Preferred Modes of Secondary Male Students*

For secondary male students, as shown in Figure 4.17, it was found that 51% of the students and their families preferred private car and 38% preferred the school bus. The remaining 11% of the students preferred other modes (walking, public bus, carpool, and limousine/taxi).

The most important factor behind the preference for the private car is the ability of the students to drive cars, and the possibility of obtaining driving licences, for those students who are in second and third level, as well the

dependence of some families on their sons to transport the younger children to school. This dependence, ultimately, reduces the burden on the older members of the families. Many families would prefer the school bus. However, the non-availability of it for male students hinders the use of it.

**Figure 4.17**



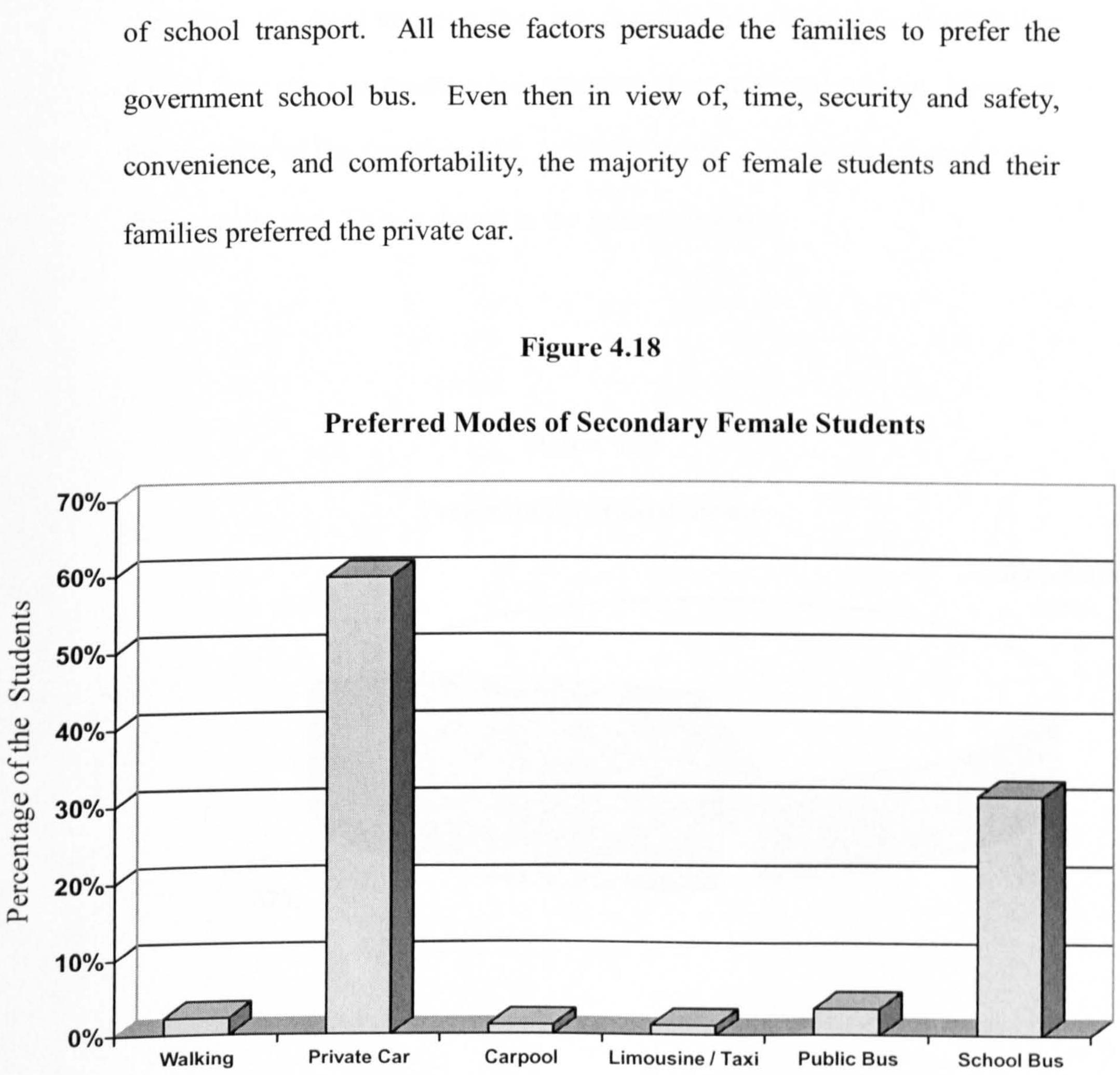

### 4.6.6 *The Preferred Modes of Secondary Female Students*

At this stage, the female students prefer two out of the six modes, as shown in Figure 4.18. It is found that 59.6% of the students and their families preferred the private car, and 31% preferred the school bus. The remaining

students preferred other modes (walking, public transport, carpool and limousine/taxi). This pattern of preference is explained by the perception of the cost, safety, and comfortability of the school bus. Also this trend indicates the success of the government school bus, which carries out the mission of transporting female students. The government school bus is preferred, because the private car increases the burden on the family, such as purchasing a new car, and hiring a driver, or assigning any of the family members to the mission of school transport. All these factors persuade the families to prefer the government school bus. Even then in view of, time, security and safety, convenience, and comfortability, the majority of female students and their families preferred the private car.

**Figure 4.18**

**Preferred Modes of Secondary Female Students**

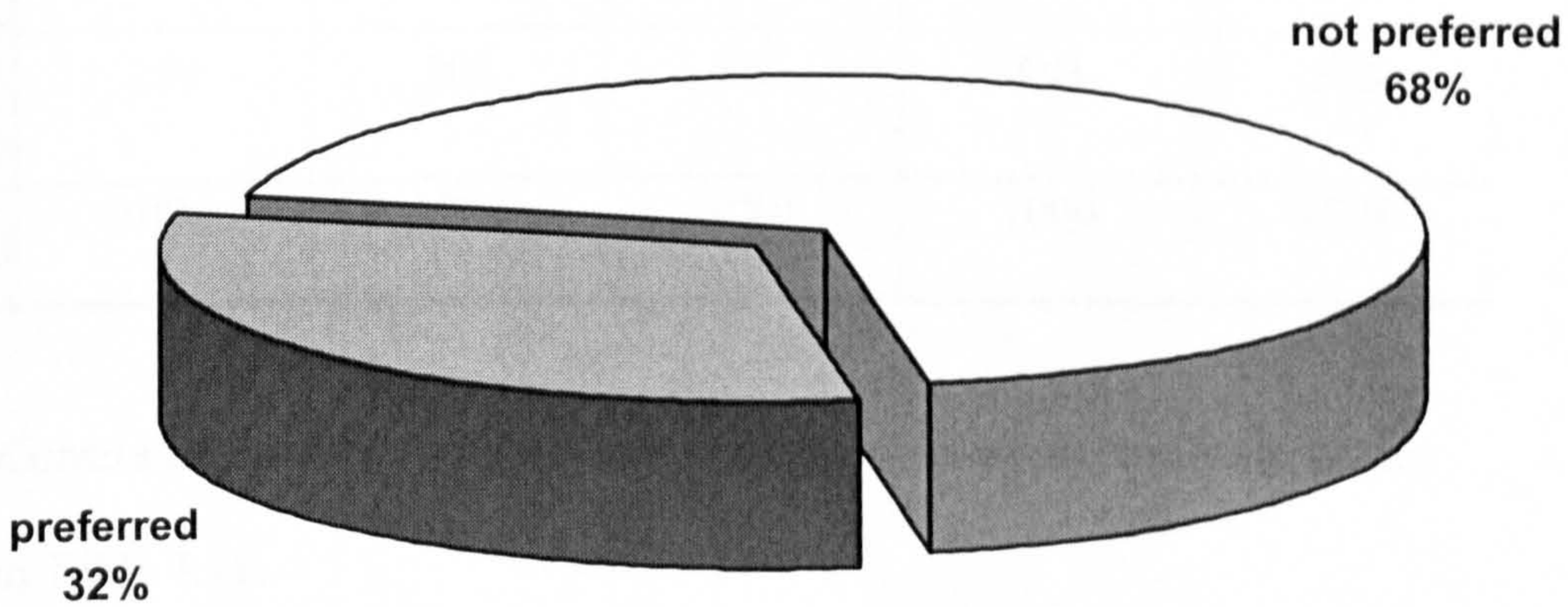


## 4.7 CONSTRAINTS PREVENTING THE USE OF PREFERRED MODES

When studying the preferred means of school transport, and the ones already in use, it was found that 319, which are 31.8% of the families, prefer the means of school transport they are already using. This indicates that they do not face any constraints when selecting their preferred means. However, the majority of the families: 685, or 68.2% prefer other modes than the ones they actually use. This is shown in the following figure.

**Figure 4.19**

**Preferability of used modes**



The constraints are the following:

1 – High transport time.

2 – Non-availability of preferred mode.

3 – The high expense of the preferred modes.

4 – Non availability of safety procedures.

5- Congestion in the bus.

**Table 4.10**

**Constraints of not using preferred modes.**

| | | PR1 | PR2 | PR3 | PR4 | PR5 |
|---|---|---|---|---|---|---|
| | | **Frequency** | **Frequency** | **Frequency** | **Frequency** | **Frequency** |
| VALID | 0 | 745 | 698 | 743 | 441 | 751 |
| | 1 | 259 | 306 | 261 | 563 | 253 |
| TOTAL | | 1004 | 1004 | 1004 | 1004 | 1004 |

Constraints hindering the students from using their preferred modes are shown in Table 4.11.

**Table 4.11**

**Constraints hindering the use of preferred modes**

| The Modes | Obstacles* | | | | |
|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** |
| Walk | **60%** | 0% | 0% | **15%** | 0% |
| Private Car | 0% | **28%** | **52%** | 0% | 0% |
| Rented Bus | **14%** | **72%** | **48%** | **27%** | 0% |
| School Bus | **26%** | 0% | 0% | **48%** | **100%** |

- Percent of Saudi Households having constraints hindering the use of preferred school transportation modes.

The first constraint mentioned above is the biggest stumbling block to the selection of the preferred means. The preferred means, as mentioned earlier, are the government school bus and private car, rented bus and walking. The nonavailability of the government school bus for male students is viewed as an obstacle by almost 69.5% of the students; also the government school transport does not cover all the female students.

The constraint which prevents many families from using the government school transport is the congestion inside the bus. This congestion of the female students compels their families to use alternative means that

guarantee convenience for their daughters. The congestion inside the bus implies that the number of female students exceeds the number of seats available.

Another constraint, No. (2), is the fact that the preferred means of transport cannot reach the houses of the students. This is because the government school transport follows one route; those whose houses are not located near the bus route find themselves compelled to use another mode to reach that route. This situation embarrasses the families, as well as the female students, due to the time wasted to reach the bus stop, and the wasted time spent waiting for the bus's arrival. Consequently, the families are compelled to select an alternative means. It is worth mentioning that those who have private means of transport do not confront such problems.

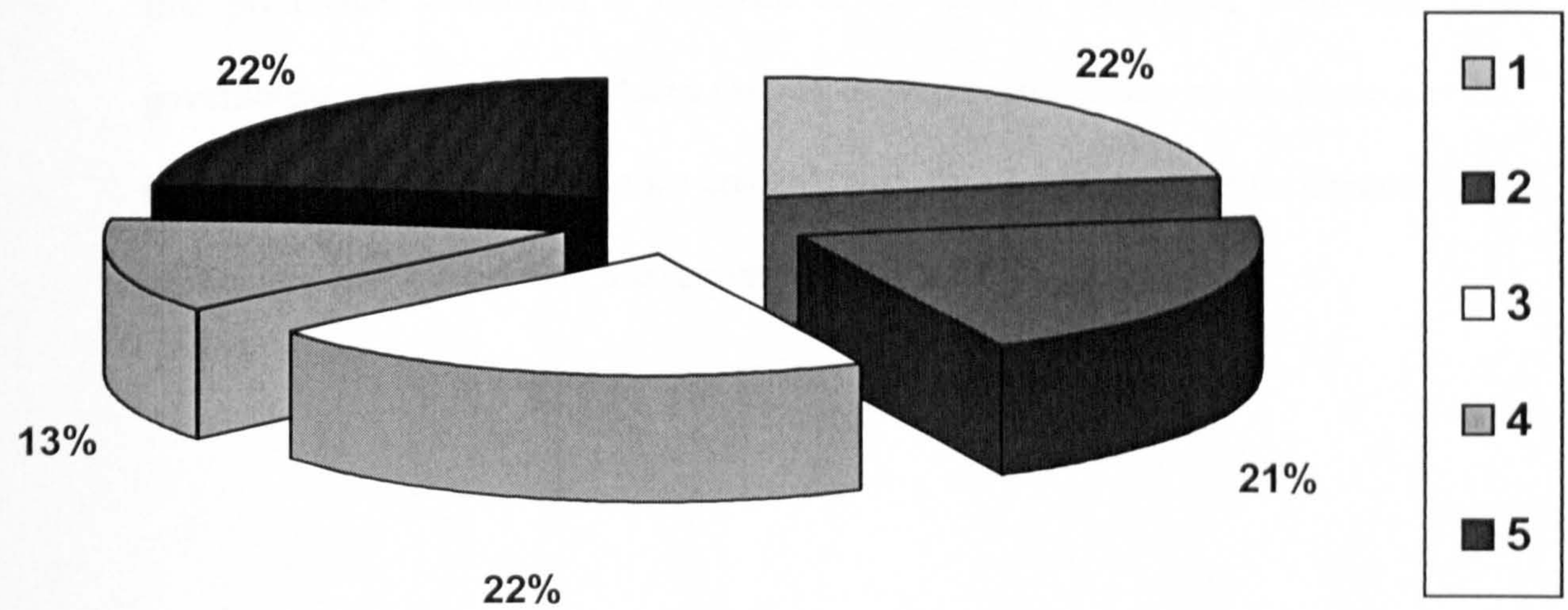
The constraint No. (3): the high cost of the preferred means accounts for 22% of the total number of the obstacles mentioned earlier. This is due to the high cost of some means, such as limousine/taxi, and private cars. The distribution of constraints is shown in Table 4.12 and Figure 4.20.

## Table 4.12

## Constraints Preventing the Use of Preferred Modes

| PROB.No. | TOTAL | PERCENTAGE |
|---|---|---|
| 1 | 745 | 22% |
| 2 | 698 | 21% |
| 3 | 743 | 22% |
| 4 | 441 | 13% |
| 5 | 751 | 22% |

**Figure 4.20**
**Percentage of the Constraints**
**Preventing the Use of Preferred Modes.**



## 4.8 SUMMARY

When reviewing the preferred means in all the educational stages, it is observed that the male students concentrate on three out of six means, while the female students concentrate on four out of the six means. The preferred Modes are as follows:

Mode No. (1): Walking

Mode No. (2): Private Car

Mode No. (6): Government School Bus

Mode No. (5): Public Bus.

The range of preference and choice of the male and female students varies from one stage to another and between male and female students. The first preference sometimes is confined to the private car mode, while the government school transport takes priority at some other times, as we observe in the intermediate stage for male students and the secondary stage for female students. These preferences are shown in Table 4.13.

**Table 4.13**

**Preferred Modes For School Transportation**

| Educational level | Male | | | | Female | | | |
|---|---|---|---|---|---|---|---|---|
| | First Mode | Second Mode | Third Mode | Fourth Mode | First Mode | Second Mode | Third Mode | Fourth Mode |
| **Elementary** | Private Car | Walk | School Bus | Public bus | Private Car | School Bus | Walk | Public bus |
| **Intermediate** | School Bus | Walk | Private Car | Car Pool | Private Car | School Bus | Walk | Public bus |
| **Secondary** | Private Car | Walk | School Bus | Public bus | School Bus | Private Car | Walk | Public bus |

For a comparative view of the preferred modes, Tables 4.14 and 4.15 indicate the following:

Preference for walking decreases as level of education increases for both male and female students.

Intermediate male and female students prefer school buses more than those studying in any other stages.

Intermediate male and secondary female students prefer private cars more than school buses. This preference due to that high percentage of households have high income, as shown in Table 4.16.

## Table 4.14

## Preferred (P) Modes for Male(M) and Female(F).

| MODES | ELEMENTARY | | TOTAL | INTERMEDIATE | | TOTAL | SECONDARY | | TOTAL | ALL | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M.P. | F.P | | M.P. | F.P. | | M.P. | F.P. | | M.P. | F.P. | |
| **1. Walk** | 57 | 21 | 78 | 35 | 12 | 47 | 25 | 4 | 29 | 117 | 35 | 152 |
| **2. Private Car** | 101 | 104 | 205 | 89 | 101 | 190 | 88 | 102 | 190 | 278 | 266 | 544 |
| **3. Carpool** | 7 | 7 | 14 | 6 | 2 | 08 | 1 | 4 | 05 | 14 | 11 | 25 |
| **4. Limousine/Taxi** | 2 | 1 | 03 | 5 | 1 | 06 | 1 | 2 | 03 | 8 | 3 | 11 |
| **5. Public Bus** | 7 | 17 | 24 | 4 | 5 | 09 | 4 | 6 | 10 | 15 | 25 | 40 |
| **6. School Bus** | 28 | 33 | 61 | 20 | 38 | 58 | 11 | 53 | 64 | 59 | 82 | 141 |
| | | | | | | | | | | | | |
| **TOTAL** | **202** | **183** | **385** | **159** | **159** | **318** | **130** | **171** | **301** | **491** | **422** | **913** |

**Table 4.15**

**Percentage of Preferred Modes for Male and Female.**

| Mode | MEL | FEL | MINT | FINT | MSEC | FSEC |
|---|---|---|---|---|---|---|
| **Walk** | 28.2 | 11.5 | 22.0 | 7.5 | 19.2 | 2.3 |
| **Private Car** | 50.0 | 56.8 | 56.0 | 63.5 | 67.7 | 59.6 |
| **Carpool** | 3.5 | 3.8 | 1.3 | 0.6 | 0.8 | 1.3 |
| **Limousine/Taxi** | 1.0 | 0.5 | 3.1 | 0.6 | 0.8 | 1.3 |
| **Public Bus** | 3.5 | 9.3 | 2.5 | 3.1 | 3.1 | 3.5 |
| **School Bus** | 13.9 | 18.0 | 12.6 | 23.9 | 8.5 | 31.0 |
| **TOTAL** | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

The abbreviations are:

MEL: Male Elementary

FEL: Female Elementary

MINT: Male Intermediate

FINT: Female Intermediate

MSEC: Male Secondary

FSEC: Female Secondary

**Table 4.16**

**Frequency percent distribution of respondents by income**

| Income level | Frequency | Percent |
|---|---|---|
| 1 (>2000SR) | 201 | 20.0 |
| 2 (2001-4000SR) | 128 | 12.7 |
| 3 (4001-6000SR) | 177 | 17.6 |
| 4 (6000-8000SR) | 113 | 11.3 |
| 5 (8001-10000SR) | 92 | 9.2 |
| 6 (10001-12000SR) | 105 | 10.5 |
| 7 (12001-14000SR) | 54 | 5.4 |
| 8 (<14000SR) | 134 | 13.3 |

# 5 THE CALIBRATION OF THE SCHOOL TRIPS MODE CHOICE MODELS


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# 5. THE CALIBRATION OF THE SCHOOL TRIPS MODE CHOICE MODELS

The mode choice models generated for the various educational levels by the BLOGIT computerized statistical estimation package under the study are presented here.

The Theoretical Model

The school trips mode choice model has the following form:

$$P^i_k = EXP(V_{ki}) / \sum_j EXP(V_{ji})$$

Where

$P^i_k$ = probability of a tripmaker i choosing mode k out of j alternatives.

$V_{ki}$ = the systematic component of utility function of alternative k to tripmaker i.

The utility function $V_{ki}$ is function of socio economic charecterstics of i and charecterstics of mode k.

The probability of a tripmaker choosing a particular mode alternative is a function of the characteristics of the tripmaker, such as income,

age, and sex, and of the characteristics of that mode relative to alternative modes. If a variable appears only in the utility function of mode K, then it is a mode-specific variable which assumes a value of zero in all j # k model utilities. If a variable appears in the utility function of all modes, it is considered a generic variable, which takes on different values across the utilities for different modes.

## 5.1 Model Specification

Different specifications for the models have been evaluated, to determine which specification best replicates the data for each educational level. These specifications include the variables that have been found in the literature review to influence the student choice, such as:

Total travel time (TTIME) (Access time, Waiting time and In-vehicle time)

Comfort (COM)

Convenience (CON)

Security and Safety (SAFE)

Expenses and Cost (EXPENSES)

Student (STUDENT) (Number of students in the household)

Household's Income (INCOME)

Number of family cars (CARS), and

Distance (DISTANCE).

Different model specifications were tested, as can be seen in Appendix C. Many alternatives developed through the use of data of the used and preferred modes for each level of education were considered as the first step. Next, a number of combinations of the alternatives were considered. The purpose of developing all these models was to investigate choice at different levels of education and between male and female at different levels; and between actual mode choice and preferred mode choice. The alternatives that emerged finally are:

A. 1. Elementary male student used modes (MEU),

2. Elementary male student preferred modes (MEP),

3. Elementary female student used modes (FEU),

4. Elementary female student preferred modes (FEP),

5. Intermediate male student used modes (MIU),

6. Intermediate male student preferred modes (MIP),

7. Intermediate female student used modes (FIU),

8. Intermediate female student preferred modes(FIP),

9. Secondary male student used modes (MSU),

10. Secondary male student preferred modes (MSP),

11. Secondary female student used modes (FSU),

12. Secondary female student preferred modes (FSP),

13. Male, Elementary, Intermediate, Secondary Used Modes (MEISU),

14. Male, Elementary, Intermediate, Secondary preferred Modes (MEISP),

15. Male Intermediate, Secondary Used Modes (MISU),

16. Male Intermediate, Secondary preferred Modes (MISP),

17. Female, Elementary, Intermediate, Secondary Used Modes (FEISU),

18. Female, Elementary, Intermediate, Secondary preferred Modes (FEISP),

19. Female Intermediate, Secondary Used Modes (FISU),

20. Female Intermediate, Secondary preferred Modes (FISP),

21. Male and Female Used Modes ( MFU),

22. Male and Female preferred Modes (MFP).

Each model estimate is based on a different modal utility function. Of all the model specifications tested, the most satisfactory eleven models (based on rho-squared $\rho^2$) for the school trips (male and female) are given in Tables 5.1 to 5.12. These ten models are the following:

B. 1. MEU. Male Elementary Used Modes.

2. MIP. Male Intermediate Preferred Modes.

3. MISU. Male Intermediate, Secondary Used Modes.

4. MEISU. Male Elementary, Intermediate, Secondary Used Modes.

5. FEU. Female Elementary Used Modes.

6. FIU. Female Intermediate Used Modes.

7. FSP. Female Secondary Preferred Modes.

8. FEIU. Female Elementary and Intermediate Used Modes.

9. FEIP. Female Elementary and Intermediate Preferred Modes.

10. FEISU. Female, Elementary, Intermediate, Secondary Used Modes.

11. MFU. Male and Female Used Modes.

Four modes are prefered by the students for school trips. These modes are used for choice models:

1. Walking
2. Private Cars
3. Government School Buses, and
4. Rented Buses.

## 5.2 Mode Choice Models

The following are Model specification which is determined to be the best in explaining the choice of an alternative for the school trips. The best mode choice model is the one with the following rules:

1- High utility (goodness of fit),

2- High t-statistics for all of the generic and specific variables, and

3- Expected sign for all independent variables.

Several specifications for male and female used and preferred models were tested to reach to the best model replicates the pupils choices. A model can be rejected, even it has high goodness of fit ,if some of the independent variables have un expected sign/ or low t-statistics. The model which have the three rules mentioned above is the best model.

## 5.2.1 Male Students' Mode Choice Models

### *5.2.1.1 Male Elementary Stages (MEU)*

Several specifications for male elementary used models were tested, as can be seen in Appendix C, Table 1. From these, the best model was chosen, as in Table 5.1, which consists of 12 attributes: two of these 12 are generic variables and the others are specific to used modes. This model was tested six times to overcome the problems of low t-statistics and unexpected signs. Model number 2 shows a high goodness of fit (rho-squared 0.790). However, it was rejected for two reasons: the expenses variables had very low t-statistics (0.380), and the expenses had an unexpected plus sign. This means that as expenses increase, the probability of choosing the mode by the elementary male students increases, which is not logical.

At the second trial, model number 6 showed a high goodness of fit (rho-squared 0.769) but the number of students specific to car had a low t-statistic, and hence the model was rejected.

The third trial, number 4, shows a good explanation for the behaviour, (rho-squared 0.743) even though it was rejected due to the same problems as in the first trial: that expenses have very low t-statistics.

In the fourth trial model, number 5, all of the independent variables have good t-statistics and expected signs, and a high goodness of fit (rho-squared 0.736), indicating that, e.g., if the time decreases, the probability of choosing that mode increases, and if comfortability increases, the probability of choosing this mode by students increases. The utility function for each mode is given below:

For rented bus mode(RB)

$$U_{RB} = -0.175\ \text{Time} + 0.110\ \text{Com}$$

For school bus mode(SB)

$$U_{SB} = -0.651 - 0.175\ \text{Time} + 0.110\ \text{Com} + 0.339\ \text{BBoGl}$$

For private car mode(C)

$$Uc = +0.790 - 0.175\ Time + 0.110\ Com + 0.594\ CBoy + 1.878\ CDist - 0.131 CCost + 0.143 CInc.$$

For walk mode(W)

$$U_w = +3.155 - 0.175\ Time + 0.110\ Com - 0.750\ WDist - 0.411\ WInc$$

# TABLE 5.1

## MODEL RESULTS FOR MODE CHOICE MODELS FOR MALES ELEMENTARY USED (ESTIMATED VARIABLE COEFFICIENTS T – STATISTICS)

| IND. VARIABLE | | MODEL 1 | MODEL 2 | MODEL 3 | MODEL 4 | MODEL 5 | MODEL 6 |
|---|---|---|---|---|---|---|---|
| ASC –WALK | (0) | 3.570(3.763) | 3.887(2.793) | 4.173(6.028) | 4.376(3.087) | 3.155(2.890) | 4.425(5.150) |
| ASC – CAR | (0) | 2.291(1.051) | -4.475(-0.809) | 0.807(1.066) | 2.726(1.140) | 0.790(0.388) | -0.944(-0.381) |
| ASC – BUS | (0) | 0.908(1.316) | -0.195(-0.137) | -0.247(-0.263) | 0.615(0.455) | -0.651(-0.598) | -0.744(-0.620) |
| WDIST | (4) | -0.910(-3.100) | -0.242(-0.730) | -0.911(-3.263) | -0.858(-2.786) | -0.750(-2.532) | 0.522(0.779) |
| WCAR | (35) | | -0.375(-0.755) | | | | |
| WINC | (36) | | | | -0.312(-1.226) | -0.411(-1.993) | |
| WBOY | (37) | | | | | | |
| WGIRL | (38) | | | | | | |
| WBE | (39) | | | | | | |
| WBI | (40) | | | | | | |
| WTIME | (45) | | | | | | -0.213(-2.502) |
| CATIME | (46) | | 1.705(1.530) | | | | 1.331(2.052) |
| BTIME | (47) | | 0.176(2.611) | | | | |
| RTIME | (48) | | 0.177(3.088) | 0.039(1.478) | | | |
| CCOST | (49) | -0.098(-3.417) | -0.100(-2.046) | | -0.090(-2.956) | -0.131(-3.765) | -0.092(-2.661) |
| RCOST | (50) | | | | | | |
| CINC | (51) | 0.108(3.749) | 0.097(2.154) | 0.025(6.132) | 0.100(3.413) | 0.143(3.922) | 0.096(2.757) |
| CTIMEU | (52) | | | | | | |
| CDIST | (53) | 2.100(1.593) | 1.357(1.094) | -0.022(-0.213) | 2.399(1.771) | 1.878(1.590) | |
| CCAR | (54) | | | 0.110(0.403) | 0.005(0.006) | | |
| CCOSTU | (55) | -0.312(-0.818) | | | -0.592(-0.990) | | |
| CBOY | (56) | | | | | 0.594(1.250) | |
| CGIRL | (57) | | | | | | |
| CBI | (59) | | | | | | |
| BTIMEU | (65) | -0.067(-0.740) | | | | | |
| BDIST | (66) | -0.067(-0.741) | | | -0.134(-1.294) | | |
| BCAR | (67) | | -1.014(-1.488) | 0.341(2.159) | -0.713(-1.413) | | -0.627(-1.160) |
| BING | (68) | | 0.680(2.499) | | 0.339(1.134) | | 0.463(1.960) |
| BBOY | (69) | | | | | | |
| WBOGL | (77) | 0.048(0.493) | 0.182(1.371) | | 0.088(0.752) | | |
| CBOGL | (78) | 0.147(0.053) | 0.496(0.978) | | 0.162(0.556) | | |
| BBOGL | (79) | | | -0.046(-0.399) | | 0.339(1.506) | 0.020(0.164) |
| COM | (82) | 0.069(0.378) | | -0.024(-0.203) | 0.078(0.411) | 0.110(0.579) | |
| CON | (83) | -0.149(-0.890) | | | | | |
| TIM | (84) | | -0.133(-0.811) | | | -0.175(-1.001) | -0.065(-0.431) |
| SAF | (85) | | | | | | |
| EXP | (86) | | 0.086(0.380) | | -0.008(-0.037) | | -0.090(-0.408) |
| RHO SQUARED | | 0.722 | 0.790 | 0.542 | 0.743 | 0.736 | 0.769 |

### *5.2.1.2 Male Intermediate Stages (MIP)*

Several specifications for Male Intermediate Preferred mode were tested, as can be seen in Appendix C, Table 4. From these, the best model was chosen, as in Table 5.2, that consists of sixteen (16) attributes; five of these are generic variables and the others are specific to the preferred modes. This model was tested many times to overcome the problems of unexpected signs and low t-statistics. Model number 5 shows a high goodness of fit (rho-squared 0.817) but it was rejected for three reasons: if the expenses increase the probability of choosing a mode by the intermediate male student increase, which is not logical; second, the convenience variable has very low t-statistics (0.107); and third, the variable students (MF) specific to walk mode has very low t-statistics (0.076).

In the second trial, all the independent variables show better t-statistics than the first trial, and have expected signs. Model number 3 shows a good fit (rho-squared 0.714), indicating that, e.g., if time decreases, the probability of choosing the mode increases, and if safety increases, the probability of choosing this mode by the student increases, as shown on the following utility function for each mode:

For rented bus mode(RB)

$$U_{RB} = -0.037 \text{ Time} + 0.192 \text{ Safety}$$

For school bus mode(SB)

$$U_{SB} = -4.848 - 0.037 \text{ Time} + 0.192 \text{ Safety} + 0.078 \text{BBOGL}$$

For private car mode(C)

$$U_C = +3.443 - 0.037 \text{ Time} + 0.192 \text{ Safety} + 7.243$$

$$\text{CDist} - 0.044 \text{ CCost} + 0.049 \text{Cinc}$$

For walk mode(W)

$$U_W = +3.386 - 0.037 \text{ Time} + 0.192 \text{ Safety} + 0.024$$

$$\text{WBoy} - 0.087 \text{ WInc}$$

# TABLE 5.2

## MODEL RESULTS FOR MODE CHOICE MODELS FOR MALE INTERMEDIATE PREFFERED (ESTIMATED VARIABLE COEFFICIENTS T- STATISTICS)

| IND. VARIABLE | | MODEL 1 | MODEL 2 | MODEL 3 | MODEL 4 | MODEL 5 |
|---|---|---|---|---|---|---|
| ASC –WALK | (0) | 2.227(2.256) | 1.084(1.500) | 3.386(2.996) | 1.069(1.487) | 3.434(1.848) |
| ASC – CAR | (0) | -2.171(-1.787) | -1.772(-1.323) | 3.443(3.215) | -2.461(-2.568) | -0.302(-0.133) |
| ASC – BUS | (0) | -4.445(-2.005) | -0.163(-0.158) | -4.848(-0.978) | -2.501(-2.162) | -1.200(-0.288) |
| WDIST | (4) | -0.096(-0.656) | -0.086(-0.789) | | -0.076(-0.700) | 5.202(2.819) |
| WCAR | (35) | 0.263(0.695) | 0.353(1.070) | | 0.631(1.572) | 0.123(0.247) |
| WINC | (36) | -0.138(-0.751) | | -0.087(-0.609) | -0.119(-0.804) | |
| WBOY | (37) | | -0.235(-1.476) | 0.024(0.143) | -0.209(-1.451) | |
| WGIRL | (38) | | | | | |
| WBE | (39) | | | | | |
| WBI | (40) | -0.181(-0.334) | | | | |
| WTIME | (45) | -0.106(-2.556) | | | | |
| CATIME | (46) | 0.995(3.694) | 1.059(4.291) | | | 0.941(3.028) |
| BTIME | (47) | 0.863(1.638) | | | | 2.336(2.954) |
| RTIME | (48) | | | | | 2.027(2.961) |
| CCOST | (49) | -0.024(-4.451) | -0.024(-4.769) | -0.044(-2.890) | -0.024(-4.664) | -0.027(-3.235) |
| RCOST | (50) | | | | | |
| CINC | (51) | 0.015(4.138) | 0.016(4.418) | 0.049(3.336) | 0.016(4.388) | 0.022(2.914) |
| CTIMEU | (52) | | | | | |
| CDIST | (53) | 0.185(0.696) | | 7.243(4.425) | 0.410(0.889) | 5.669(2.874) |
| CCAR | (54) | | | | | |
| CCOSTU | (55) | 0.147(0.654) | | | | |
| CBOY | (56) | | | | | |
| CGIRL | (57) | | | | | |
| CBI | (59) | -0.731(-0.958) | | | | |
| BDIST | (66) | -1.937(-1.413) | | | | |
| BCAR | (67) | | | | | -3.829(-1.424) |
| BING | (68) | 0.096(0.206) | | | 0.197(0.811) | 0.682(0.871) |
| BBOY | (69) | | | | | |
| WBOGL | (77) | | | | | -0.018(-0.076) |
| CBOGL | (78) | | -0.017(-0.117) | | | 0.173(0.643) |
| BBOGL | (79) | | -0.281(-1.632) | 0.078(0.184) | | |
| COM | (82) | | -0.308(-1.741) | | -0.222(-1.560) | |
| CON | (83) | | 0.086(0.610) | | 0.060(0.440) | |
| TIM | (84) | -0.162(-1.222) | -0.055(-0.410) | -0.037(-0.227) | | -0.021(-0.107) |
| SAF | (85) | | 0.160(1.119) | 0.192(1.003) | | |
| EXP | (86) | -0.087(-0.532) | -0.069(-0.463) | | | 0.207(0.849) |
| RHO SQUARED | | 0.639 | 0.538 | 0.714 | 0.531 | 0.817 |

### *5.2.1.3 Male Intermediate and Secondary Stages (MISU)*

For the Intermediate and Secondary Used Modes model, several specifications were tested, as can be seen in Appendix C. From these, the best twelve models were chosen, as in Tables 5.3a and 5.3b in accordance with their goodness of fit. Some were rejected due to unexpected signs of some generic variables, and/or due to low t-statistics.

Model number 4 was the best of all. The model consists of 13 attributes: two of these are generic and the others are specific to the used modes. This model has the highest goodness of fit (rho-squared 0.832) of all the models. It also shows good t-statistics and expected signs. The following is the Male Intermediate & Secondary utility function for each used mode:

For rented bus mode(RB)

$$U_{RB} = -0.106\text{Tim} - 0.143\ \text{Exp}$$

For school bus mode(SB)

$$U_{SB} = +6.566 - 0.106\,Tim - 0.143\,Exp - 0.235\,BDist$$

For private car mode(C)

$$U_c = -14.233 - 0.106\,Tim - 0.143\,Exp - 0.235\,CBI + 1.906\,CCar - 0.061\,CCost - 0.110\,CInc$$

For walk mode(W)

$$U_w = +1.703 - 0.106\,Time - 0.143\,Exp + 0.361\,WBI - 0.165\,WInc + 0.081\,WCar - 1.685\,WDist$$

**TABLE 5.3a**

**MODEL RESULTS FOR MODE CHOICE MODELS FOR INTERMEDIATE AND SECONDARY BOYS USED (ESTIMATED VARIABLE COEFFICIENTS T-STATISTICS)**

| INDIVIDUAL VARIABLE | | MODEL 1 | MODEL 2 | MODEL 3 | MODEL 4 | MODEL 5 | MODEL 6 | MODEL 7 | MODEL 8 |
|---|---|---|---|---|---|---|---|---|---|
| ASC – WALK | (0) | 5.518(4.580) | 5.260(4.488) | 4.737(3.821) | 6.566(4.781) | 6.222(4.562) | 4.156(4.757) | 6.473(5.397) | 4.101(3.734) |
| ASC – CAR | (0) | -1.689(-0.721) | -0.878(-0.682) | -0.824(-0.608) | -14.233(-1.102) | -8.494(-0.968) | -7.479(-1.304) | 0.188(0.132) | -8.045(-1.167) |
| ASC – BUS | (0) | 1.415(1.325) | 1.192(1.128) | 1.015(0.989) | 1.703(2.349) | 0.679(0.715) | 1.184(2.309) | 2.288(2.132) | 0.843(0.869) |
| WDIST | (4) | -1.451(-3.429) | -1.639(-3.700) | -1.685(-3.707) | -0.540(-0.907) | | -1.533(-3.485) | -1.765(-4.071) | -1.445(-3.324) |
| WCAR | (35) | | | 0.081(0.185) | | | | | 0.174(0.474) |
| WINC | (36) | -0.094(-0.613) | | -0.165(-0.782) | -0.156(-0.866) | -0.303(-1.726) | | 0.037(0.227) | -0.218(-1.198) |
| WBOY | (37) | 0.140(0.623) | | | | 0.327(1.277) | | | |
| WGIRL | (38) | | 0.061(0.252) | | | | | | |
| WBI | (40) | | | | 0.361(0.653) | | | | |
| WTIME | (45) | | | | | -0.266(-4.026) | | | |
| CATIME | (46) | | | | | | | | |
| BTIME | (47) | 0.004(0.258) | | | | | | | |
| RTIME | (48) | 0.018(0.820) | | | | | | 0.015(0.507) | |
| CCOST | (49) | -0.015(-1.403) | | | | -0.039(-1.363) | -0.032(-1.650) | | -0.031(-1.575) |
| CINC | (51) | 0.060(4.239) | 0.074(5.156) | 0.073(5.179) | 0.110(1.596) | 0.088(1.761) | 0.077(2.913) | 0.067(5.393) | 0.081(2.459) |
| CDIST | (53) | 1.315(1.544) | -0.57(-0.726) | -0.041(-0.543) | | -0.131(-0.151) | 3.111(1.497) | -0.068(-0.813) | 2.985(1.526) |
| CCAR | (54) | | | -0.127(-0.192) | | -2.342(-1.107) | -1.806(-1.668) | | |
| CCOSTU | (55) | | | | 1.906(1.319) | | 0.761(1.255) | | |
| CBOY | (56) | | | | | | | | 1.196(1.341) |
| CGIRL | (57) | | -0.241(-0.773) | | | | | | |
| CBI | (59) | | | | -4.453(-0.877) | | | | |
| BTIMEU | (65) | | | | | | | | |
| BDIST | (66) | | | | -0.235(-1.713) | | | -0.046(-0.612) | |
| BCAR | (67) | | 0.099(0.254) | | | | | | |
| BINC | (68) | | 0.148(0.706) | | | | | | |
| BBOY | (69) | | -0.189(-0.812) | | | | | | -0.140(-0.406) |
| BGIRL | (70) | | 0.033(0.128) | | | | | | |
| WBOGL | (77) | | | 0.130(0.759) | | | 0.057(0.685) | | 0.131(0.858) |
| CBOGL | (78) | | | -0.114(-0.460) | | 0.917(1.044) | 0.538(1.357) | -0.108(-0.676) | |
| BBOGL | (79) | 0.037(0.310) | | 0.046(0.303) | | 0.081(0.595) | | -0.015(-0.173) | 0.131(0.620) |
| COM | (82) | | 0.593(2.468) | 0.584(2.411) | | | -.193(1.014) | 0.388(2.024) | 0.188(1.045) |
| CON | (83) | | -0.399(-2.225) | -0.423(-2.192) | | | -0.397(-2.261) | | -0.417(-2.341) |
| TIM | (84) | 0.033(0.210) | | 0.039(0.197) | -0.106(-0.658) | | | | |
| SAF | (85) | -0.414(-2.418) | -0.728(-3.105) | -0.637(-2.929) | | | | -0.678(-3.080) | |
| EXP | (86 | | | -0.280(-1.659) | -0.143(-0.765) | -0.225(-1.278) | | | |
| RHO SQUARED | | 0.801 | 0.797 | 0.802 | 0.832 | 0.818 | 0.801 | 0.786 | 0.801 |

## TABLE 5.3b

### MODEL RESULTS FOR MODE CHOICE FOR BOYS INTERMEDIATE AND SECONDARY USED (ESTIMATED VARIABLE COEFFICIENTS T – STATISTICS)

| IND. VARIABLE | | MODEL 1 | MODEL 2 | MODEL 3 | MODEL 4 | MODEL 5 |
|---|---|---|---|---|---|---|
| ASC –WALK | (0) | 5.711(5.567) | 5.817(3.632) | 5.774(3.645) | 6.442(4.574) | |
| ASC – CAR | (0) | -3.042(-1.262) | -2.713(-1.118) | -2.737(-1.128) | -2.464(-1.012) | |
| ASC – BUS | (0) | 0.674(0.778) | 0.572(0.438) | 0.517(0.403) | 1.261(1.475) | |
| WDIST | (4) | -0.433(-0.777) | | | | |
| WCAR | (35) | | | | | |
| WINC | (36) | | -0.091(-0.315) | -0.085(-0.295) | -0.197(-1.179) | |
| WBOY | (37) | | | | | |
| WGIRL | (38) | | | | | |
| WBE | (39) | | | | | |
| WBI | (40) | | | | | |
| WTIME | (45) | -0.203(-2.597) | -0.213(-3.111) | -0.211(-3.131) | -0.215(-3.134) | |
| CATIME | (46) | 0.782(1.375) | 1.191(1.261) | 1.209(1.266) | 1.128(1.223) | |
| BTIME | (47) | | 0.102(1.683) | 0.103(1.685) | 0.107(1.803) | |
| RTIME | (48) | | -0.041(-0.973) | -0.042(-0.992) | -0.040(-0.957) | |
| CCOST | (49) | 0.018(-1.461) | -0.022(-1.422) | -0.023(-1.431) | -0.022(-1.451) | |
| RCOST | (50) | | | | | |
| CINC | ( 51) | 0.060(3.637) | 0.057(3.362) | 0.057(3.365) | 0.055(3.342) | |
| CTIMEU | (52) | | | | | |
| CDIST | (53) | | -0.597(-0.832) | -0.606(-0.835) | -0.519(-0.717) | |
| CCAR | (54) | | | | | |
| CCOSTU | (55) | | | | | |
| CBOY | (56) | | | | | |
| CGIRL | (57) | | | | | |
| CBI | (59) | | | | | |
| BTIMEU | (65) | | | | | |
| BDIST | (66) | | -0.400(-1.954) | -0.401(-1.952) | -0.404(-2.027) | |
| BCAR | (67) | -0.070(-0.229) | | | | |
| BING | (68) | 0.205(1.078) | 0.162(0.547) | 0.169(0.571) | | |
| BBOY | (69) | | | | | |
| WBOGL | (77) | | | | | |
| CBOGL | (78) | | | | | |
| BBOGL | (79) | -0.032(-0.318) | | | | |
| COM | (82) | | 0.038(0.217) | | 0.057(0.323) | |
| CON | (83) | | | | | |
| TIM | (84) | -0.127(-0.875) | -0.155(-0.862) | -0.135(-0.880) | -0.140(-0.785) | |
| SAF | (85) | | | | | |
| EXP | (86) | -0.240(-1.3720 | -0.159(-0.898) | -0.161(-0.906) | | |
| RHO SQUARED | | 0.811 | 0.825 | 0.825 | 0.822 | |

### *5.2.1.4 All Male Used (MU)*

The best model, as shown in Table 5.4, is model number 7, with (rho-squared 0.793) goodness of fit and good t-statistics, but it was rejected due to unexpected negative signs of the Car variable specific to Car mode, which means that if one percent increased in number of cars the probability of choosing car mode will be decreased by 0.670, which is not logical.

The second and third models in relation to the goodness of fit (rho-squared 0.785, 0.779) were rejected due to unexpected signs of two of the generic variables, Time and Convenience, and Safety and Convenience, respectively.

The fourth model shows goodness of fit (rho-squared 0.778) and expected signs, also good t-statistics. The following is the utility function for each mode:

For rented bus mode(RB)

$$U_{RB} = -0.077\ \text{Time} - 0.154\ \text{Exp}$$

For school bus mode(SB)

$$U_{SB} = 0.150 - 0.077\ \text{Time} - 0.154\ \text{Exp} - 0.216\ \text{BCar} - 0.285\ \text{BInc} - 0.024\ \text{BBoGl}$$

For private car mode(C)

$$U_{C} = -0.089 - 0.077\ \text{Time} - 0.154\ \text{Exp} + 0.068\ \text{CInc} - 0.059\ \text{CCost}$$

For walk mode(W)

$$U_{W} = 4.835 - 0.077\ \text{Time} - 0.154\ \text{Exp} - 0.079\ \text{WDist}$$

# TABLE 5.4

## MODEL RESULTS FOR MODE CHOICE MODELS FOR BOYS USED (ESTIMATED VARIABLE COEFFICIENTS T- STATISTICS)

| IND. VARIABLE | | MODEL 1 | MODEL 2 | MODEL 3 | MODEL 4 | MODEL 5 | MODEL 6 | MODEL 7 |
|---|---|---|---|---|---|---|---|---|
| ASC-WALK | (0) | 3.814(4.157) | 4.835(7.716) | 4.116(5.136) | 4.626(7.407) | 4.075(5.183) | 3.281(4.391) | 5.402(5.767) |
| ASC – CAR | (0) | 0.744(0.479) | -0.089(-0.065) | -2.147(-0.910) | -0.177(-0.128) | 0.861(0.586) | 4.168(4.344) | 0.194(0.138) |
| ASC – BUS | (0) | -0.021(-0.022) | 0.150(0.220) | 0.786(0.984) | -0.107(-0.156) | 0.603(0.792) | 1.014(1.284) | 0.311(0.373) |
| WDIST | (4) | -1.066(-4.163) | -0.079(0.215) | -0.931(-3.701) | 0.221(0.598) | -0.958(-3.524) | | |
| WCAR | (35) | | | -0.214(-0.749) | | | -0.290(-1.173) | |
| WINC | (36) | -0.072(-0.353) | | | | -0.133(-0.953) | -0.107(-0.763) | -0.111(-0.703) |
| WBOY | (37) | | | | | 0.238(1.891) | | |
| WGIRL | (38) | | | | | | | |
| WTIME | (45) | | | | -0.210(-3.999) | | | -0.171(-4.297) |
| CATIME | (46) | | | 1.322(2.884) | 1.014(2.800) | | | 1.049(2.871) |
| BTIME | (47) | 0.115(3.184) | | 0.017(1.030) | | 0.016(0.863) | | 0.099(2.532) |
| RTIME | (48) | | | 0.047(2.323) | | 0.036(1.892) | 0.071(4.518) | -0.017(-0.665) |
| CCOST | (49) | -0.076(-3.615) | -0.059(-2.687) | -0.064(-2.858) | -0.059(-2.660) | -0.082(-3.859) | -0.106(-5.277) | -0.060(-2.594) |
| CINC | ( 51) | 0.089(4.351) | 0.068(3.203) | 0.069(3.254) | 0.067(3.136) | 0.094(4.510) | 0.134(6.550) | 0.068(3.079) |
| CDIST | (53) | 1.539(2.241) | | | | 1.796(2.514) | | -0.240(-0.670) |
| CCAR | (54) | | | | | | -0.201(-0.484) | |
| | | -0.077(-0.272) | | | | | | -0.110(-0.642) |
| CCOSTU | (55) | | | | | | | |
| CGIRL | (57) | | | | | | | |
| BTIMEU | (65) | -0.383(-3.272) | | | | | 0.114(1.888) | -0.367(-2.699) |
| BDIST | (66) | -0.279(-0.951) | -0.216(-0.779) | -0.487(-1.399) | -0.199(-0.678) | | -0.553(-1.759) | |
| BCAR | (67) | 0.235(1.123) | -0.285(2.049) | 0.348(2.486) | 0.353(2.361) | 0.172(1.151) | 0.293(1.793) | 0.170(1.005) |
| BINC | (68) | 0.181(1.342) | | 0.096(1.293) | | | | |
| WBOGL | (77) | 0.261(1.330) | | 0.334(1.505) | | 0.205(1.313) | -0.048(-0.385) | |
| CBOGL | (78) | 0.115(0.773) | -0.024(-0.298) | | -0.052(-0.642) | | | |
| BBOGL | (79) | | | 0.267(1.830) | | 0.263(1.833) | | |
| COM | (82) | | | -0.272(-2.226) | -0.279(-2.430) | -0.265(-2.215) | -0.268(-3.114) | |
| CON | (83) | | -0.077(-0.770) | | 0.050(0.439) | | | -0.094(-0.906) |
| TIM | (84) | -0.186(-1.859) | | -0.263(-2.110) | | -0.265(-2.182) | | |
| SAF | (85) | | -0.154(-1.221) | | -0.136(-1.083) | | -0.128(-1.217) | -0.077(-0.598) |
| EXP | (86) | | | | | | | |
| RHO SQUARED | | 0.771 | 0.778 | 0.779 | 0.785 | 0.763 | 0.695 | 0.793 |

### 5.2.2 Female Students' Mode Choice Models

#### *5.2.2.1 Female Elementary Stages (FEU)*

In Table 5.5, the best model was number 5, which has goodness of fit (rho-squared 0.745) and high t-statistics, but it was rejected, due to unexpected negative signs of the comfortability, which is a generic variable. This means if one percent decreased on comfortability the probability of choosing the mode will be increased by 1.942, which is not logical.

Another two models show the same goodness of fit (rho-squared 0.740). Model one was rejected due to the unexpected negative sign of the safety variable, which is a generic variable. This means if one percent decreased on safety the probability of choosing this mode will be increased by 1.427, which is not logical.

Model number 3 has expected signs and good t-statistics for all variables. The utility function for each mode is given below:

For rented bus mode(RB)

$$U_{RB} = -0.247 \text{ Time } -0.161 \text{ Exp} \quad (160)$$

For school bus mode(SB)

$$U_{SB} = +0.827 - 0.247\,\text{Time} - 0.161\,\text{Exp} - 0.674\,\text{BCar} - 0.432\,\text{BInc} - 0.195\,\text{BBoGl}$$

For private car mode(C)

$$U_{C} = -6.212 - 0.247\,\text{Time} - 0.161\,\text{Exp} + 0.085\,\text{CInc} - 0.091\,\text{CCost}$$

For walk mode(W)

$$U_{W} = +3.294 - 0.247\,\text{Time} - 0.161\,\text{Exp} - 0.088\,\text{WDist}$$

# TABLE 5.5

## MODEL RESULTS FOR MODE CHOICE MODELS FOR ELEMENTARY GIRLS USED (ESTIMATED VARIABLE COEFFICIENTS T- STATISTICS

| IND. VARIABLE | | MODEL 1 | MODEL 2 | MODEL 3 | MODEL 4 | MODEL 5 | MODEL 6 | MODEL 7 |
|---|---|---|---|---|---|---|---|---|
| ASC-WALK | (0) | 4.008(2.773) | 4.606(3.855) | 3.294(4.089) | 4.957(4.509) | 3.922(3.029) | 4.492(3.176) | 3.549(3.040) |
| ASC – CAR | (0) | -1.110(-0.416) | 1.065(1.009) | -6.212(-1.559) | 1.377(1.357) | -7.108(-0.639) | -0.456(-0.187) | -1.138(-1.173) |
| ASC – BUS | (0) | 1.213(0.875) | 1.572(1.384) | 0.827(0.842) | 1.685(1.584) | 0.857(0.628) | 1.444(1.026) | -0.014(-0.019) |
| WDIST | (4) | -0.978(-2.767) | -1.182(-3.163) | -0.088(-0.162) | -1.037(-2.681) | -1.080(-2.769) | -1.037(-2.914) | -0.134(-0.224) |
| WINC | (36) | -0.124(-0.599) | -0.195(-1.073) | | -0.260(-1.373) | | -0.131(-0.678) | |
| WBOY | (37) | | -0.053(-0.252) | | | | | |
| WGIRL | (38) | | | | | | | -0.155(-2.087) |
| WTIME | (45) | | | | | | | 0.117(2.121) |
| CATIME | (46) | | 0.015(0.657) | | | | | |
| BTIME | (47) | 0.175(2.875) | | | 0.079(1.657) | 0.173(2.832) | 0.178(2.959) | |
| RTIME | (48) | | 0.038(1.426) | | 0.078(2.090) | | | |
| CCOST | (49) | -0.034(-2.212) | | -0.091(-2.240) | | -0.065(-1.183) | -0.033(-2.191) | |
| CINC | (51) | 0.076(3.089) | 0.039(5.872) | 0.085(2.408) | -0.041(5.834) | 0.143(1.166) | 0.075(3.301) | 0.039(5.793) |
| CDIST | (53) | 2.396(1.693) | -0.105(-1.064) | | 0.104(0.679) | 5.471(1.096) | 2.333(1.658) | -0.173(-2.245) |
| CCAR | (54) | | | | -0.727(-2.001) | -4.216(-0.838) | | |
| | | 0.080(0.169) | | | | 1.518(0.699) | | -0.045(-0.248) |
| CCOSTU | (55) | | | | | | | |
| CGIRL | (57) | | | | | | | -0.006(-0.135) |
| BTIMEU | (65) | -0.478(-2.816) | | | | -0.504(-3.006) | -0.503(-3.016) | -0.415(-2.563) |
| BDIST | (66) | -0.846(-1.956) | -0.313(-0.810) | -0.674(-1.793) | -0.616(-1.506) | -0.737(-1.725) | -0.820(-1.940) | -0.343(-0.814) |
| BCAR | (67) | 0.674(2.584) | 0.329(1.870) | -0.432(2.268) | 0.370(2.064) | 0.699(2.817) | 0.648(2.535) | 0.433(2.095) |
| BINC | (68) | -0.076(-0.526) | | | | -0.155(-1.066) | -0.107(-0.747) | 0.154(1.362) |
| WBOGL | (77) | -0.662(-1.745) | -0.400(-2.683) | | -0.281(-2.074) | -0.898(-1.137) | -0.626(-2.201) | |
| CBOGL | (78) | -0.424(-2.286) | -0.253(-1.852) | -0.195(-1.566) | -0.272(-2.197) | -0.437(-2.317) | -0.440(-2.322) | -0.120(-0.882) |
| BBOGL | (79) | | | | | -0.319(-1.942) | | -0.057(-0.365) |
| COM | (82) | | | | | | | |
| CON | (83) | -0.173(-1.083) | -0.199(-1.544) | -0.247(-1.664) | -0.193(-1.427) | | | -0.153(-1.045) |
| TIM | (84) | -0.219(-1.427) | -0.266(-1.919) | | -0.318(-2.157) | | -0.252(-1.682) | -0.221(-1.468) |
| SAF | (85) | | 0.057(0.411) | -0.161(-1.030) | 0.116(0.790) | -0.080(-0.470) | | 0.109(0.783) |
| EXP | (86) | | | | | | | |
| RHO SQUARED | | 0.740 | 0.604 | 0.740 | 0.621 | 0.745 | 0.736 | 0.611 |

### *5.2.2.2 Female Intermediate Stages (FIU)*

For female students in intermediate stages the best model in terms of goodness of fit is model number 2 (rho-squared 0.811), as in Table 5.6. All variables show high t-statistics and expected signs, except the generic variables have an unexpected negative sign, which is not logical, therefore it was rejected.

Model number 6 shows expected signs for all variables and good t-statistics. This model has goodness of fit (rho-squared 0.740).

The following is the utility function for each mode:

For rented bus mode (RB)

$$U_{RB} = -0.158 \text{ Time } -0.266 \text{ Exp}$$

For school bus mode(SB)

$$U_{SB} = -4.505 \ -0.158 \text{ Time } -0.266 \text{ Exp } -0.688 \text{ BCar}$$

$$-1.064 \text{ BInc} -0.234 \text{ BBoGl}$$

For private car mode(C)

$$Uc = -3.254 - 0.158\ \text{Time} - 0.266\ \text{Exp} + 0.050\ \text{CInc} - 0.055\ \text{CCost}$$

For walk mode(W)

$$Uw = 2.815 - 0.158\ \text{Time} - 0.266\ \text{Exp} - 2.110\ \text{WDist}$$

# TABLE 5.6

## MODEL RESULTS FOR MODE CHOICE MODELS FOR GIRLS INTERMEDIATE USED (ESTIMATED VARIABLE COEFFICIENTS T- STATISTICS)

| IND. VARIABLE | | MODEL 1 | MODEL 2 | MODEL 3 | MODEL 4 | MODEL 5 | MODEL 6 |
|---|---|---|---|---|---|---|---|
| ASC –WALK | (0) | 4.383(3.2340 | 4.380(3.222) | 4.228(3.198) | 5.151(4.719) | 5.269(3.798) | 2.815(2.915) |
| ASC – CAR | (0) | 2.108(1.286) | -6.638(-1.579) | 2.266(1.385) | 1.186(1.208) | -6.039(-1.467) | -3.254(-1.952) |
| ASC – BUS | (0) | -5.934(-1.997) | -12.308(-3.023) | -5.771(-1.953) | 2.063(2.521) | -0.763(-0.830) | -4.505(-2.302) |
| WDIST | (4) | -2.262(-3.717) | -1.334(-3.468) | -2.511(-3.824) | -1.395(-3.426) | | -2.110(-1.608) |
| WCAR | (35) | | | | -0.212(-0.526) | | |
| WINC | (36) | -0.065(-0.322) | -0.181(-0.798) | | -0.314(-1.678) | -0.370(-1.822) | |
| WBOY | (37) | | | | | | |
| WGIRL | (38) | | | | | | |
| WBE | (39) | | | | | | |
| WBI | (40) | | | | | | |
| WTIME | (45) | | -0.151(-1.909) | | | -0.224(-2.792) | -0.045(-0.311) |
| CATIME | (46) | | 1.887(2.093) | | | 1.871(1.915) | 1.104(2.710) |
| BTIME | (47) | 0.129(2.120) | 0.050(0.896) | -0.123(2.038) | | 0.111(2.026) | |
| RTIME | (48) | | 0.215(3.143) | | | 0.066(1.814) | |
| CCOST | (49) | -0.046(-3.811) | -0.076(-2.001) | -0.050(-3.929) | | -0.076(-2.005) | -0.050(-3.592) |
| RCOST | (50) | | | | | | |
| CINC | (51) | 0.061(4.522) | 0.073(2.210) | 0.062(4.646) | 0.041(5.874) | 0.069(2.255) | 0.055(3.738) |
| CTIMEU | (52) | | | | -0.126(-1.623) | | |
| CDIST | (53) | 0.958(1.549) | 2.128(1.410) | 1.109(1.720) | -0.808(-2.127) | 1.871(1.283) | |
| CCAR | (54) | | | -0.238(-0.462) | | | |
| CCOSTU | (55) | | | | | | |
| CBOY | (56) | | | | | | |
| CGIRL | (57) | | | | | | |
| CBI | (59) | | | | | | |
| BDIST | (66) | -0.300(-1.941) | 0.604(2.359) | -0.284(-1.806) | | -0.234(-1.269) | |
| BCAR | (67) | -0.625(-1.330) | -1.740(-2.408) | -0.639(-1.388) | | -0.097(-0.274) | -0.688(-1.620) |
| BING | (68) | 1.364(2.916) | 2.434(3.273) | | | | -1.064(3.317) |
| BBOY | (69) | | | | | | |
| WBOGL | (77) | -0.169(-1.237) | | -0.230(-1.762) | | | |
| CBOGL | (78) | -0.363(-1.787) | | -0.348(-1.656) | -0.324(-2.252) | | |
| BBOGL | (79) | -0.375(-1.596) | | -0.433(-1.771) | -0.285(-2.456) | | -0.234(-1.266) |
| COM | (82) | -0.327(-1.859) | | -0.311(-2.109) | -0.137(-0.828) | -0.185(-1.020) | |
| CON | (83) | 0.026(0.153) | -0.198(-1.117) | | -0.164(-1.164) | 0.071(0.417) | |
| TIM | (84) | | -0.140(-0.732) | | -0.101(-0.743) | 0.161(0.898) | -0.158(-0.995) |
| SAF | (85) | | | | -0.256(-1.725) | -0.153(-0.831) | |
| EXP | (86) | | | -0.301(-1.435) | 0.113(0.790) | -0.135(-0.708) | -0.266(-1.432) |
| RHO SQUARED | | 0.714 | 0.811 | 0.720 | 0.610 | 0.728 | 0.740 |

### *5.2.2.3 Female Secondary Stages (FSP)*

Several specifications for female secondary preferred models were tested, as can be seen in Appendix C. From these, the best model was chosen, as in Table 5.7, which consists of 15 attributes; five of them are generic variables and the others are specific to preferred modes. This model was tested five times to overcome the problems of low t-statistics and unexpected signs.

From these models, model number 4 is the best. It shows high t-statistics and expected signs for all variables. The model has goodness of fit (rho-squared 0.753). The following is the utility function for each mode in this model:

For rented bus mode(RB)

$$U_{RB} = -0.099\ \text{Time} + 0.416\ \text{Con}$$

For school bus mode(SB)

$$U_{SB} = -0.810 + 0.416\ Con - 0.099\ Time - 0.486\ BCar - 0.537\ Binc$$

For private car mode(C)

$$U_{C} = +0.133 - 0.099\ Time + 0.416\ Con + 0.024\ CInc - 0.026\ CCost + 1.369\ CDist$$

For walk mode(W)

$$U_{W} = +5.008 - 0.099\ Time + 0.416\ Con - 1.245\ WInc$$

## TABLE 5.7

### MODEL RESULTS FOR MODE CHOICE MODELS FOR SECONDARY GIRLS PREFERRED (ESTIMATED VARIABLE COEFFICIENTS T- STATISTICS)

| IND. VARIABLE | | MODEL 1 | MODEL 2 | MODEL 3 | MODEL 4 | MODEL 5 |
|---|---|---|---|---|---|---|
| ASC-WALK | (0) | 2.118(0.915) | 2.900(1.426) | 0.220(0.097) | 5.008(1.689) | 5.573(1.899) |
| ASC – CAR | (0) | 3.141(1.490) | 4.644(2.764) | 3.715(3.432) | 0.133(0.113) | 0.269(0.231) |
| ASC – BUS | (0) | -0.914(-0.740) | 0.304(0.314) | -0.926(-0.852) | -0.900(-0.632) | -0.705(-0.568) |
| WDIST | (4) | -1.956(-1.057) | -0.652(-0.441) | | | |
| WCAR | (35) | -0.235(-0.203) | | 0.385(0.303) | | |
| WINC | (36) | | -0.967(-0.941) | -1.727(-1.520) | -1.245(-0.945) | -1.283(-1.007) |
| WBOY | (37) | | | 0.338(0.716) | | |
| WGIRL | (38) | | | | | |
| WBI | (40) | | | | | |
| WTIME | (45) | | | | | -0.150(-1.061) |
| CATIME | (46) | 0.864(3.293) | | | | 0.715(2.632) |
| BTIME | (47) | 0.088(1.880) | 0.134(2.320) | | | |
| RTIME | (48) | 0.166(3.284) | 0.317(2.804) | 0.066(2.885) | | 0.373(2.882) |
| CCOST | (49) | -0.025(-3.986) | -0.022(-3.732) | -0.030(-4.059) | -0.026(-3.818) | -0.027(-3.831) |
| CINC | (51) | 0.024(4.398) | 0.022(3.981) | 0.036(5.204) | 0.024(4.327) | 0.025(4.400) |
| CDIST | (53) | | 1.287(2.909) | | 1.369(2.478) | 1.492(2.533) |
| CCAR | (54) | | | 0.787(1.779) | | |
| CCOSTU | (55) | | | | | |
| CBOY | (56) | | | | | |
| CGIRL | (57) | | | | | |
| CBI | (59) | | | | | |
| BTIMEU | (65) | | | 0.044(0.378) | | 0.410(2.320) |
| BDIST | (66) | -0.564(-1.362) | | -0.507(-1.310) | -0.486(-1.176) | |
| BCAR | (67) | 0.427(1.865) | | 0.360(1.842) | -0.537(1.969) | 0.404(1.980) |
| BINC | (68) | | | | | |
| BBOY | (69) | | | | | |
| WBOGL | (77) | -0.309(-1.550) | -0.243(-1.684) | -0.244(-1.924) | | |
| CBOGL | (78) | | | | | |
| BBOGL | (79) | -0.309(-1.111) | -0.086(-0.396) | | | |
| COM | (82) | 0.478(1.673) | | | 0.416(1.569) | 0.465(1.729) |
| CON | (83) | | | | -0.099(-0.409) | -0.064(-0.275) |
| TIM | (84) | | 0.081(0.377) | | | |
| SAF | (85) | | | 0.141(0.944) | | |
| EXP | (86) | | | | | |
| RHO SQUARED | | 0.714 | 0.668 | 0.573 | 0.753 | 0.735 |

### *5.2.2.4 Female Elementary And Intermediate Stages Used (FEIU)*

The second model shows the highest goodness of fit (rho-squared 0.744), as in Table 5.8, even though it was rejected due to unexpected signs of the generic variable Convenience, that means if the convenience decreased 1% there will be an increase of 1.544 for this mode, which is not logical. The second reason is that the income variable specific to walking mode shows low t-statistics.

The second and third models show low t-statistics on the income variable specific to walking, therefore they were rejected. The fourth model shows goodness of fit (rho-squared 0.708), better t-statistics than the previous models, and all variables show expected signs. The model is:

For rented bus mode(RB)

$$U_{RB} = -0.140\ \text{Time} - 0.094\ \text{Exp}$$

For school bus mode(SB)

$$U_{SB} = -0.903 - 0.140\,\text{Time} - 0.094\,\text{Exp} - 0.517\,\text{BCar} - 0.554\,\text{BInc} - 0.203\,\text{BBoGl}$$

For private car mode(C)

$$U_{C} = -2.936 - 0.140\,\text{Time} - 0.094\,\text{Exp} + 0.062\,\text{CInc} - 0.059\,\text{CCost}$$

For walk mode(W)

$$U_{W} = +3.154 - 0.140\,\text{Time} - 0.094\,\text{Exp} - 0.598\,\text{WDist}$$

## TABLE 5.8

### MODEL RESULT FOR MODE CHOICE FOR GIRLS ELEMNTARY INTERMEDIATE USE

### (ESTIMATED VARIABLE COEFFICIENTS T – STATISTICS)

| IND. VARIABLE | | MODEL 1 | MODEL 2 | MODEL 3 | MODEL 4 | MODEL 5 |
|---|---|---|---|---|---|---|
| ASC –WALK | (0) | 3.154(5.271) | 3.458(4.830) | 3.638(5.115) | 3.733(5.231) | |
| ASC – CAR | (0) | -2.936(-2.320) | -5.535(-1.999) | -5.184(-1.912) | -5.101(-1.881) | |
| ASC – BUS | (0) | -0.903(-1.209) | -2.056(-2.430) | -2.148(-2.773) | -1.944(-2.641) | |
| WDIST | (4) | -0.598(-0.995) | | | | |
| WCAR | (35) | | | | | |
| WINC | (36) | | -0.037(-0.290) | -0.051(-0.405) | -0.052(-0.411) | |
| WBOY | (37) | | | | | |
| WGIRL | (38) | | | | | |
| WBE | (39) | | | | | |
| WBI | (40) | | | | | |
| WTIME | (45) | | -0.147(-3.547) | -0.144(-3.501) | -0.144(-3.507) | |
| CATIME | (46) | | 2.167(2.784) | 2.053(2.674) | 2.042(2.666) | |
| BTIME | (47) | | 0.069(3.268) | 0.048(1.398) | | |
| RTIME | (48) | | 0.97(3.892) | 0.097(3.139) | 0.107(3.484) | |
| CCOST | (49) | -0.059(-4.058) | -0.078(-2.712) | -0.078(-2.632) | -0.078(-2.619) | |
| RCOST | (50) | | | | | |
| CINC | ( 51) | 0.062(4.536) | 0.072(3.020) | 0.074(2.945) | 0.074(2.930) | |
| CTIMEU | (52) | | | | | |
| CDIST | (53) | | 1.632(1.510) | 1.536(1.522) | 1.556(1.541) | |
| CCAR | (54) | | | | | |
| CCOSTU | (55) | | | | | |
| CBOY | (56) | | | | | |
| CGIRL | (57) | | | | | |
| CBI | (59) | | | | | |
| BTIMEU | (65) | | | | | |
| BDIST | (66) | | | 0.074(0.560) | 0.228(2.997) | |
| BCAR | (67) | -0.517(-1.960) | -0.970(-3.160) | | | |
| BING | (68) | -0.554(4.038) | 0.770(4.373) | 0.489(3.766) | 0.491(3.848) | |
| BBOY | (69) | | | | | |
| WBOGL | (77) | | | | | |
| CBOGL | (78) | | | | | |
| BBOGL | (79) | -0.203(-2.056) | | | | |
| COM | (82) | | | | | |
| CON | (83) | | -0.156(-1.544) | | | |
| TIM | (84) | -0.140(-1.426) | -0.068(-0.640) | -0.124(-1.235) | -0.130(-1.295) | |
| SAF | (85) | | | | | |
| EXP | (86) | -0.094(-0.891) | | | | |
| RHO SQUARED | | 0.708 | 0.744 | 0.725 | 0.722 | |

### *5.2.2.5 Elementary & Intermediate Stages Preferred (FEIP)*

Several specifications were tested for elementary and intermediate preferred stages, as can be seen in Appendix C. From these, the best model in terms of goodness of fit was chosen, as in Table 5.9.

At the first trial, model number 4 had the highest goodness of fit (rho-squared 0.774), but it was rejected due to the number of cars specific to car mode (CCar), and the distance specific to car, having unexpected signs.

Model number 2 has the second highest goodness of fit (rho-squared 0.773) although it was rejected because of unexpected signs of distance variable specific to car. This is due to an increase in distance for the intermediate stage, compared to the elementary stage, and due to a larger preference for bus mode at this stage.

Model number 3 shows high goodness of fit (rho-squared 0.751) but it was rejected due to unexpected signs of the comfortability of the generic variables.

The fourth trial, model number 1, shows the highest goodness of fit (rho-squared 0.749) of all the models. It also shows good t-statistics and expected signs. The following are the FEIP models:

For rented bus mode(RB)

$$U_{RB} = -0.106\ Tim - 0.037\ Exp$$

For school bus mode(SB)

$$U_{SB} = 0.656 - 0.106\ Tim - 0.037 Exp + 0.358\ BInc - 0.505\ BCar$$

For private car mode(C)

$$Uc = -1.857 - 0.106\ Tim - 0.037 Exp + 0.287\ CBoGl + 0.099\ CDist - 0.060\ Ccost$$

For walk mode(W)

$$U_w = 4.206 - 0.106\ Tim - 0.037 Exp + 0.073\ WBoGl - 0.213\ WCar - 0.966\ WDist$$

## TABLE 5.9

### MODEL RESULTS FOR MODE CHOICE MODELS FOR ELE.&INT. GIRLS PREFERRED (ESTIMATED VARIABLE COEFFICIENTS T- STATISTICS)

| IND. VARIABLE | MODEL 1 | MODEL 2 | MODEL 3 | MODEL 4 | MODEL 5 | MODEL 6 |
|---|---|---|---|---|---|---|
| ASC-WALK (0) | 4.206(4.509) | 6.001(6.391) | 4.619(6.157) | 5.912(6.071) | 3.745(4.642) | 2.945(3.992) |
| ASC – CAR (0) | -1.857(-0.753) | 1.047(0.564) | 0.427(0.302) | -4.121(-1.311) | 0.594(0.425) | -4.383(-1.452) |
| ASC – BUS (0) | 0.656(0.723) | 1.205(2.468) | 0.556(0.826) | 0.395(0.550) | 0.128(0.169) | -1.840(-2.193) |
| WDIST (4) | -0.966(-3.488) | 0.154(0.339) | 0.101(0.237) | | -1.102(-3.647) | -1.062(-3.139) |
| WCAR (35) | -0.213(-0.746) | | | | 0.105(0.406) | -0.179(-0.749) |
| WINC (36) | | -0.312(-2.329) | | -0.466(-3.228) | -0.314(-2.347) | |
| WBOY (37) | | | 0.146(1.003) | 0.470(2.404) | | |
| WGIRL (38) | | | | | | |
| WBI (40) | | 0.498(1.129) | | | | |
| WTIME (45) | | -0.176(-2.830) | -0.195(-3.219) | -0.223(-4.566) | | |
| CATIME (46) | | 1.004(2.736) | 0.835(2.377) | 1.713(2.601) | | 1.973(2.559) |
| BTIME (47) | | 0.067(2.097) | | | | 0.073(3.433) |
| RTIME (48) | | | | | | 0.098(3.865) |
| CCOST (49) | -0.060(-2.837) | -0.058(-2.549) | -0.058(-2.464) | -0.072(-2.540) | -0.085(-3.608) | -0.079(-2.459) |
| CINC (51) | 0.064(3.388) | 0.067(3.017) | 0.067(2.971) | 0.077(2.916) | 0.098(4.146) | 0.080(2.715) |
| CDIST (53) | 0.099(0.216) | -0.228(-0.636) | | 0.088(0.220) | 1.477(2.015) | 1.587(1.563) |
| CCAR (54) | | | | -1.216(-1.784) | | |
| | | -0.115(-0.474) | | | | |
| CCOSTU (55) | | | | | 0.483(1.702) | |
| CBOY (56) | | | | | | |
| CGIRL (57) | | -0.165(-0.157) | | | | |
| CBI (59) | | | | | | |
| BTIMEU (65) | | -0.240(-2.451) | | | | |
| BDIST (66) | -0.505(-1.384) | | | | | -0.974(-3.136) |
| BCAR (67) | 0.358(2.513) | | | | | 0.755(4.592) |
| BINC (68) | | | | | -0.058(-0.254) | |
| BBOY (69) | 0.073(0.922) | | | | 0.197(1.716) | 0.032(0.400) |
| WBOGL (77) | 0.287(1.198) | | | 0.750(2.201) | | -0.250(-1.293) |
| CBOGL (78) | | | 0.043(0.464) | 0.078(0.740) | 0.144(0.916) | |
| BBOGL (79) | | | -0.060(-0.569) | | 0.097(0.775) | |
| COM (82) | | | | | -0.233(-1.920) | |
| CON (83) | -0.106(-1.029) | -0.076(-0.675) | | | | -0.146(-1.421) |
| TIM (84) | | | | | | |
| SAF (85) | -0.037(-0.246) | | | | | |
| EXP (86) | | | | | | |
| RHO SQUARED | 0.749 | 0.773 | 0.751 | 0.774 | 0.732 | 0.737 |

### 5.2.2.6 All Female Stages (FU)

For all female stages, as shown in Table 5.10, model number 2 shows the highest goodness of fit (rho-squared 0.722). However, it was rejected due to the low t-statistics of two variables. One of these is the time, which is a generic variable, and the second one is the income variable specific to walk mode.

Model number 3 has goodness of fit (rho-squared 0.720 ): in this model all variables have expected signs, but as in the first model, the two variables have low t-statistics, therefore it was rejected.

Model number 1 shows better t-statistics and all variables have expected signs and high goodness of fit (rho-squared 0.706). The following is the utility function for the model:

For rented bus mode(RB)

$$U_{RB} = -0.036\ \text{Time} - 0.133\ \text{Exp}$$

For school bus mode(SB)

$$U_{SB} = -1.667 - 0.036\,\text{Time} - 0.133\,\text{Exp} - 0.624\,\text{BCar} - 0.176\,\text{BBoGl}$$

For private car mode(C)

$$U_{C} = -2.583 - 0.036\,\text{Time} - 0.133\,\text{Exp} + 0.072\,\text{CInc} - 0.069\,\text{CCost}$$

For walk mode(W)

$$U_{W} = +3.040 - 0.036\,\text{Time} - 0.133\,\text{Exp} - 0.657\,\text{WDist}$$

## TABLE 5.10

### MODEL RESULT FOR MODE CHOICE FOR GIRLS ELEMENTARY INTERMEDIATE AND SECONDARY USED (ESTIMATED VARIABLE COEFFICIENTS T – STATISTICS)

| IND. VARIABLE | | MODEL 1 | MODEL 2 | MODEL 3 | MODEL 4 | MODEL 5 |
|---|---|---|---|---|---|---|
| ASC –WALK | (0) | 3.040(6.063) | 3.487(5.988) | 3.543(6.079) | | |
| ASC – CAR | (0) | -2.583(-2.475) | -3.908(-2.395) | -3.858(-2.362) | | |
| ASC – BUS | (0) | -1.667(-2.670) | -2.696(-3.920) | -2.542(-3.874) | | |
| WDIST | (4) | -0.657(-1.196) | | | | |
| WCAR | (35) | | | | | |
| WINC | (36) | | -0.034(-0.359) | -0.028(-0.295) | | |
| WBOY | (37) | | | | | |
| WGIRL | (38) | | | | | |
| WBE | (39) | | | | | |
| WBI | (40) | | | | | |
| WTIME | (45) | | -0.157(-4.312) | -0.158(-4.350) | | |
| CATIME | (46) | 1.280(4.705) | 1.606(4.070) | 1.608(4.072) | | |
| BTIME | (47) | | 0.052(1.590) | | | |
| RTIME | (48) | | 0.109(4.111) | 0.115(4.444) | | |
| CCOST | (49) | -0.069(-4.481) | -0.076(-4.231) | -0.077(-4.231) | | |
| RCOST | (50) | | | | | |
| CINC | (51) | 0.072(4.692) | 0.075(4.420) | 0.075(4.420) | | |
| CTIMEU | (52) | | | | | |
| CDIST | (53) | | 1.157(2.472) | 1.177(2.506) | | |
| CCAR | (54) | | | | | |
| CCOSTU | (55) | | | | | |
| CBOY | (56) | | | | | |
| CGIRL | (57) | | | | | |
| CBI | (59) | | | | | |
| BTIMEU | (65) | | | | | |
| BDIST | (66) | | 0.088(0.737) | 0.250(3.918) | | |
| BCAR | (67) | -0.624(-2.811) | | | | |
| BING | (68) | | 0.515(4.773) | 0.521(4.941) | | |
| BBOY | (69) | | | | | |
| WBOGL | (77) | | | | | |
| CBOGL | (78) | | | | | |
| BBOGL | (79) | -0.176(-2.125) | | | | |
| COM | (82) | | | | | |
| CON | (83) | | | | | |
| TIM | (84) | -0.036(-0.449) | -0.026(-0.328) | -0.028(-0.345) | | |
| SAF | (85) | | | | | |
| EXP | (86) | -0.133(-1.492) | | | | |
| RHO SQUARED | | 0.706 | 0.722 | 0.720 | | |

### 5.2.3 Male & Female Used Modes (MFU)

Many models were tested for male and female used modes, as in Table 5.11. Most of the models show a low goodness of fit and some of the independent variables have low t-statistics, mainly in those variables specific to walk, due to the combination of male and female, and some have unexpected signs. For this reason the model was rejected.

Model number 3 is the best: it shows high goodness of fit (rho-squared 0.742). However, it was rejected due to three reasons. All generic variables have unexpected signs; the time variable has a plus sign and convenience has a minus sign, which is not logical. Also, the time variable generic to all modes has low t-statistics.

The second model, number 5, shows high t-statistics, and high goodness of fit (rho-squared 0.725) but was rejected due to the unexpected sign of BDist.

The third model still shows a high goodness of fit (rho-squared 0.721), expected signs for all variables and high t-statistics. The following is the utility function for each mode for model number 2:

For rented bus mode(RB)

$$U_{RB} = -0.036\ \text{Time} - 0.103\ \text{Exp}$$

For school bus mode(SB)

$$U_{SB} = -1.074 - 0.036\ \text{Time} - 0.103\ \text{Exp} - 0.494\ \text{BCar} - 0.471\ \text{BInc} - 0.091\ \text{BBoGl}$$

For private car mode(C)

$$U_C = -1.847 - 0.036\ \text{Time} - 0.103\ \text{Exp} + 0.071\ \text{CInc} - 0.066\ \text{CCost}$$

For walk mode(W)

$$U_W = 3.771 - 0.036\ \text{Time} - 0.103\ \text{Exp} - 0.055\ \text{WDist}$$

## TABLE 5.11

## MODEL RESULTS FOR MODE CHOICE MODELS FOR BOYS GIRLS USED (ESTIMATED VARIABLE COEFFICIENTS T- STATISTICS

| IND. VARIABLE | | MODEL 1 | MODEL 2 | MODEL 3 | MODEL 4 | MODEL 5 |
|---|---|---|---|---|---|---|
| ASC-WALK | (0) | 2.808(7.229) | 3.771(10.273) | 4.286(9.285) | 4.309(9.449) | 4.461(9.769) |
| ASC – CAR | (0) | -2.323(-2.019) | -1.847(-2.233) | -2.062(-2.062) | -1.905(-1.945) | -1.818(-1.855) |
| ASC – BUS | (0) | -1.519(-3.667) | -1.074(-2.436) | -1.081(-2.343) | -1.360(-3.068) | -1.109(-2.656) |
| WDIST | (4) | -1.379(-8.043) | -0.055(-0.2080 | | | |
| WCAR | (35) | -0.095(-0.788) | | | | |
| WINC | (36) | | | -0.080(-1.084) | -0.082(-1.129) | -0.085(-1.171) |
| WBOY | (37) | | | | | |
| WGIRL | (38) | | | | | |
| WBI | (40) | | | | | |
| WTIME | (45) | | | -0.179(-6.973) | -0.175(-6.900) | -0.179(-7.082) |
| CATIME | (46) | 1.166(5.225) | | 1.204(5.372) | 1.192(5.335) | 1.192(5.332) |
| BTIME | (47) | 0.007(0.817) | | 0.045(3.258) | 0.058(2.464) | |
| RTIME | (48) | | | 0.075(5.217) | 0.061(3.588) | 0.069(4.075) |
| CCOST | (49) | -0.064(-5.441) | -0.066(-5.720) | -0.062(-5.337) | -0.065(-5.428) | -0.065(-5.425) |
| CINC | ( 51) | 0.069(5.888) | 0.071(6.210) | 0.067(5.780) | 0.070(5.847) | 0.070(5.849) |
| CDIST | (53) | 0.319(1.256) | | 0.441(1.825) | 0.401(1.674) | 0.412(1.725) |
| CCAR | (54) | | | | | |
| CCOSTU | (55) | | | | | |
| CBOY | (56) | | | | | |
| CGIRL | (57) | | | | | |
| CBI | (59) | | | | | |
| BTIMEU | (65) | | | | -0.058(-0.680) | 0.113(2.186) |
| BDIST | (66) | -0.612(-3.613) | -0.494(-2.888) | -0.830(-4.472) | | |
| BCAR | (67) | 0.450(5.729) | 0.471(5.788) | 0.563(5.895) | 0.323(4.207) | 0.318(4.272) |
| BINC | (68) | | | | | |
| BBOY | (69) | 0.012(0.285) | | | | |
| WBOGL | (77) | -0.0269-0.277) | | | | |
| CBOGL | (78) | | -0.091(-1.671) | | | |
| BBOGL | (79) | | | | | |
| COM | (82) | | | -0.166(-2.635) | | |
| CON | (83) | -0.066(-1.166) | -0.036(-0.626) | 0.020(0.304) | -0.039(-0.659) | -0.043(-0.733) |
| TIM | (84) | | | | | |
| SAF | (85) | -0.1019-1.483) | -0.103(-1.500) | | | |
| EXP | (86) | | | | | |
| RHO SQUARED | | 0.704 | 0.721 | 0.742 | 0.728 | 0.725 |

The basic choice model was estimated using the B logit method after eliminating respondents who did not provide data on at least one alternative, and who did not provide data on the chosen mode.

A series of issues were investigated in arriving at the final model, such as :

Issue 1: The original data provided information on six alternatives, and the mode choice models concentrated on four of them, since two of the alternatives (carpool, and limousine/taxi) were used by very few students and not likely to be preferred.

Issue 2: A series of tests of the significance of alternative specifications of variables was undertaken, bearing in mind that certain variables were not seperately defined for some alternatives modes, such as walktime, waiting time and in-vehicle time for school bus and public bus modes, the cost of driver, cost of oil and repairs in the case of private car mode, knowing that two alternative modes (walk, school bus) had no direct cost.

Issue 3: Five generic variables were used, i.e. comfortability, convenience, time, cost and safety.

Issue 4: The first model estimation output examined the signs and relative values of the coefficients estimates and the significance of individual coefficients, with the estimation of more than one specification to compare goodness-of-fit measures. A specification with a higher maximum value of likelihood function is considered to be better.

## 5.3 PREDICTION SUCCESS FOR THE SELECTED MODAL SPLIT MODELS

The prediction success of the selected models is presented in Tables 5.12 to 5.21. The tables show the actual number of students choosing the alternative, the predicted number of students choosing the alternative mode, and the prediction ratio of the predicted models defined as actual / predicted. For the MEU (male students in elementary level)/actual used mode model, the prediction ratios are 86%, 98%, 31% and 26%, and are almost correctly predicted by the model for walk and car modes.

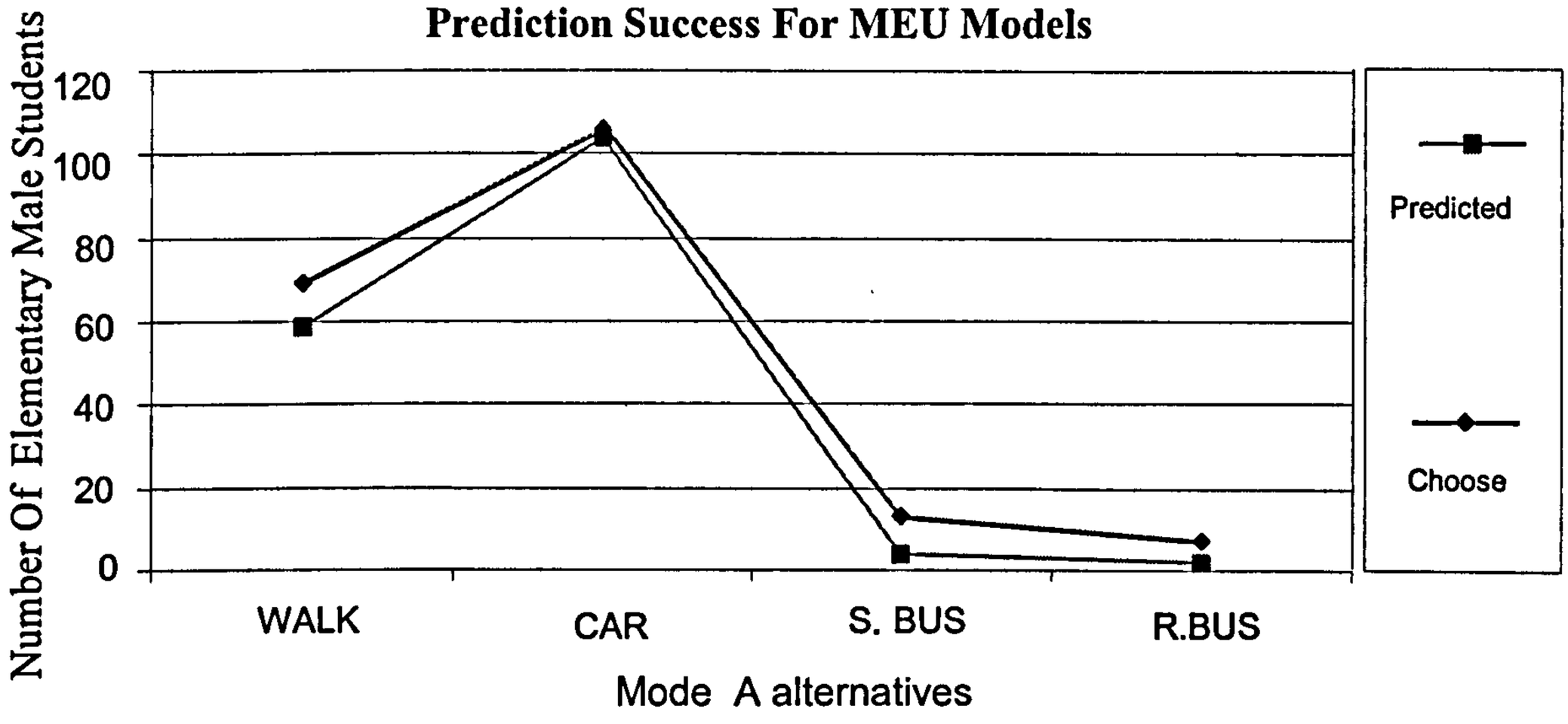
**Table 5.12**

**Prediction Success Table For MEU Model**

| | Mode Alternatives | | | |
|---|---|---|---|---|
| | Walk | Car | School Bus | Rented Bus |
| Number Of Students Choosing This Alternative | 69 | 106 | 13 | 7 |
| Number Of Students Correctly Predicted By The Model | 59 | 104 | 4 | 2 |
| Prediction Ratio | 86% | 98% | 31% | 26% |

**Figure 5.1**

**Prediction Success For MEU Models**




The prediction ratios for two stages combined together (male intermediate and secondary school level model of actual mode used) are 90%, 99%, 56%, 20%, for walk, car, bus and rented bus modes respectively. This late model for the combined stages is better than the elementary model in terms of prediction ratios.

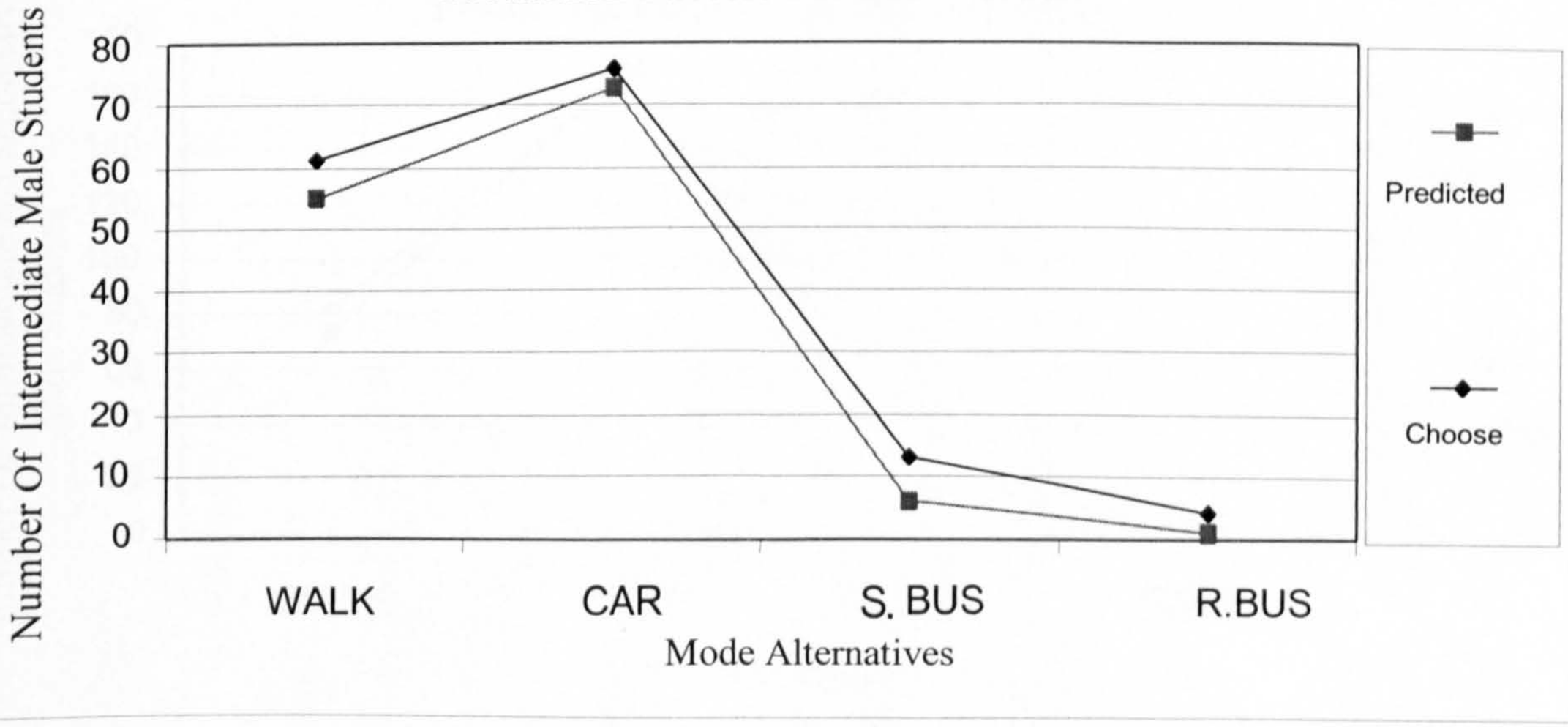
## Table 5.13

## Prediction Success Table For MIP Model

| | Mode Alternatives | | | |
|---|---|---|---|---|
| | Walk | Car | School Bus | Rented Bus |
| Number Of Students Choosing This Alternative | 61 | 76 | 13 | 4 |
| Number Of Students Correctly Predicted By The Model | 55 | 73 | 6 | 1 |
| Prediction Ratio | 90% | 96% | 46% | 25% |

## Figure 5.2

## Prediction Success For MIP Models

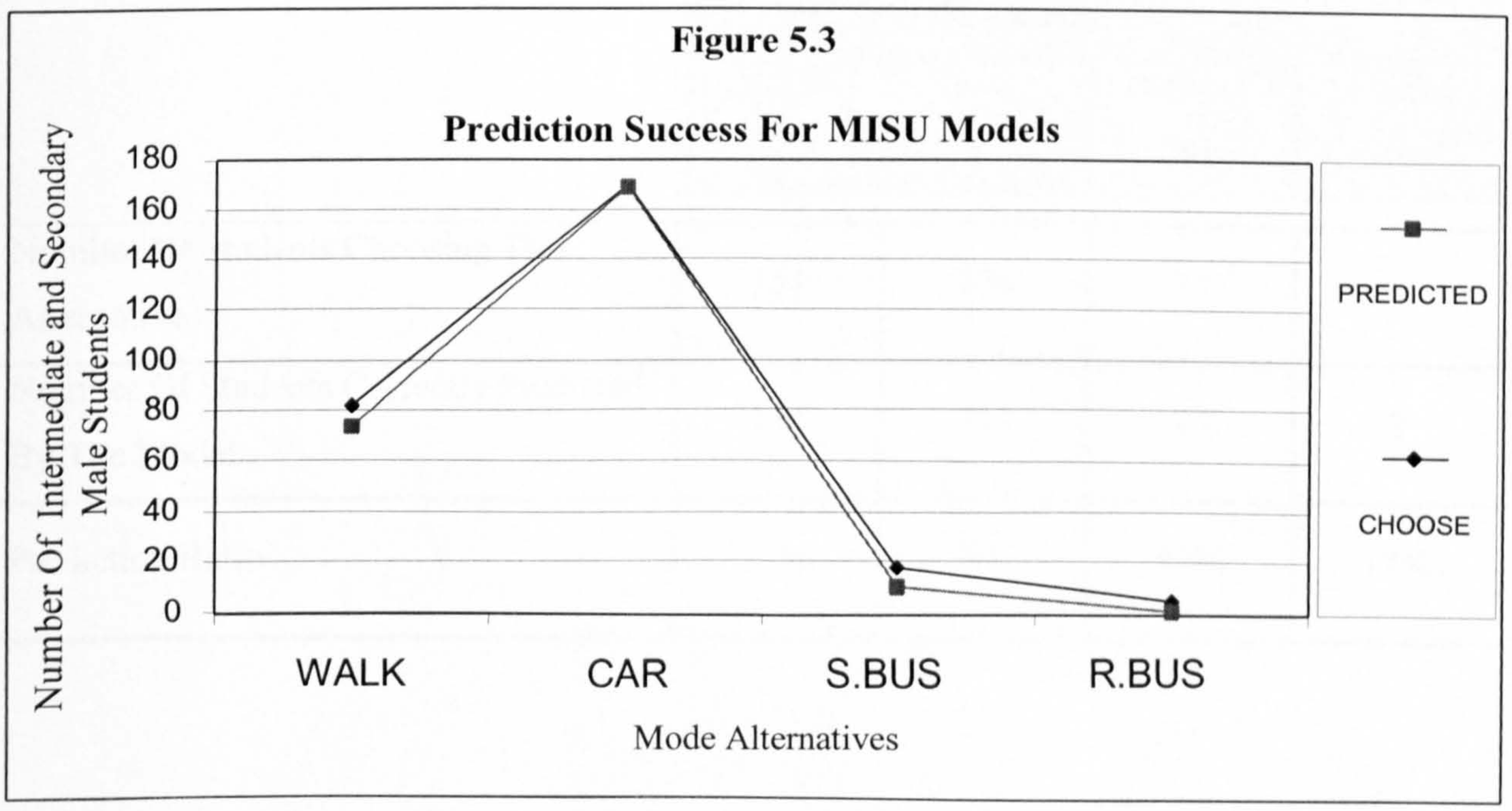


## Table 5.14

## Prediction Success Table For MISU Model

| | Mode Alternatives | | | |
|---|---|---|---|---|
| | Walk | Car | School Bus | Rented Bus |
| Number Of Students Choosing This Alternative | 82 | 170 | 18 | 5 |
| Number Of Students Correctly Predicted By The Model | 74 | 169 | 10 | 1 |
| Prediction Ratio | 90% | 99% | 56% | 20% |

## Figure 5.3



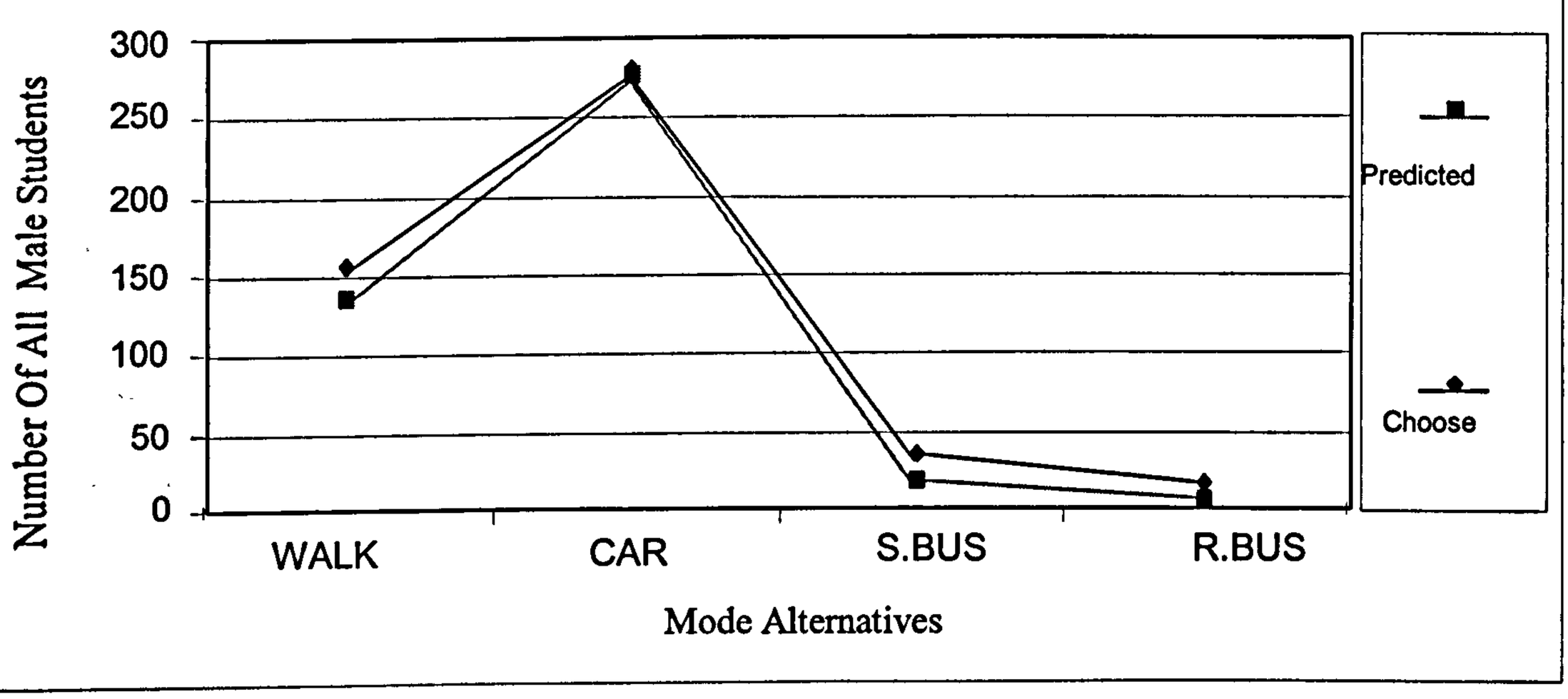
For the combination of all male educational stages, the prediction ratios are 87% for walk, 99% for car, 42% for bus and 17% for rented bus. Such ratios are expected due to the ability of the students in secondary schools to have driving licences and their ability to drive, which raises the predicted ratio of choosing the car and decreases the ratio of choosing the bus.

**Table 5.15**

**Prediction Success Table For MU Model**

| | **Mode Alternatives** | | | |
|---|---|---|---|---|
| | Walk | Car | School Bus | Rented Bus |
| Number Of Students Choosing This Alternative | 151 | 276 | 31 | 12 |
| Number Of Students Correctly Predicted By The Model | 132 | 273 | 13 | 2 |
| Prediction Ratio | 87% | 99% | 42% | 17% |

**Figure 5.4**
**Prediction Success For MU Models**



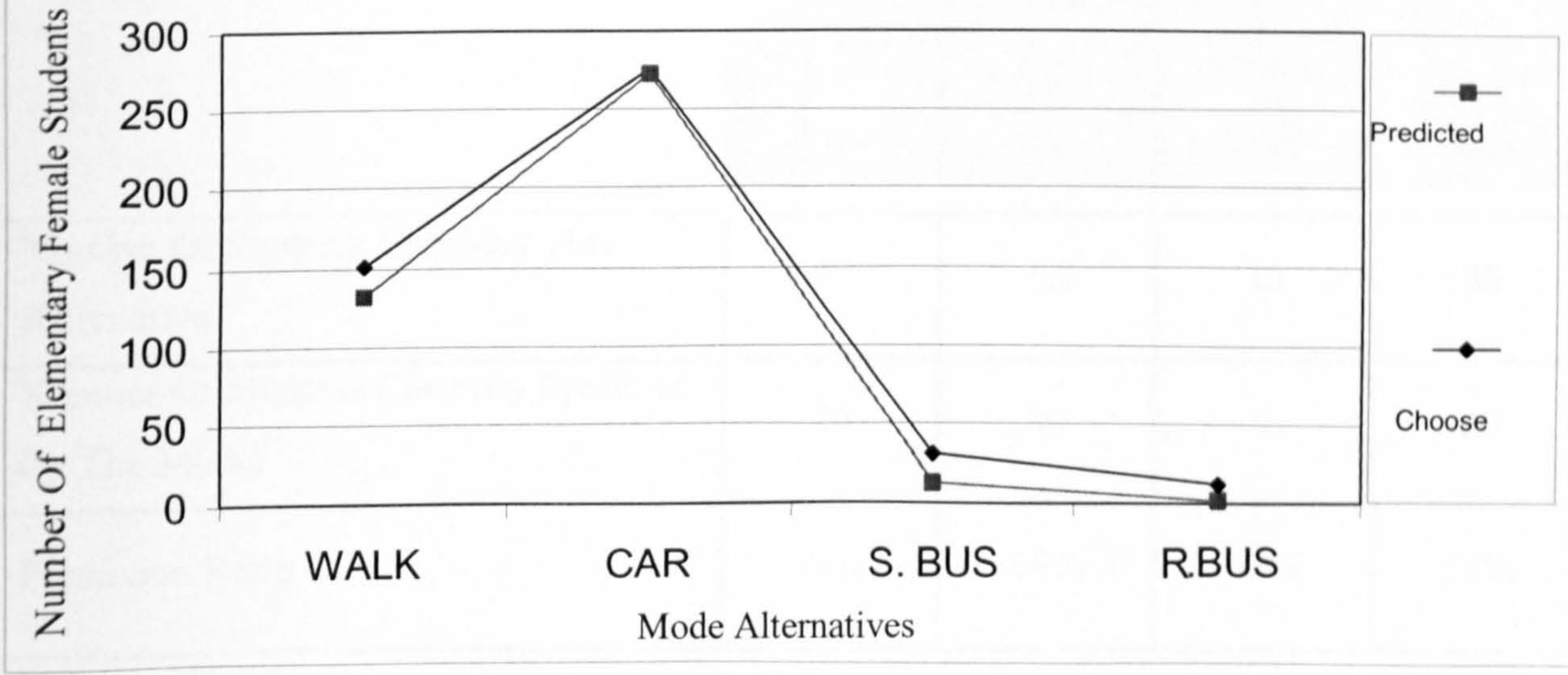

A comparison of observed and predicted cell frequencies in Table 5.16 shows that the correctly predicted value for the car is larger than for all of the rest of the modes. The overall prediction ratios, 78%, 99%, 55%, 33%, for the FEU (female students in elementary level/ for actual mode used) model, as can be seen in Table 5.16, are correctly predicted by the model for walk and car modes. Since the schools are near the houses, the model predicts a high percentage for walk and car, rather than school bus or rented bus.

## Table 5.16

## Prediction Success Table For FEU Model

| | Mode Alternatives | | | |
|---|---|---|---|---|
| | Walk | Car | School Bus | Rented Bus |
| Number Of Students Choosing This Alternative | 44 | 98 | 20 | 12 |
| Number Of Students Correctly Predicted By The Model | 35 | 97 | 11 | 4 |
| Prediction Ratio | 78% | 99% | 55% | 33% |

## Figure 5.5
## Prediction Success For FEU Models



For the second stage (FIU), there is an increase in using the rented bus of more than 50% over the previous stage, and there is also an increase in using the school bus. Since the schools are further away than the elementary schools, the overall prediction ratios are, 74%, 96%, 62% and 67% respectively.

In the third stage, the secondary level, (FSP), which shows better prediction ratios for private car and rented bus, there is a decrease in the percentage of walking to schools, and these changes in using the modes are all due to the increase in distance. The ratios are 50%, 97%, 56% and 77%.

**Table 5.17**

**Prediction Success Table For FIU Model**

| | **Mode Alternatives** | | | |
|---|---|---|---|---|
| | Walk | Car | School Bus | Rented Bus |
| Number Of Students Choosing This Alternative | 27 | 83 | 13 | 30 |
| Number Of Students Correctly Predicted By The Model | 20 | 80 | 8 | 20 |
| Prediction Ratio | 74% | 96% | 62% | 67% |

**Figure 5.6**

**Prediction Success For FIU Models**

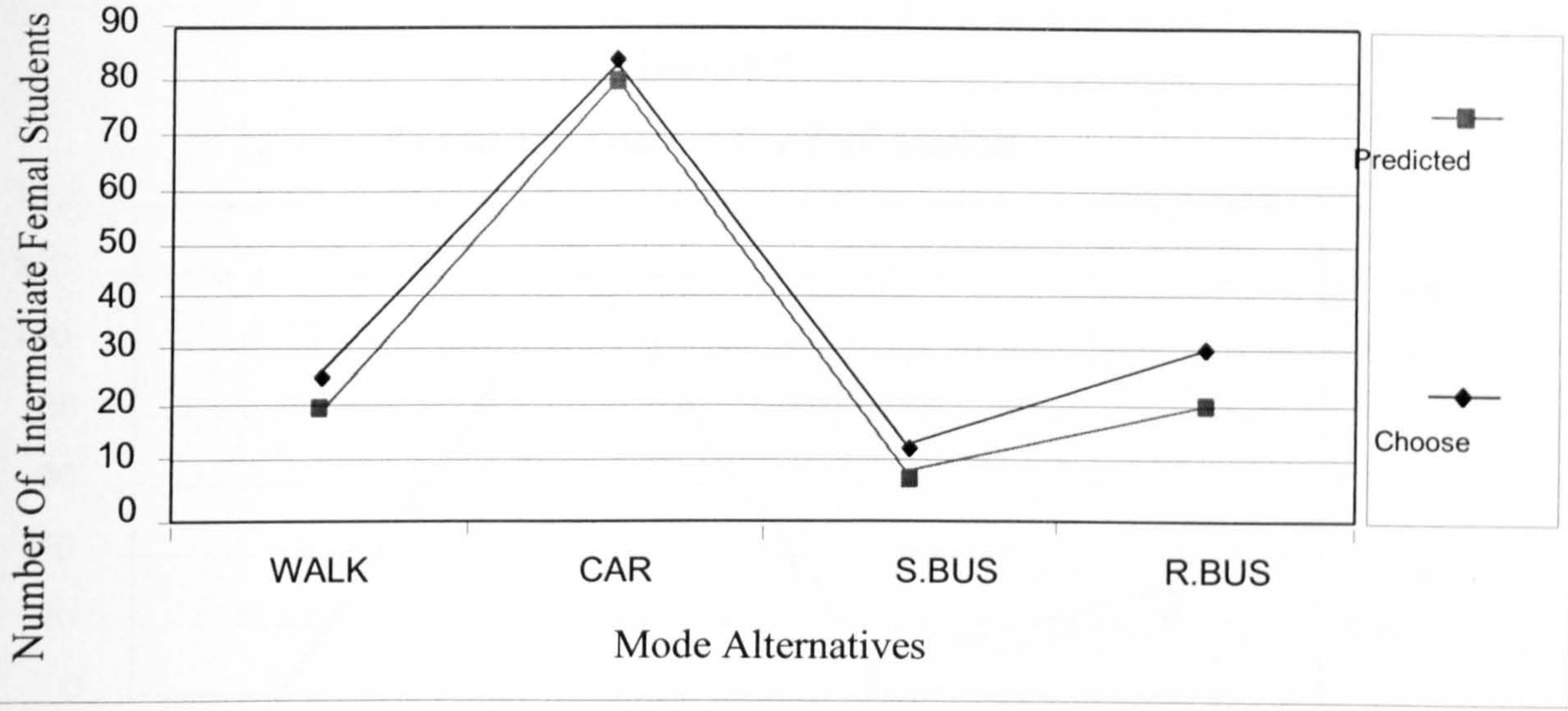


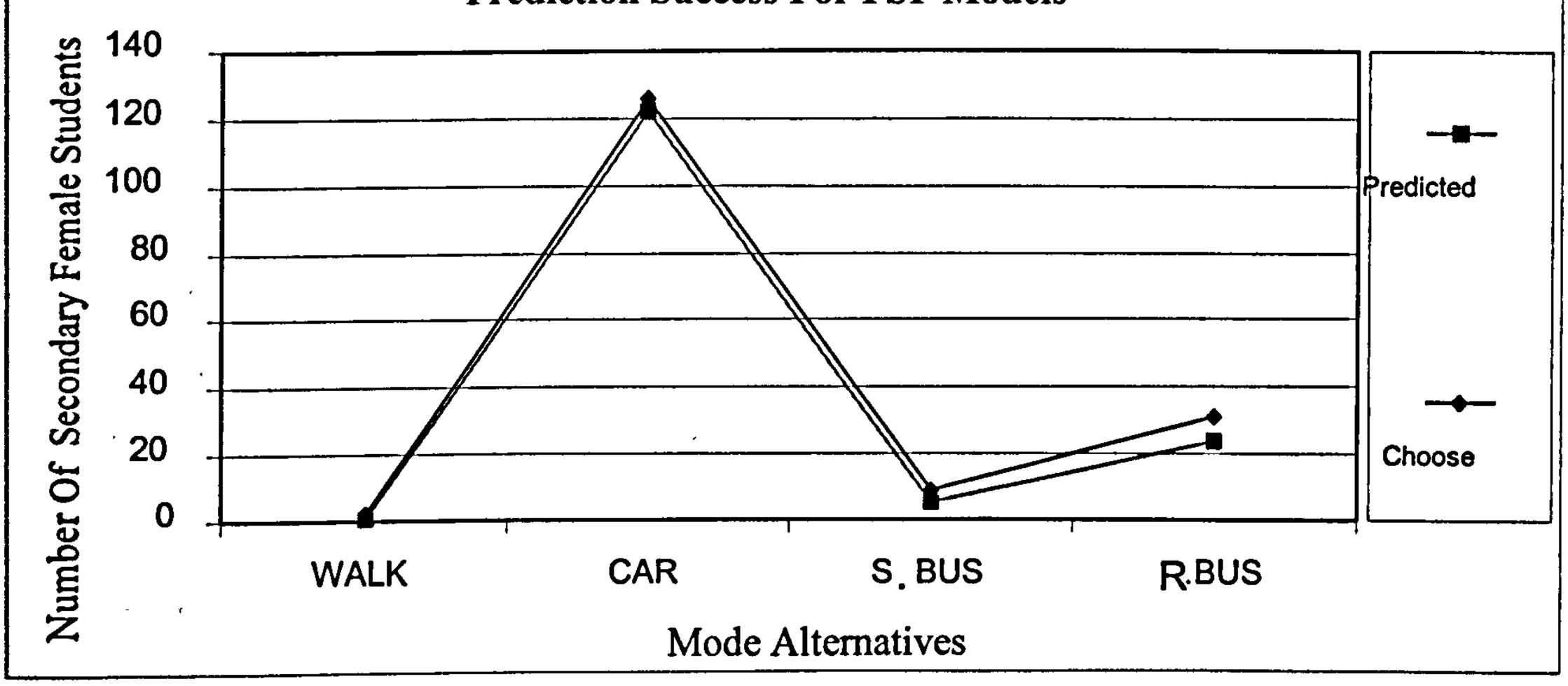

**Table 5.18**

**Prediction Success Table For FSP Model.**

| | Mode Alternatives | | | |
|---|---|---|---|---|
| | Walk | Car | School Bus | Rented Bus |
| Number Of Students Choosing This Alternative | 2 | 126 | 9 | 31 |
| Number Of Students Correctly Predicted By The Model | 1 | 22 | 5 | 24 |
| Prediction Ratio | 50% | 97% | 56% | 77% |

**Figure 5.7**

**Prediction Success For FSP Models**




Female elementary and intermediate (FEIU) are 76%, 98%, 52% and 48% for walk, car, bus and rented bus modes respectively, showing a higher percentage on walking modes than in the intermediate stage and lower than in the elementary stage.

These are better prediction ratios than the next model, which is the combination of all female educational stages (FU). The ratios are 71% for walk, 97% for car, 49% for bus, and 54% for rented bus.

**Table 5.19**

**Prediction Success Table For FEIU Model**

| | Mode Alternatives | | | |
|---|---|---|---|---|
| | Walk | Car | School Bus | Rented Bus |
| Number Of Students Choosing This Alternative | 71 | 181 | 33 | 42 |
| Number Of Students Correctly Predicted By The Model | 54 | 178 | 17 | 20 |
| Prediction Ratio | 76% | 98% | 52% | 48% |

**Figure 5.8**

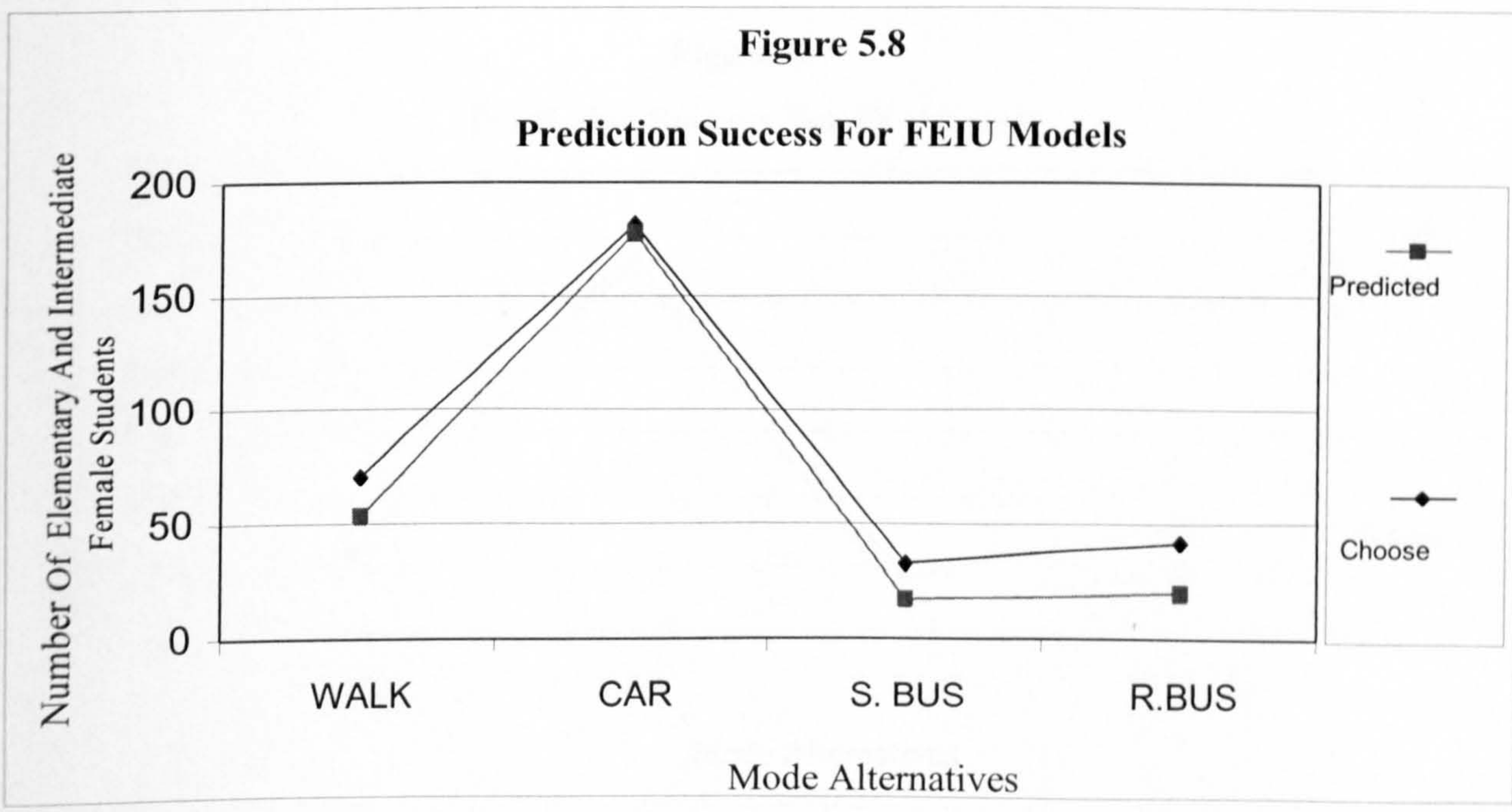


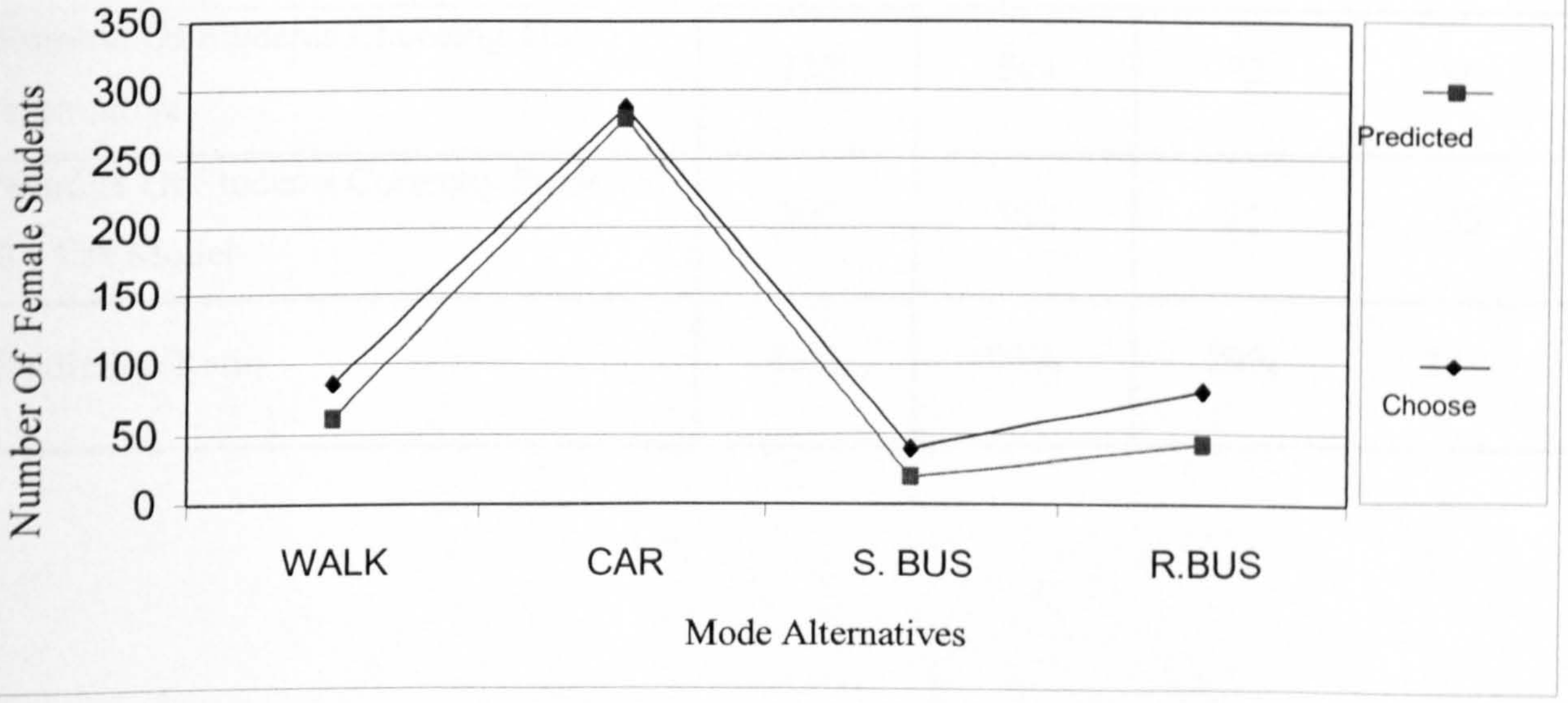
**Table 5.20**

**Prediction Success Table For FU Model**

| | Mode Alternatives | | | |
|---|---|---|---|---|
| | Walk | Car | School Bus | Rented Bus |
| Number Of Students Choosing This Alternative | 87 | 288 | 41 | 80 |
| Number Of Students Correctly Predicted By The Model | 62 | 280 | 20 | 43 |
| Prediction Ratio | 71% | 97% | 49% | 45% |

**Figure 5.9**

**Prediction Success For FU Models**



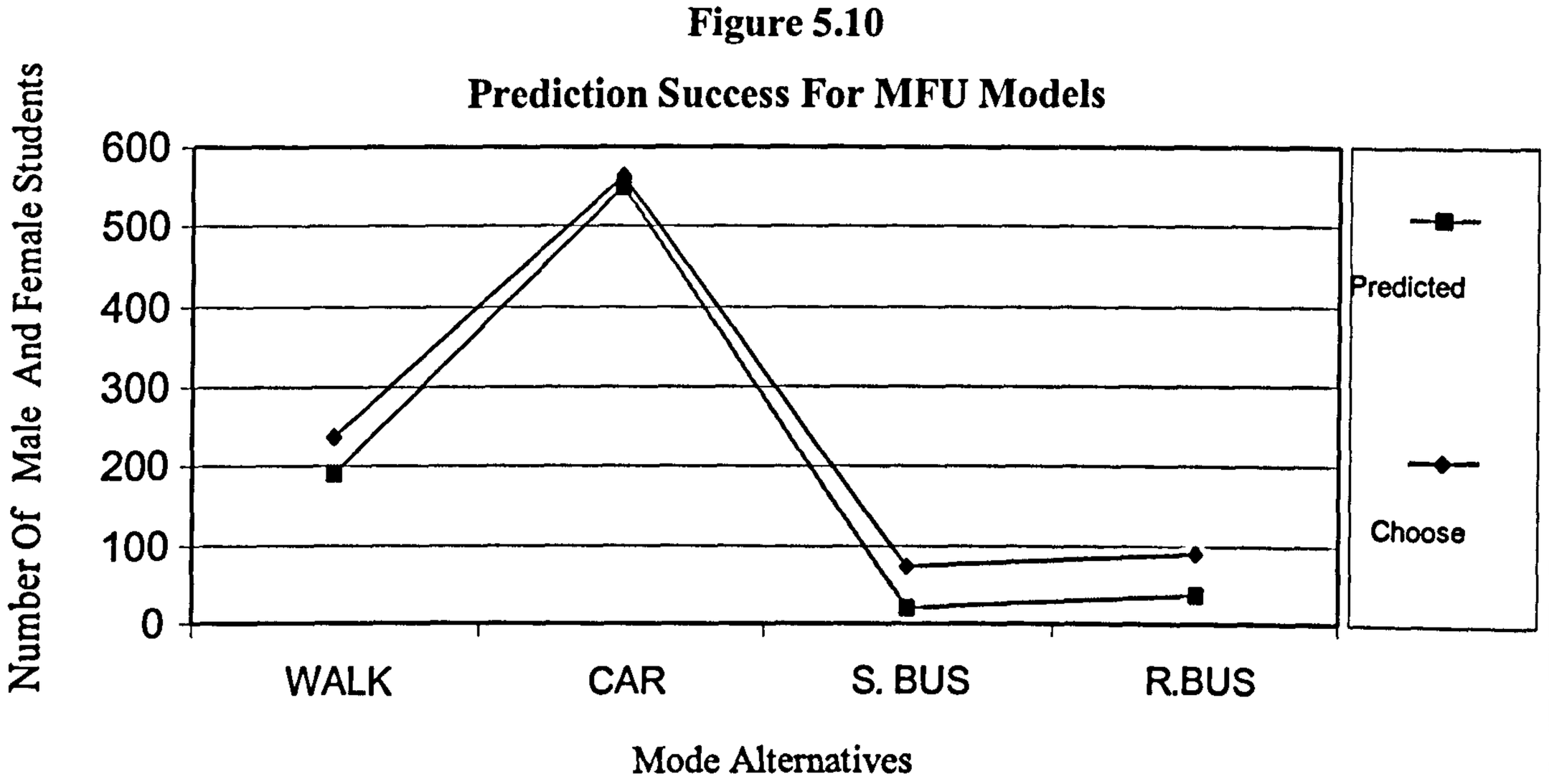
For the combination of all boys and girls (MFU), the prediction ratios are 80%, 98%, 29% and 38%, indicating that the most used modes are the first two modes, (walking and private car) due to the effect of distance from elementary schools for both male and female, and the ability of Secondary Male students to drive. When distance increases for the Intermediate and Secondary stages, the use of school bus and rented bus increases.

**Table 5.21**

**Prediction Success Table For MFU Model**

| | **Mode Alternatives** | | | |
|---|---|---|---|---|
| | Walk | Car | School Bus | Rented Bus |
| Number Of Students Choosing This Alternative | 238 | 564 | 72 | 90 |
| Number Of Students Correctly Predicted By The Model | 190 | 552 | 21 | 35 |
| Prediction Ratio | 80% | 98% | 29% | 38% |

**Figure 5.10**


Prediction Success For MFU Models
Number Of Male And Female Students
600
500
400
300
200
100
0
WALK
CAR
S. BUS
R.BUS
Mode Alternatives
Predicted
Choose

# 5.4 AGGREGATE ELASTICITIES OF THE ESTIMATED MODELS

Many practical transportation policy issues are concerned with mode choice (Koppelman and Lerman, 1986). For example, the gain or loss in transit revenues caused by a fare increase depends on how travelers' mode choices are affected by the increase. If few current transit riders switch to other modes because of the fare increase, transit revenues will increase proportionally to the increase in fare. But if many riders switch to other modes, revenues will increase less proportionally to the fare increase and may decrease. Similarly, the effects of changes in transit routes and schedules on ridership, revenues, and traffic congestion all depend how the changes affect individual travelers' mode choices. The effectiveness of programs to encourage rider sharing, for example preferential parking or preferential access to freeways for carpools, also depends on how the programs affect mode choice. In most situations, planners must choose among a variety of fare schedules and service designs. An understanding of the separate and combined effects of these decisions on travel mode choice is essential to selection of the best plan to meet specific transportation objectives.

The importance of mode choice in transportation policy analysis and decision making has led to a variety of methods for predicting the effects of policy measures on travelers' mode choices. Two well-known and frequently used prediction methods are the method of elasticities and aggregate mode split modeling.

Aggregate point elasticities for the school trips of the chosen modes are presented in Tables 5.22 to 5.30. A direct elasticity is the percentage change in market share caused by a 1 percent change in the attribute of that mode. Cross elasticity is the percent change in market share for an alternative caused by a 1 percent change in an attribute of another alternative j.

The estimated elasticities can be interpreted as follows. For male students the direct elasticity, for example, for income specific to walk in the MEU model is -0.256. This means that a one percent increase in the income, all else remaining constant, causes a 0.256% decrease in the overall probability of walk choice. This choice shows the importance of income in choosing a mode.

**Table 5.22**

**Weighted Aggregated Elasticity For MEU**

| INDP. VARIABLE | MODE ALTERNATIVES | | | |
|---|---|---|---|---|
| | 1- WALK | 2- CAR | 3 – S. BUS | 4- R. BUS |
| WDIST | -0.168 | | | |
| WINC | -0.256 | | | |
| CINC | | 0.365 | | |
| CDIST | | 0.047 | | |
| CBOY | | 0.035 | | |
| CCOST | | -0.358 | | |
| BBOGL | | | 1.536 | |
| COM | 0.055 | 0.003 | 0.197 | 0.281 |
| TIM | -0.065 | -0.007 | -0.305 | -0.438 |

For MIP, as shown in Table 5.23, for distance specific to car, a one percent increase in distance causes a 0.638 increase in the overall probability of private car choice. The direct elasticity, for example, for actual time specific to rented bus in the MISU model is -0.250, as shown in Table5.24. This means that a one percent increase in the actual time by rented bus, all else remaining constant, causes a 0.250% decrease in the overall probability of the bus choice.

**Table 5.23**

**Weighted Aggregated Elasticity For MIP**

| WEDP. VARIABLE | MODE ALTERNATIVES | | | |
|---|---|---|---|---|
| | 1- WALK | 2- CAR | 3 – S. BUS | 4- R. BUS |
| WDIST | 2.659 | | | |
| WINC | -0.097 | | | |
| WBOY | 0.026 | | | |
| CCOST | | -0.476 | | |
| CINC | | 0.473 | | |
| CDIST | | 0.638 | | |
| BBOGL | | | 0.118 | |
| TIM | -0.036 | -0.006 | -0.024 | -0.019 |
| SAF | 0.186 | 0.026 | 0.081 | 0.079 |

**Table 5.24**

**Weighted Aggregated Elasticity For MISU**

| WEDP. VARIABLE | MODE ALTERNATIVES | | | |
|---|---|---|---|---|
| | 1- WALK | 2- CAR | 3 – S. BUS | 4- R. BUS |
| WDIST | -0.077 | | | |
| WINC | -0.062 | | | |
| WBI | 0.030 | | | |
| CCOST | | -0.070 | | |
| CINC | | 0.031 | | |
| CBI | | -0.022 | | |
| BDIST | | | -0.477 | |
| TIM | -0.039 | -0.001 | -0.206 | -0.250 |
| EXP | -0.020 | -0.001 | -0.146 | -0.213 |

In the last model for male students MU, as shown in Table 5.25, for example, a one percent increase in owning a private car causes a 0.189% decrease in the overall probability of bus choice. The direct elasticity, for example, for actual time specific to rented bus in the MU model is -0.234. This means that a one percent increase in the actual time by rented bus, all else remaining constant, causes a 0.234% decrease in the overall probability of the bus choice. This choice shows the importance of time to the students; if time decreases the probability of bus choice increases.

**Table 5.25**

**Weighted Aggregated Elasticity for MU**

| INDP. VARIABLE | MODE ALTERNATIVES | | | |
|---|---|---|---|---|
| | 1- WALK | 2- CAR | 3 – S. BUS | 4- R. BUS |
| WDIST | 0.013 | | | |
| CINC | | 0.091 | | |
| CCOST | | -0.097 | | |
| BCAR | | | -0.189 | |
| BINC | | | -0.659 | |
| BBOGL | | | -0.091 | |
| TIME | -0.035 | -0.001 | -0.155 | -0.234 |
| EXP | -0.025 | -0.003 | -0.158 | -0.342 |

For female students: (as in Table 5.26) the direct elasticity, for example, for the bus mode variable expense in the FEU model is 0.262; this means that a one-percent decrease in the expense of the rented bus mode, all else remaining constant, causes a 0.262% increase in the overall probability of rented bus choice.

**Table 5.26**

**Weighted Aggregated Elasticity for FEU**

| INDP. VARIABLE | MODE ALTERNATIVES | | | |
|---|---|---|---|---|
| | 1- WALK | 2- CAR | 3 – S. BUS | 4- R. BUS |
| WDIST | -0.025 | | | |
| CINC | | 0.179 | | |
| CCOST | | -0.145 | | |
| BCAR | | | -0.475 | |
| BINC | | | -0.884 | |
| BBOGL | | | -0.540 | |
| TIME | -0.167 | -0.003 | -0.431 | -0.528 |
| EXP | -0.045 | -0.005 | -0.142 | -0.262 |

For female students at intermediate level, as in Table 5.27, for example, a one percent increase in car specific to bus mode, all else remaining constant, causes a 0.520% decrease in bus choice. It is clear that the increase of time and exp/cost leads to a decrease in the number of students using that mode. The highest percentage is for the cost of the rented bus mode: if there is a one percent increase in the cost there will be a decrease of 0.287% in the students using the rented bus mode, whereas for time the highest decrease is for school bus: if there is a one percent increase in travel time, there will be a decrease of 0.268% in the students using the school bus mode…etc.

**Table 5.27**

**Weighted Aggregated Elasticity for FIU**

| INDP. VARIABLE | MODE ALTERNATIVES | | | |
|---|---|---|---|---|
| | 1- WALK | 2- CAR | 3 – S. BUS | 4- R. BUS |
| WDIST | -0.617 | | | |
| CINC | | 0.291 | | |
| CCOST | | -0.286 | | |
| BCAR | | | -0.520 | |
| BINC | | | -2.783 | |
| BBOGL | | | -0.665 | |
| TIME | -0.151 | -0.006 | -0.268 | -0.224 |
| EXP | -0.074 | -0.016 | -0.165 | -0.287 |

For the secondary stage, as in Table 5.28, a one percent increase in convenience causes a 0.715% increase in choosing the school bus mode, showing the importance of the convenience variable for school bus choice. The highest percentage is for income in relation to school bus mode. If there is a one percent increase in income, all else remaining constant, there will be a decrease of 1.162% in the students using the school bus mode.

**Table 5.28**

**Weighted Aggregated Elasticity for FSP**

| INDP. VARIABLE | MODE ALTERNATIVES | | | |
|---|---|---|---|---|
| | 1- WALK | 2- CAR | 3 – S. BUS | 4- R. BUS |
| WINC | -1.198 | | | |
| CINC | | 0.203 | | |
| CCOST | | -0.141 | | |
| CDIST | | 0.089 | | |
| BCAR | | | -0.464 | |
| BINC | | | -1.162 | |
| CON | 0.611 | 0.032 | 0.715 | 0.345 |
| TIME | -0.169 | -0.006 | -0.180 | -0.081 |

Weighted Aggregated Elasticity For FEIU is shown in Table 5.29, It is clear, for example, that if there is a one percent increase in owning private cars, all else remaining constant, there will be a decrease of 0.404 in the students using school bus mode, and if there is a one percent increase in number of boys and girls in the family, consequently there will be a decrease of 0.622 of those students using school bus mode.

**Table 5.29**

**Weighted Aggregated Elasticity for FEIU**

| INDP. VARIABLE | MODE ALTERNATIVES | | | |
|---|---|---|---|---|
| | 1- WALK | 2- CAR | 3 – S. BUS | 4- R. BUS |
| WDIST | -0.185 | | | |
| CINC | | 0.241 | | |
| CCOST | | -0.231 | | |
| BCAR | | -0.404 | | |
| BINC | | | -1.388 | |
| BBOGL | | | -0.622 | |
| TIME | -0.118 | -0.004 | -0.265 | -0.280 |
| EXP | -0.028 | -0.005 | -0.083 | -0.143 |

For all female students in all general educational levels, as shown in Table 5.30, for example, if there is a one percent increase in income, there will be an increase of 0.323 in those students using the private car, whereas if there is a one percent increase in owning a private car, there will be a decrease of 0.555% in those students using school bus.

**Table 5.30**

**Weighted Aggregated Elasticity for FU**

| INDP. VARIABLE | MODE ALTERNATIVES | | | |
|---|---|---|---|---|
| | 1- WALK | 2- CAR | 3 – S. BUS | 4- R. BUS |
| WDIST | -0.226 | | | |
| CINC | | 0.323 | | |
| CCOST | | -0.323 | | |
| BCAR | | | -0.555 | |
| BBOGL | | | -0.590 | |
| TIME | -0.035 | -0.001 | -0.075 | -0.061 |
| EXP | -0.045 | -0.008 | -0.121 | -0.169 |

For all male and female students in all general educational levels, as shown in Table 5.31, for example, when time and expense decreases there will be an increase in the students using that mode. If the time decreases by one percent, the number of male and female students using the rented bus mode will increase by 0.807%. When the cost of private car increases by one percent, the number of students using the private car mode will decrease by 0.225%.

**Table 5. 31**

**Weighted Aggregated Elasticity for MFU**

| INDP. VARIABLE | MODE ALTERNATIVES | | | |
|---|---|---|---|---|
| | 1- WALK | 2- CAR | 3 – S. BUS | 4- R. BUS |
| WDIST | -0.015 | | | |
| CINC | | 0.220 | | |
| CCOST | | -0.225 | | |
| BCAR | | | -0.461 | |
| BINC | | | -1.311 | |
| BBOGL | | | -0.344 | |
| TIME | -0.026 | -0.001 | -0.081 | -0.807 |
| EXP | -0.027 | -0.004 | -0.104 | -0.174 |

From the aggregate elasticities, it is possible to predict how in the future the probability of choosing a mode will be affected due to a change in one variable, or a combination of variables, as well as the effects of such changes on other modes.

## 5.5 SUMMARY

For the specific variables, the interpretation is different from one mode to another. For example, for distance specific to walking, a decrease in distance caused an increase in the probability of choosing the mode, whereas an increase in distance caused an increase in the probability of choosing the private car mode; whilst a greater increase in distance caused an increase in the probability of using school bus or rented bus.

For cars, if the number of cars increased, the probability of choosing this mode increased and caused a decrease in the choice of other modes, and so on to the least of the other specific variables.

For the generic variables, the interpretation is the same for all modes. An increase in the comfortability and convenience variables led to an increase in choosing the modes, whereas a decrease in time and expense led to an increase in probability of choosing that mode. These indications are very helpful for bus companies in order to have more users.

# 6 THE SCHOOL TRANSPORT MARKET


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# 6. THE SCHOOL TRANSPORT MARKET

## 6.1 MARKET DEMAND

This chapter shows the potential market demand for different school transport modes. This is revealed by comparing existing and preferred demand, as illustrated in Figures 6.1 to 6.4 for different modes and for all general educational levels for both Male and Female students. These figures illustrate the differences in percentage of the students using each mode and the percentage of the students preferring the mode. These differences in percentage show those students who tend to favor other school transport modes over the used mode.

### *6.1.1 Walking Mode:*

For walking mode, as in Figure 6.1, the demand for walking decreases for all levels, allowing for other modes to be used. For male students, the highest chance for other modes to share the school transport is for Male Intermediate (MI) due to the greatest decrease in walking mode among the other educational levels. For Male Elementary (ME), even though the school is near to the houses, still there is a chance for other modes rather than walking to share the Market for school transport, whereas for Male Secondary levels (MS) there is a slight increase in walking mode.

The chance of sharing the market for school transport by other modes than walking for different levels of Male students is :-

| | |
|---|---|
| MI | 17% |
| ME | 5% |
| MS | -2% |

For female students, the greatest decrease from walking mode is at the Secondary (FS) level, followed by Female Intermediate (FI). The market share chances for other modes are :

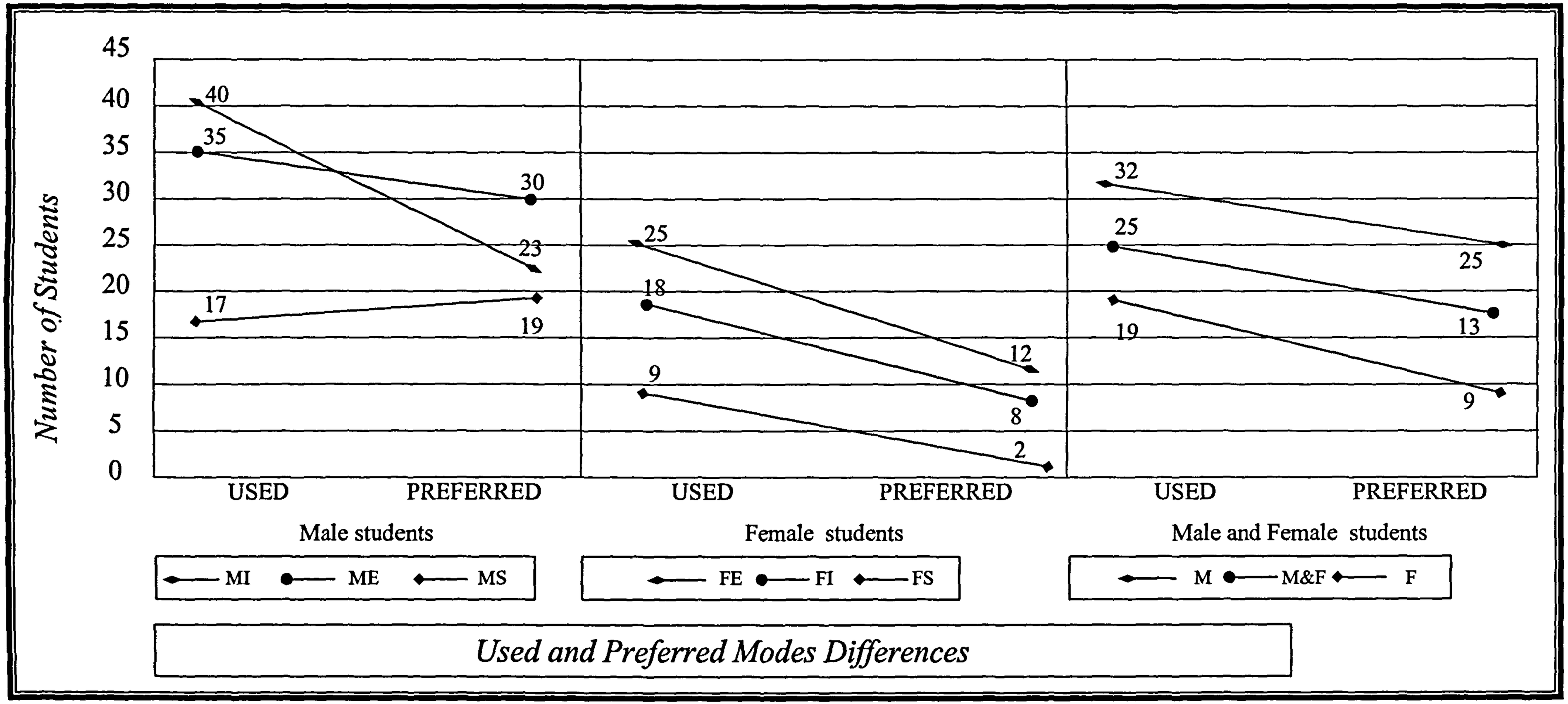
| | |
|---|---|
| FE | 13% |
| FI | 10% |
| FS | 7% |

In a comparison of all Male and Female students, in terms of walking mode, it is clear that the school transport Market for Female students is better than for Male students, whereas for all Male and Female together there is a better chance than either for Male or Female separately; The percentage of the students who tend to favor other school transport modes over walking is :

| | |
|---|---|
| M | 7% |
| M&F | 8% |
| F | 10% |

## Figure 6.1

## Existing Demand Compared to Preferred Demand for Walking Mode for School Transport.



### *6.1.2 Private Car Mode:*

The school transport market of the students who tend to favor other school transport modes over private car is lower than the school transport market preferring another mode over walking.

The highest market share comes from Male Elementary (ME) among all the other educational levels for both Male and Female. This is clearly shown in Figure 6.2. The percentage of the school transport market from those students using private car is :

| | |
|---|---|
| ME | 9% |
| MI | 2% |
| MS | -11% |

Also the market chance for Female students using the private car is different from Male Students. The Female in Intermediate level is better than Elementary and Secondary. The percentage of market chance for other modes rather than private car mode is :

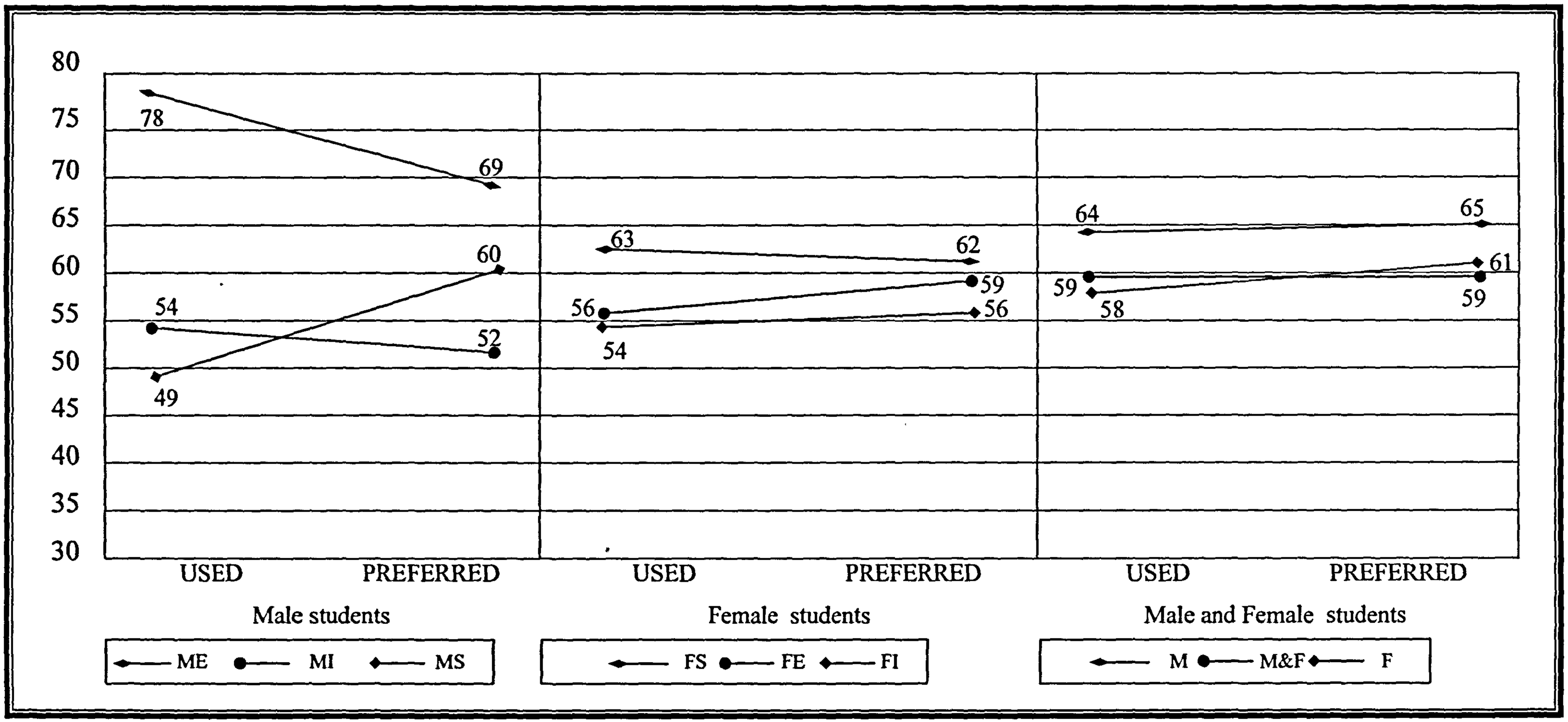
| | |
|---|---|
| FI | 1% |
| FE | -3% |
| FS | -2% |

For all M/F and M&F, it is clear that there is no Market demand for other school transport mode. Because there is no students who tend to favor other school transport rather than private car as shown on the following percentage :

| | |
|---|---|
| M | -1% |
| M&F | 0% |
| F | -3% |

## Figure 6.2

## Existing Demand Compared to Preferred Demand for Private Car Mode for School Transport.



### *6.1.3 School Bus Mode :*

For school bus, this mode is not provided for male students as for female students. For females it is provided more, and the percentage of students who tend to favor other modes over school bus mode is lower than others. The school transport market of those students using the school bus is almost the same percentage of male and female students. The highest, as in figure 6.3, is Male Intermediate followed by Male Elementary, whereas there would be no change for male in secondary level. The percentages are:-

| | |
|---|---|
| MI | 5% |
| ME | 2% |
| MS | 0% |

For female students, the highest percentage is the Female Intermediate, whereas elementary and secondary school have the same percentage:-

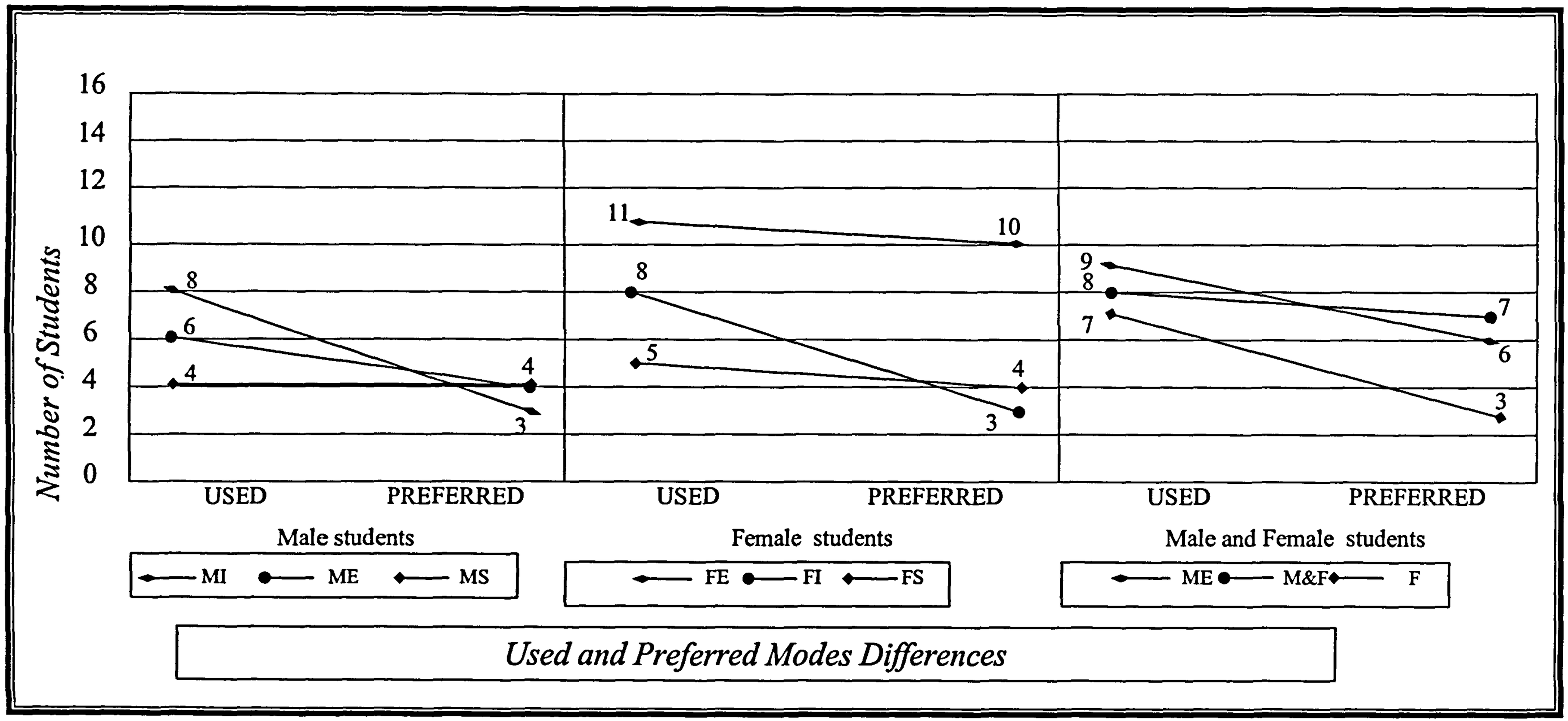
| | |
|---|---|
| FI | 5% |
| FE | 1% |
| FS | 1% |

When we compare the school transport market for those students who are tending to favor other modes over school bus modes, for all male and female, it is found that the female is the highest, followed by male students and the last is male and female students together. The percentages are :-

| | |
|---|---|
| F | 4% |
| M | 3% |
| M & F | 1% |

**Figure 6.3**

**Existing Demand Compared to Preferred Demand for School Bus Mode for School Transport.**



### *6.1.4 Public Bus Mode :*

In the case of Public Bus, as in Figure 6.4, the case is totally different. The School Transport Market demand from those students using Public Bus to alter to other modes is zero. Not only that, even the school transport market for Public Bus is increasing.

The highest market percentage comes from Male students in Elementary level, then Male Intermediate and the last level is Secondary. The school transport market demand is increasing by the percentage of male students who tend to favor Public bus over other modes:

| | |
|---|---|
| MI | 9% |
| ME | 11% |
| MS | 8% |

The market demand for the female students is also increasing for public bus. Female in Secondary is the highest, followed by Elementary then Intermediate. The following is the percentage of female students who tend to favor public bus :

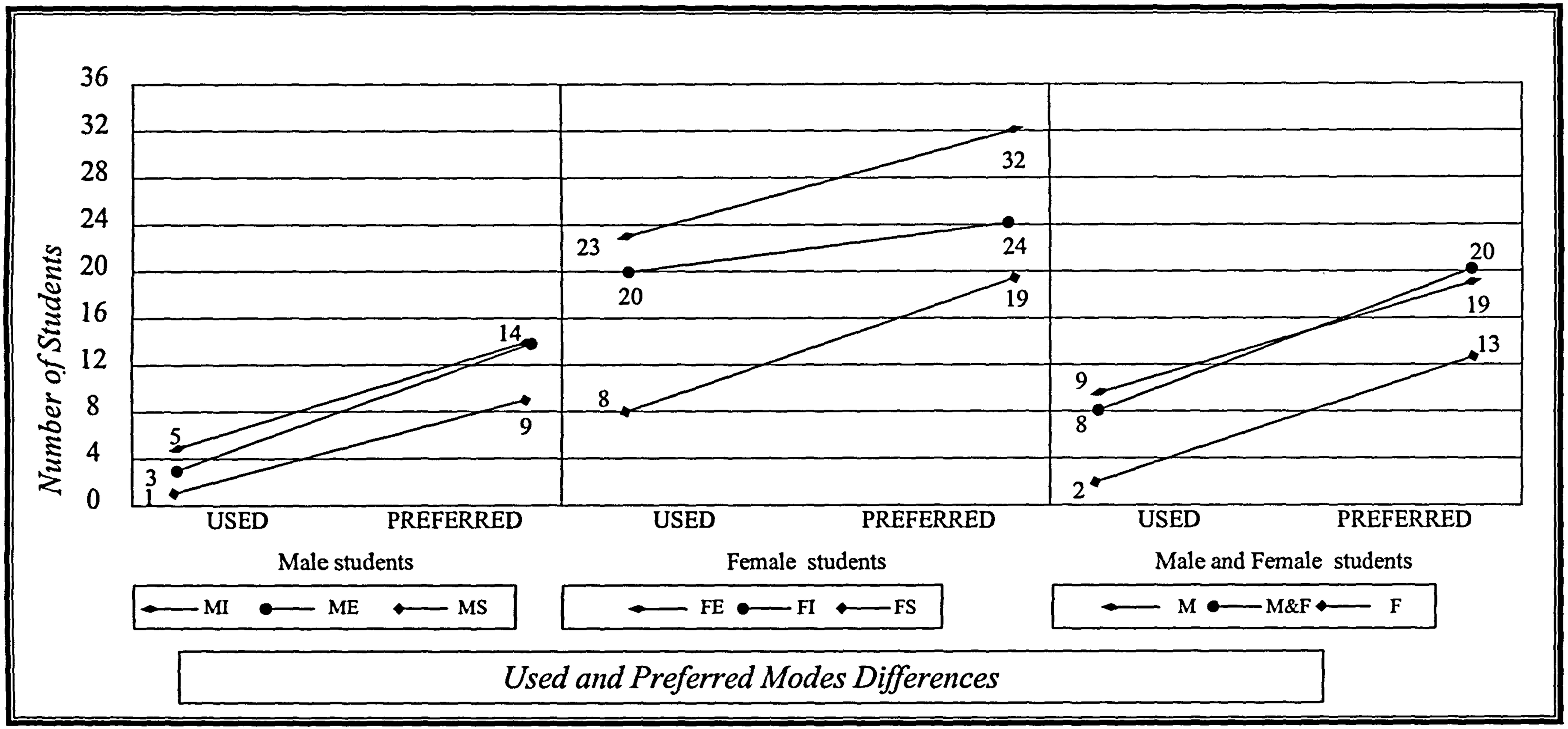
| | |
|---|---|
| FE | 9% |
| FI | 4% |
| FS | 11% |

For Male, Female and M&F, the Market demand towards using Public Bus is increasing and found to be the same percentage, which is:

| | |
|---|---|
| M | 10% |
| F | 11% |
| M & F | 12% |

## Figure 6.4

## Existing Demand Compared to Preferred Demand for Public Bus for School Transport.



## 6.2 MARKET SHARE

In order to use the benefit of this study, we have to relate the results together to understand more about the effects of the attributes, social constraints, socio-demographic factors and the availability of school transport modes on the choice of Saudi families towards choosing the preferred modes from among the different available modes. Through the research, it was found that there are some important variables affecting the choice of school transport modes. The important variables that the school transport companies should take care of are: income, cost, time, comfort, convenience, and number of children in the family. If those attributes are considered well by private companies, their school transport market share will increase and consequently revenue will also increase. The following are the attributes affecting the market share of each mode.

### *6.2.1 Income Attribute:*

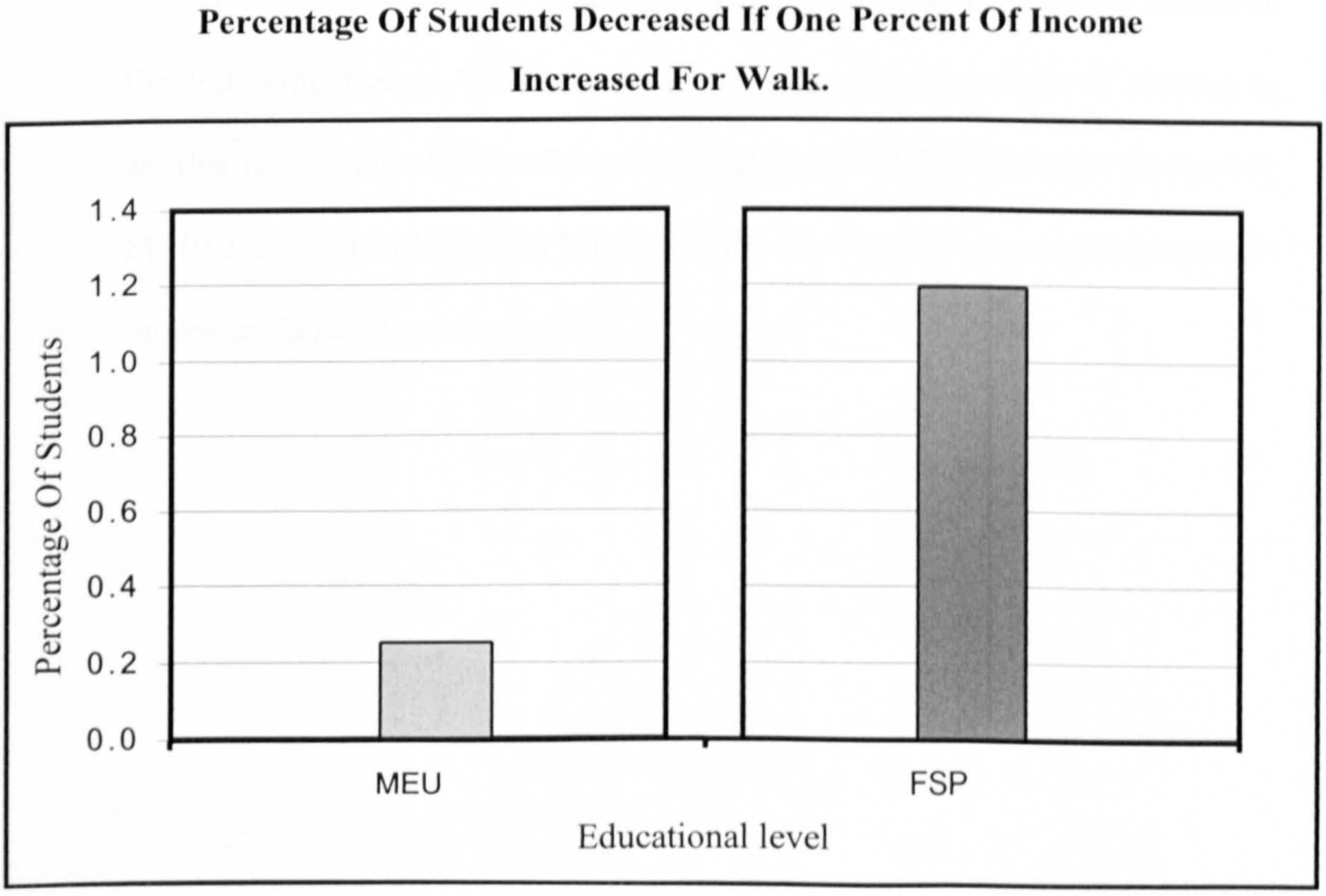
Starting with income; this variable is one of the most influential on mode choice for all levels of education. It is clear, when we know that if income increases, the mode choice preferrability increases; as shown in Figure 6.5 for walk mode. The figure shows a decrease of walking to schools for MEU and FSP. The main reason for this is the increase of income, especially

when we know that 43.0% of the high income families have one car, and 47.7% of the families have more than one car.

For high income families, the constraints of paying more fares for school transport disappeared. This is a chance for transport companies to have the children of the high income families, with the condition of promoting all other attributes for the pupils. Mode choice models proved that if one percent increased on income, the probability of choosing another mode rather than walk increased by 0.256% for MEU and 1.198% for FSP.

**Figure 6.5**

**Percentage Of Students Decreased If One Percent Of Income Increased For Walk.**



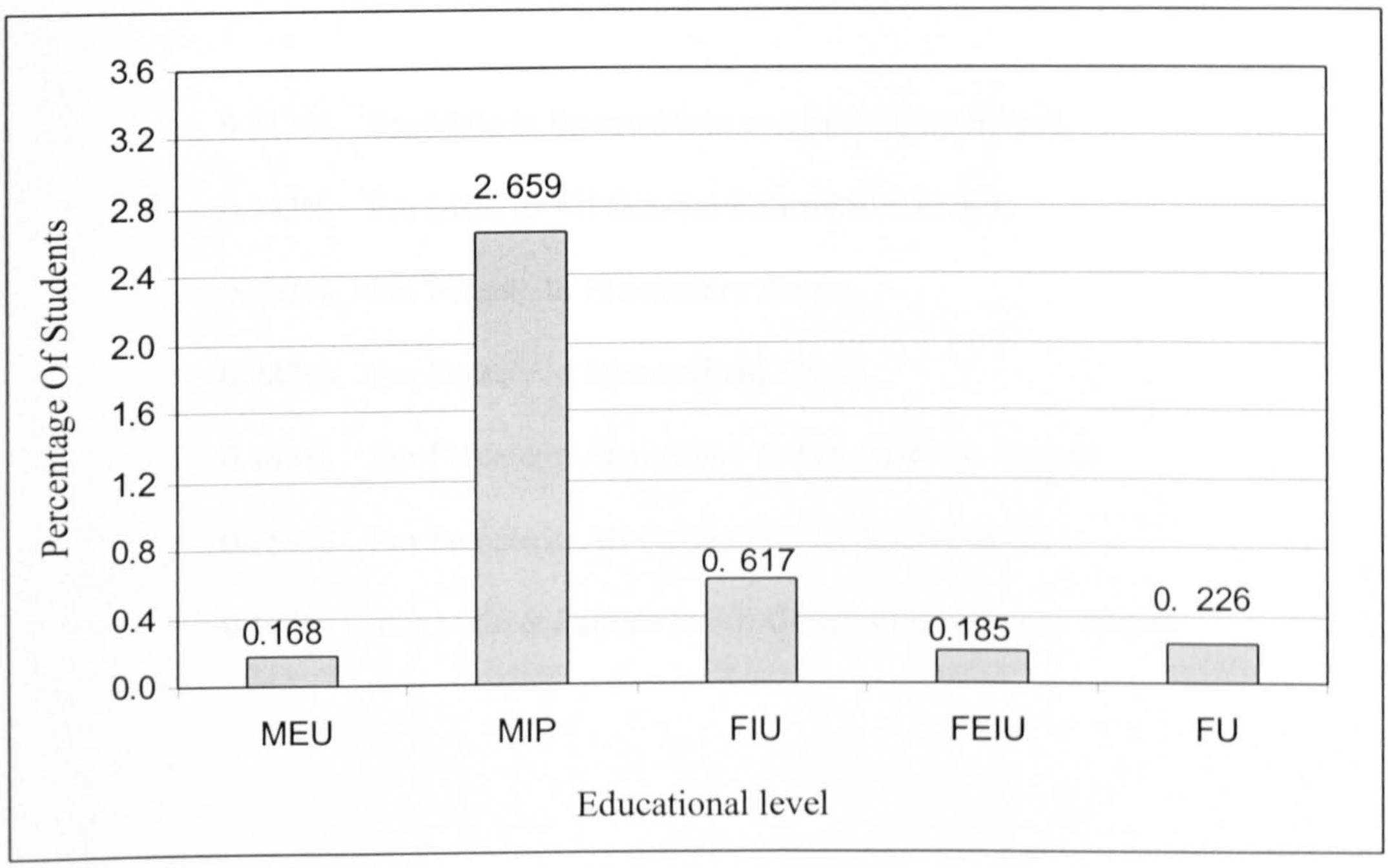
### *6.2.2 Travel Distance Attribute:*

It is reasonable to assume that sensitivity to changes in travel distance for short trips is smaller than for large distances, as in Figure 6.6. When the trip length increases, the traveler begins to perceive differences in travel distance, therefore the sensitivity is larger and significantly different from the short trips. However, for longer trips a difference of, say, one minute, is a very small fraction of the total travel distance.

Thus the sensitivity per meter of travel distance may decrease, as shown in the following figure. When distance increases, the percentage of altering to another mode rather than walking increases, as for MIP (2.659%), FIU (0.617), FU (0.226), FEI (0.185), and MEU (0.168), allowing for other school transport modes to share school transport.

**Figure 6.6**

**Percentage Of Students Decreased If One Percent Of Distance Increases For Walk.**




### *6.2.3 Cost Attribute*

Public bus companies should consider an average cost of school transport mode in order to have the job of transporting pupils. The study shows cost as the first important attribute among all other attributes in the case of Public and School buses, as shown in Figure 6.7. According to the figure, the

bus companies should start with the education stages that have the highest percentage of students willing to use the bus if the cost is decreased, which means that if the public transport companies decrease the cost by one percent, there will be an increase of the students by:

0.213% For Male in Intermediate and Secondary Stages.

0.342% For Male in All General Educational Stages.

0.262% For Female in Elementary Stages.

0.287% For Female in Intermediate Stages.

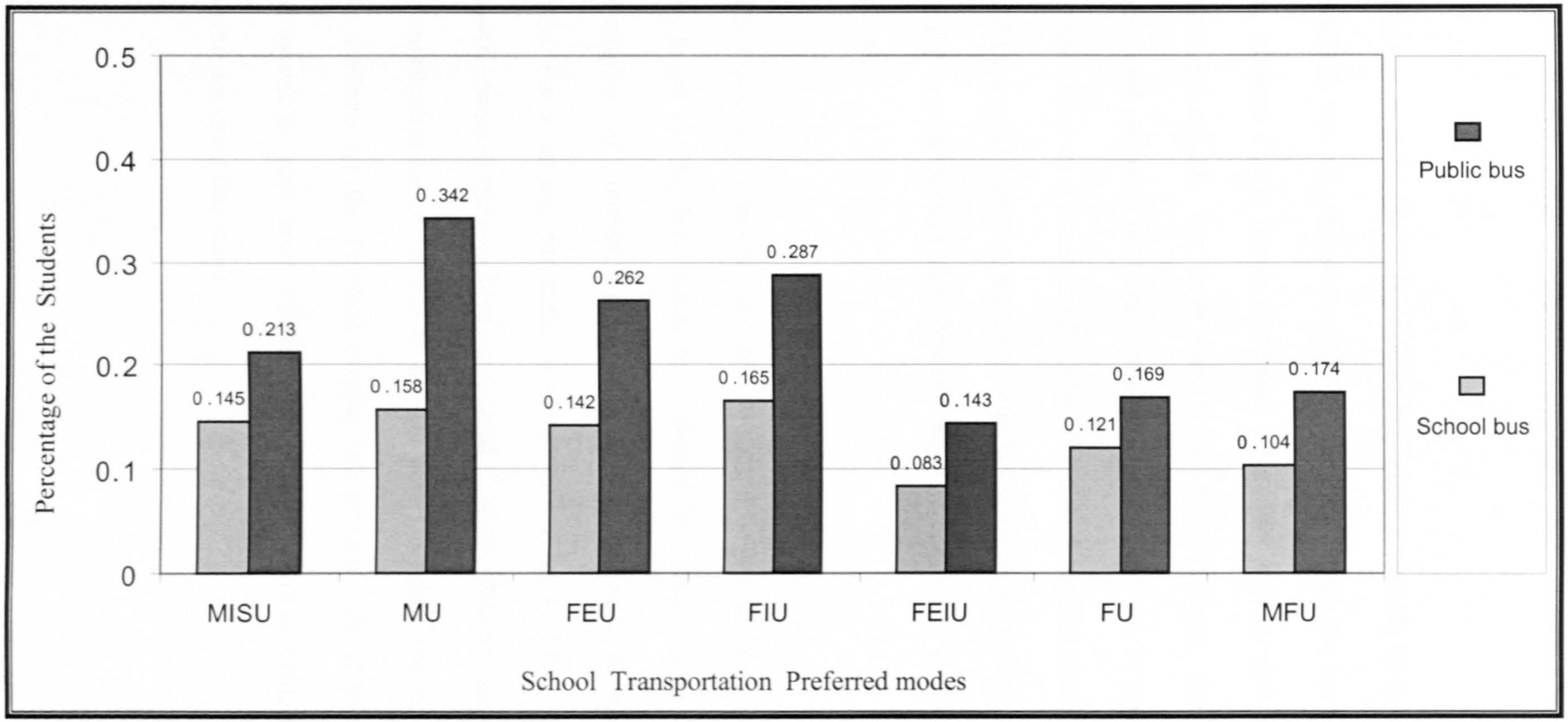
0.143% For Female in Elementary & Intermediate stages.

0.169% For Female in All General Educational Levels.

0.174% For Male & Female in All General Educational stages.

**Figure 6.7**

**Percentage Of Students Increase If One Percent Of Exp./Cost Decreases For Buses**



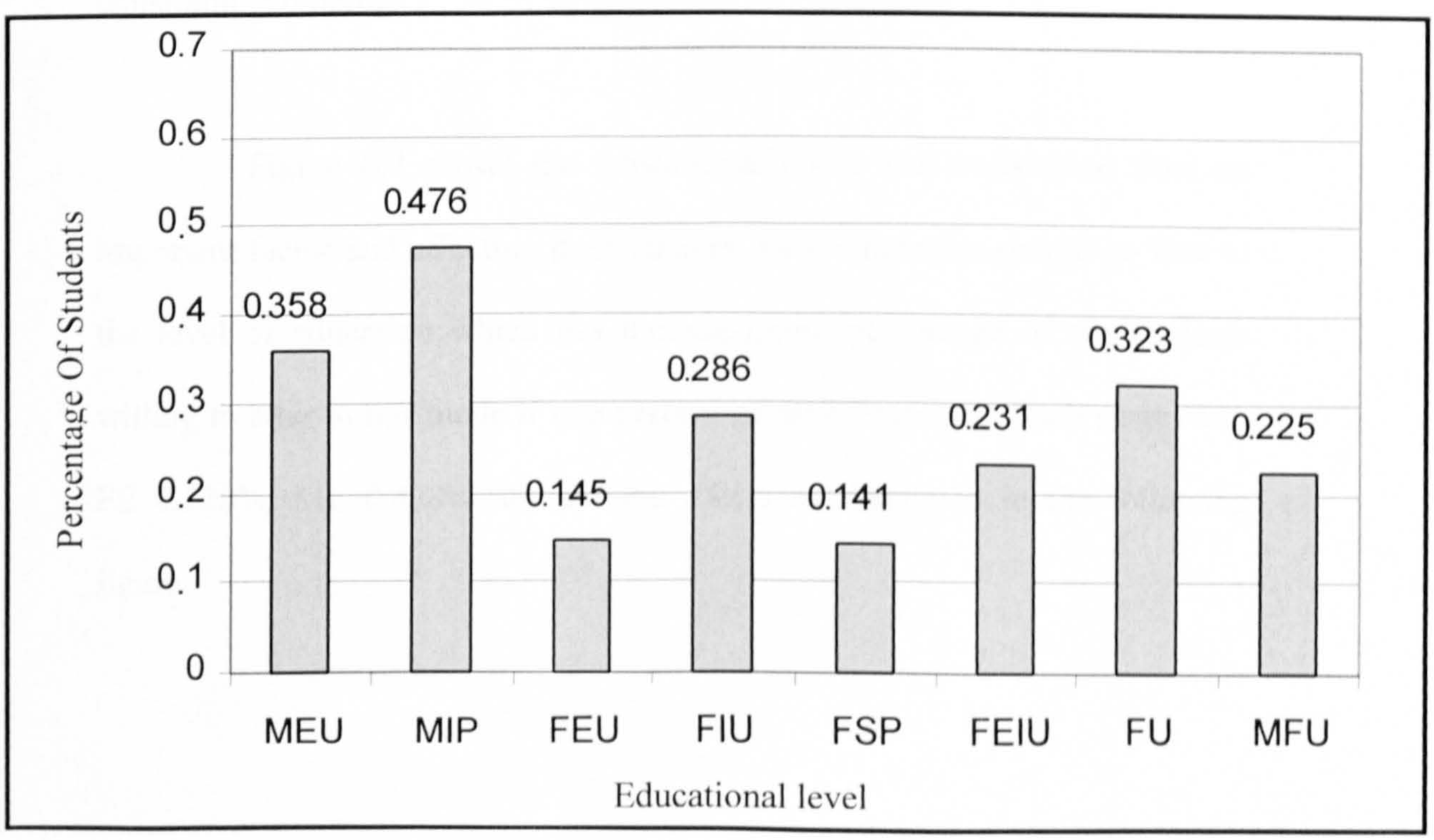
The non-cost for school bus makes this mode preferable by most, but it is not available for all, and some of the important attributes are also not available, whereas Public buses, compared with other modes, still have the lowest cost among all. For both Public and School buses, the lack of organization and provision of them caused problems of non-use by pupils. The cost was considered as a constraint by 22% of the students and their families. This could be a good indicator for the public bus companies to study the cost as one of the most important variables affecting the choices of the pupils and their families.

The mode choice models in this case should be studied well by private sectors to know exactly how much there should be a decrease in cost for different numbers of students, and for each level of education for both male and female. For example, for male in elementary stage (MEU), the mode choice model shows in the weighted aggregated elasticity (WAE) that the most used and preferable mode (which is private car) considers the cost as an important attribute for the families owning the private cars. If the cost is increased by one percent, there will be a decrease of some percentage of the students who are using this mode.

This is clearly shown in Figure 6.8, in another way: lowering the cost of public buses could absorb more students from those who are using private cars in elementary male schools, and similar to all mode choice models for all levels of education.

**Figure 6.8**

**Percentage Of Students Decreased If One Percent Of Cost Increased For Private Car.**



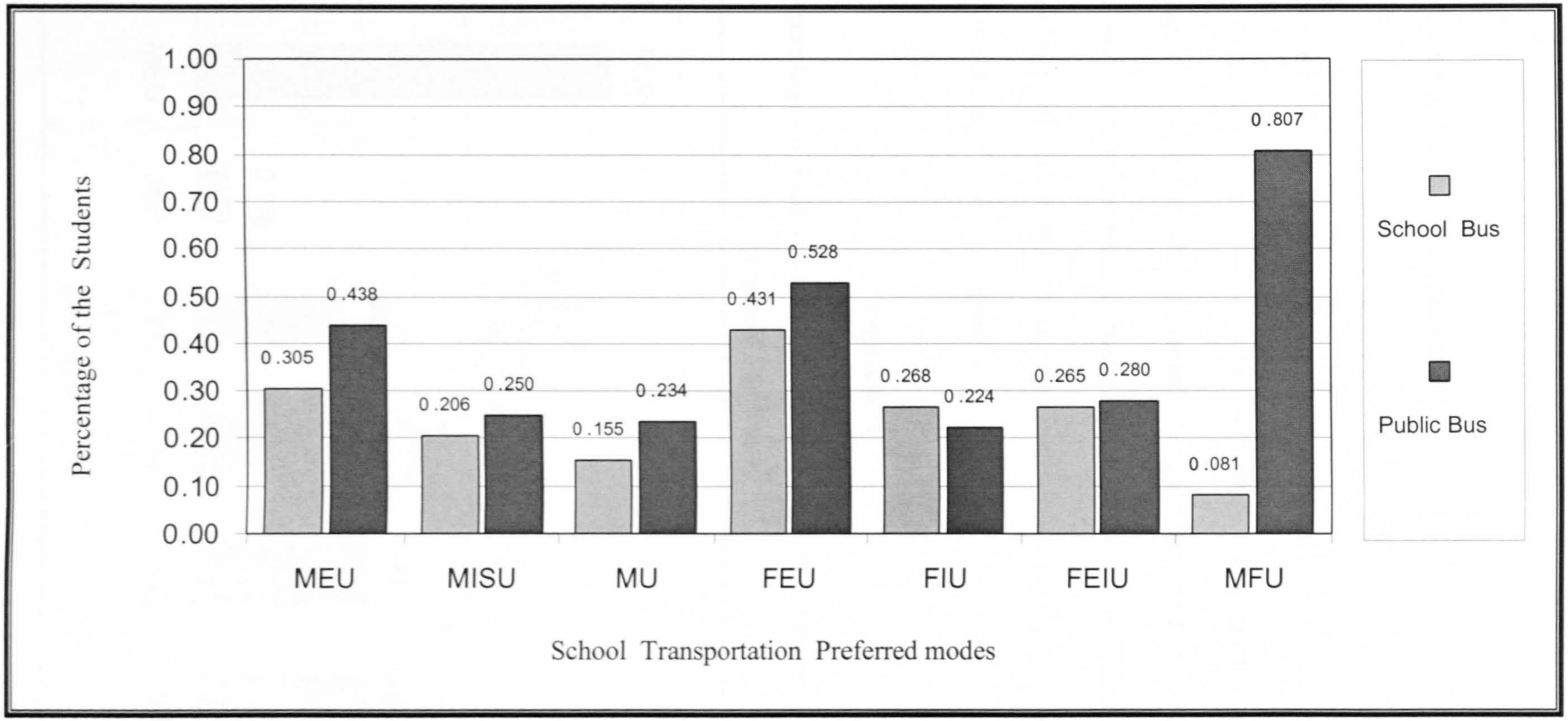
### *6.2.4 Travel Time:*

It is reasonable to assume that the sensitivity to changes in travel time for short trips is very small. When the trip length increases, the traveller begins to perceive differences in travel time and therefore the sensitivity per minute in the second range (20-50) is larger and significantly different from zero. However, for yet longer trips a difference of, say, one minute, is very small fraction of the total travel time. Thus the sensitivity per minute travel time may decrease for the third range (50-80). For the very long trips (80+) the sensitivity again increases. This phenomenon is consistent with the notion of time constraint. A high disutility per minute travel would occur when the time constraint is binding.

Figure 6.9 shows the educational levels that considered time an important factor and affecting their choices. Bus companies should go first to the level of education which has the maximum percentage of the students willing to alter to bus mode if one percent of time decreases. Such stages are: FE 0.528%, ME 0.438% and for the others as illustrated in the following figure.

**Figure 6.9**

**Percentage Of Students Increase If One Percent Of Time Decreased For Buses**

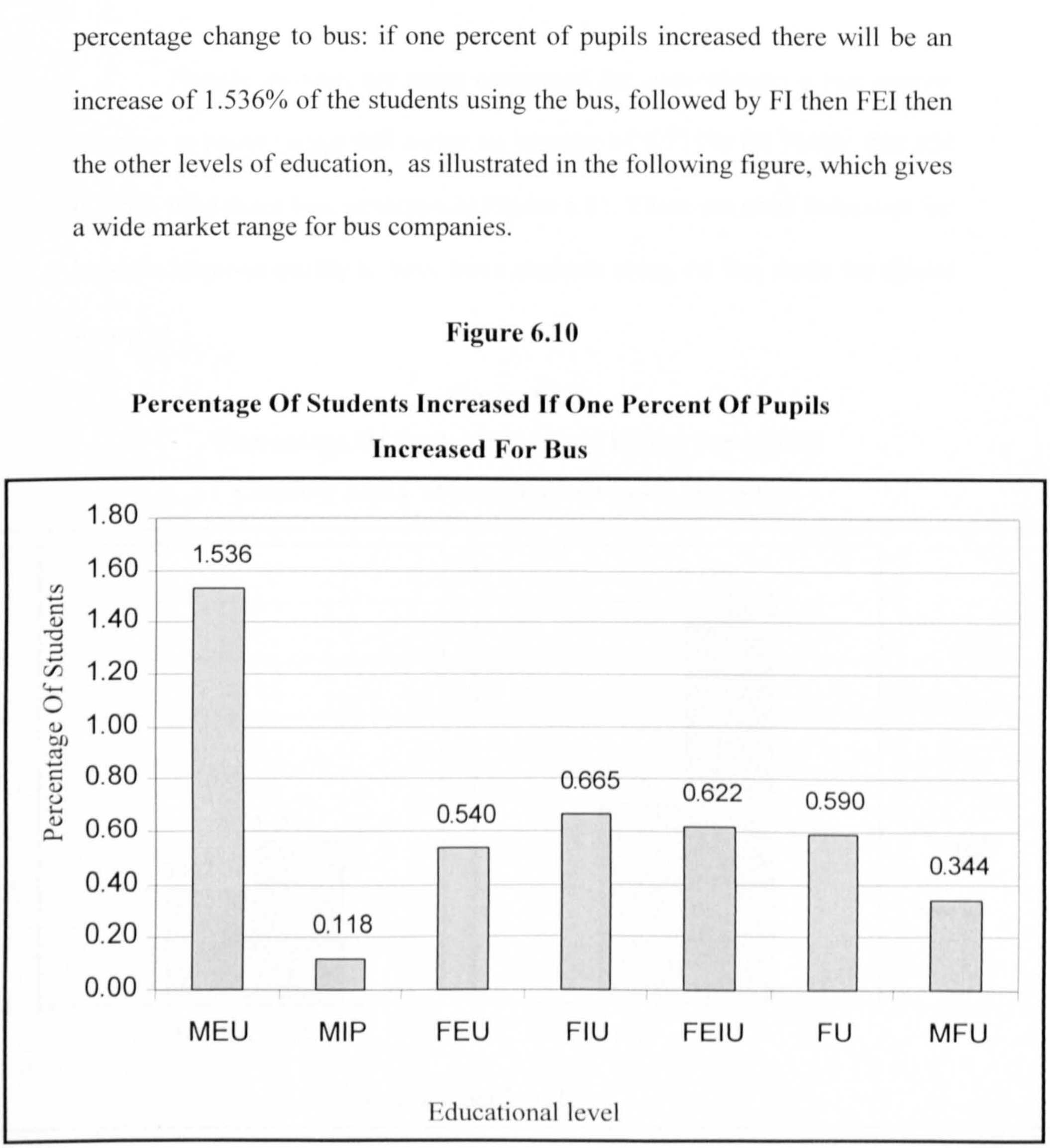


### *6.2.5 Number of Pupils in the family:*

Figure 6.10 shows the tendency of the families to go for bus, when the number of pupils increased. The male elementary stage has the maximum percentage change to bus: if one percent of pupils increased there will be an increase of 1.536% of the students using the bus, followed by FI then FEI then the other levels of education, as illustrated in the following figure, which gives a wide market range for bus companies.

**Figure 6.10**

**Percentage Of Students Increased If One Percent Of Pupils Increased For Bus**



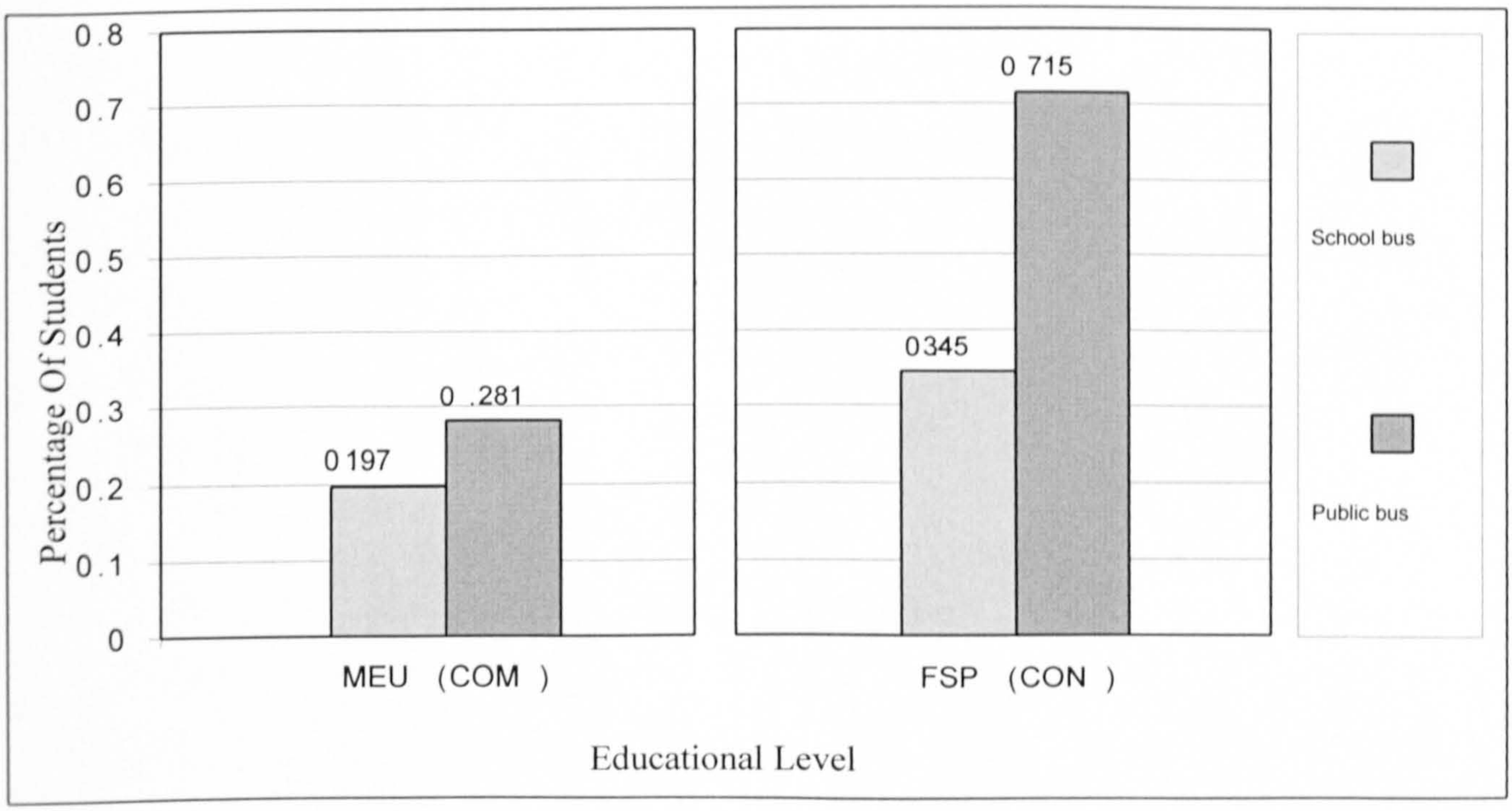
### *6.2.6 Buses' Comfortability and Convenience attributes:*

Male students in elementary are more concerned about Comfortability: an increase of one percent in comfort will cause an increase of 0.281% of the students using the Public bus and 0.197% for School bus, as in Figure 6.11.

Female students are more concerned for convenience: a one percent increase in convenience will cause an increase of 0.715% for Public Bus and 0.345% for School bus, as shown in Figure 6.11. These are good indicators for buses to improve quality to have more students using the bus mode for school transport.

**Figure 6.11**

**Percentage Of Students Increase If One Percent Of Comfort And Convenience Increased For Buses.**



# 7 APPLICATIONS OF MODELS


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# 7. APPLICATIONS OF THE MODELS

In this chapter, the use of the developed models will be explained and demonstrated through some examples. Two classes of applications will be presented: one will involve quick response techniques, and the second will cover techniques involving aggregate predictions using disaggregate models.

## 7.1 Quick Response Techniques

In this section some practical tools for finding quick answers to some practical problems will be described and demonstrated through some examples making use of the developed models. Three methods will be described here: 1) The Use of Demand Elasticities, 2) Incremental Analysis Methods, and 3) Quick Response Charts.

### *7.1.1 Estimation Using Demand Elasticities*

Elasticity of demand V with respect to X, $E_x(V)$, is defined as the percentage change in V for a 1 percent change in X and is given by the following equation (Hensher and Johnson, 1981):

$$E_x(V) = \frac{X}{V} \frac{\partial V}{\partial X} \qquad (7.1)$$

A direct elasticity is the percentage change in market share caused by a 1 percent change in the attribute of that mode. Cross elasticity is the percentage change in market share for alternative i caused by a 1 percent change in an attribute of another alternative. The disaggregate direct and cross elasticities of MNL model as described by Hensher and Johnson (1981) is given by:

$$E_{X_{jkq}}^{P_{iq}} = \beta_{jk} X_{jkq} (d_{ij} - P_{jq}) \qquad (7.2)$$

Where

$d_{ij}$ = 1 if i = j (direct point elasticity)

= 0 if i ? j (cross point elasticity)

$P_{iq}$ = probability of selecting mode i by individual q

$X_{jkq}$ = independent variable k in alternative j for individual q

$\beta_{jk}$ = coefficient estimate for parameter k in mode j utility function

$P_{jq}$ = probability of choosing mode j by individual q

***Example:***

In the utility function of School trip purpose for FIU, the generic coefficient for in-vehicle travel time (INVTT) is 1.58 as in Table 7.0. Let us assume the following values:

The mode choice probabilities

| | |
|---|---|
| Walk : | 17% |
| Private Car: | 52% |
| School Bus: | 18% |
| Public Bus: | 13% |

INVTT values (min):

| | |
|---|---|
| Walk: | 45 min |
| Private Car: | 10 min |
| School bus: | 15 min |
| Public Bus: | 15 min |

Then the direct elasticity of car probability with respect to INVTT of car can be calculated as follows:

$$E^{P_{CAR.q}}_{X_{CAR.INVTT.q}} = -1.58\ (10)\ (1 - 0.52)$$

$$= -7.584$$

which means that a 1 percent increase in travel time by car will cause 7.584 decrease in the market share of car.

The cross elasticity of car probability with respect to INVTT of bus can be calculated as follows:

$$E^{P_{CAR.q}}_{X_{BUS.INVTT.q}} = -1.58\ (15)\ (-0.13)$$

$$= +3.081$$

which means that 1 percent increase in the time of bus will cause a 3.081percent increase in the market share of car.

To find the new probabilities (or market shares) for these changes for the individual q (or market segment q), we follow the following routine:

Suppose the Bus travel time is reduced by 20% because of new small buses:

1% decrease in INVTT causes 3.081% increase in Bus market share

20% decrease in INVTT causes 20 x 3.081= 16.62% increase in Bus market share.

Therefore, the new market share of Bus will be:

= Old share (1+0.166)

= 13 (1.166)

= 15.158%

**Table 7.0**

**FIU Modal-Split Model**

| Independent Variable | Explanation | Coefficient Estimate |
|---|---|---|
| ASC-Walk | Mode-specific constant for Walk | 2.815 |
| ASC-Car | Mode-specific constant for Private Car | -3.254 |
| ASC-Bus | Mode –Specific Constant for School Bus | -4.505 |
| TIME | Total travel time in minutes | -0.158 |
| COST | Out-of-pocket total cost | -0.266 |
| WDIST | Distance for walking | -2.110 |
| CINC | Household Income for Private Car | 0.050 |
| CCOST | Cost for Private Car | -0.055 |
| BCAR | Family size of car for Bus | -0.688 |
| BINC | Household Income for Bus | -1.064 |
| BBOGL | Number of Family's pupils for Bus | -0.234 |

Equation (7.2) gives elasticities for each individual to find aggregate elasticities. One is tempted to evaluate equation (7.2) at the sample average $X_{jk}$ and $\hat{P}_j$ (average estimated $P_j$). However, since the MNL model is nonlinear, the estimated logit function does not need to pass through the point defined by these sample averages. Therefore a more preferable approach is to evaluate equation (7.2) for each individual q and then aggregate, weighing each individual elasticity by the individual's estimated probability of choice (see Hensher and Johnson, 1981). The program (BLOGIT) which was employed for model calibration gives these aggregate elasticities as part of the output.

The elasticities are summarized in Tables 7.1 to 7.8 for School trips. Let us now demonstrate the use of these aggregate elasticities by an example.

***Example:***

The Private car's cost increases by 20%. The current market shares of school trips for Female in all General Educational Levels are as given below:

| | |
|---|---|
| Walk: | 18% |
| Private Car: | 58% |
| School Bus: | 8% |
| Public Bus: | 16% |

What will be the new market share of rented bus(RB)?

For private car, direct elasticity (DE) is to be considered, which is -0.323 (from Table 7.7). Therefore:

1% increase in Private car fare will cause 0.323% decrease in Private car ridership.

20% increase in Private car fare will cause 20 x 0.323 = 6.46% decrease in private car ridership.

The new market share will be:

20 (1-0.0646) = 18.71%

For Public bus, cross elasticity (CE) will be considered. From the results the CE of Bus with respect to cost of Private car is 0.223%, which means that a 1% increase in Private car fare will cause a 0.223% increase in bus share. Therefore the new bus share will be:

16 (1+0.20(0.223)) = 16.71%

**Table 7.1**

**Aggregate Elasticities for MIP**

| | | 1. WALK | 2. CAR | 3. BUS | 4. RNT |
|---|---|---|---|---|---|
| (4) WDIST | DE= | 2.659 | .000 | .000 | .000 |
| | CE= | -8.824 | .000 | .000 | .000 |
| (5) WINC | DE= | .097 | .000 | .000 | .000 |
| | CE= | .196 | .000 | .000 | .000 |
| (6) WBOY | DE= | .026 | .000 | .000 | .000 |
| | CE= | -.056 | .000 | .000 | .000 |
| (7) CCOST | DE= | .000 | -.476 | .000 | .000 |
| | CE= | .000 | 7.204 | .000 | .000 |
| (8) CDIST | DE= | .000 | .638 | .000 | .000 |
| | CE= | .000 | -30.207 | .000 | .000 |
| (9) BBOGL | DE= | .000 | .000 | .118 | .000 |
| | CE= | .000 | .000 | -.232 | .000 |
| (10) TIM | DE= | -.036 | -.006 | -.024 | -.019 |
| | CE= | .076 | .042 | .077 | .114 |
| (11) SAF | DE= | .186 | .026 | .081 | .079 |
| | CE= | -.404 | -.219 | -.445 | -.509 |

Note: DE: Direct Elasticity CE: Cross Elasticity

**Table 7.2**

**Aggregate Elasticities for MU**

| | | 1. WALK | 2. CAR | 3. BUS | 4. RNT |
|---|---|---|---|---|---|
| (4) WDIST | DE= | .013 | .000 | .000 | .000 |
| | CE= | -.055 | .000 | .000 | .000 |
| (5) CINC | DE= | .000 | -.091 | .000 | .000 |
| | CE= | .000 | 13.061 | .000 | .000 |
| (6) CCOST | DE= | .000 | -.097 | .000 | .000 |
| | CE= | .000 | 15.021 | .000 | .000 |
| (7) BCAR | DE= | .000 | .000 | -.198 | .000 |
| | CE= | .000 | .000 | .138 | .000 |
| (8) BINC | DE= | .000 | .000 | .659 | .000 |
| | CE= | .000 | .000 | -.611 | .000 |
| (8) BBOGL | DE= | .000 | .000 | -.091 | .000 |
| | CE= | .000 | .000 | .065 | .000 |
| (9) TIM | DE= | -.035 | -.001 | -.155 | -.234 |
| | CE= | .193 | .094 | .125 | .044 |
| (10) EXP | DE= | -.025 | -.003 | -.158 | -.342 |
| | CE= | .150 | .301 | .103 | .060 |

Note: DE: Direct Elasticity CE: Cross Elasticity

**Table 7.3**
**Aggregate Elasticities for FEU**

| | | 1. WALK | 2. CAR | 3. BUS | 4. RNT |
|---|---|---|---|---|---|
| (4) WDIST | DE= | -.025 | .000 | .000 | .000 |
| | CE= | .046 | .000 | .000 | .000 |
| (5) CINC | DE= | .000 | -.178 | .000 | .000 |
| | CE= | .000 | 19.180 | .000 | .000 |
| (6) CCOST | DE= | .000 | -.145 | .000 | .000 |
| | CE= | .000 | 18.111 | .000 | .000 |
| (7) BCAR | DE= | .000 | .000 | -.475 | .000 |
| | CE= | .000 | .000 | .469 | .000 |
| (8) BINC | DE= | .000 | .000 | .884 | .000 |
| | CE= | .000 | .000 | -1.300 | .000 |
| (9) BBOGL | DE= | .000 | .000 | -.540 | .000 |
| | CE= | .000 | .000 | .504 | .000 |
| (10) TIM | DE= | -.167 | -.003 | -.431 | -.528 |
| | CE= | .490 | .324 | .512 | .274 |
| (11) EXP | DE= | -.445 | -.005 | -.142 | -.262 |
| | CE= | .147 | .327 | .145 | .172 |

Note: DE: Direct Elasticity CE: Cross Elasticity

**Table 7.4**
**Aggregate Elasticities for FIU**

| | | 1. WALK | 2. CAR | 3. BUS | 4. RNT |
|---|---|---|---|---|---|
| (4) WDIST | DE= | -.617 | .000 | .000 | .000 |
| | CE= | .820 | .000 | .000 | .000 |
| (5) CINC | DE= | .000 | .291 | .000 | .000 |
| | CE= | .000 | 9.634 | .000 | .000 |
| (6) CCOST | DE= | .000 | -.286 | .000 | .000 |
| | CE= | .000 | 10.605 | .000 | .000 |
| (7) BCAR | DE= | .000 | .000 | -.520 | .000 |
| | CE= | .000 | .000 | .591 | .000 |
| (8) BINC | DE= | .000 | .000 | 2.783 | .000 |
| | CE= | .000 | .000 | -4.579 | .000 |
| (9) BBOGL | DE= | .000 | .000 | -.665 | .000 |
| | CE= | .000 | .000 | .827 | .000 |
| (10) TIM | DE= | -.151 | -.016 | -.268 | -.224 |
| | CE= | .350 | .212 | .404 | .375 |
| (11) EXP | DE= | -.074 | -.016 | -.165 | -.287 |
| | CE= | .194 | .513 | .222 | .509 |

Note: DE: Direct Elasticity CE: Cross Elasticity

**Table 7.5**
**Aggregate Elasticities for FSP**

| | | 1. WALK | 2. CAR | 3. BUS | 4. RNT |
|---|---|---|---|---|---|
| (4) WINC | DE= | -1.197 | .000 | .000 | .000 |
| | CE= | .669 | .000 | .000 | .000 |
| (5) CINC | DE= | .000 | -.203 | .000 | .000 |
| | CE= | .000 | 4.693 | .000 | .000 |
| (6) CCOST | DE= | .000 | -.140 | .000 | .000 |
| | CE= | .000 | 4.393 | .000 | .000 |
| (7) CDIST | DE= | .000 | .090 | .000 | .000 |
| | CE= | .000 | -4.646 | .000 | .000 |
| (8) BCAR | DE= | .000 | .000 | -.464 | .000 |
| | CE= | .000 | .000 | .346 | .000 |
| (9) BINC | DE= | .000 | .000 | 1.162 | .000 |
| | CE= | .000 | .000 | -1.464 | .000 |
| (10) CON | DE= | .611 | .032 | .715 | .345 |
| | CE= | -.415 | -.650 | -.696 | -1.276 |
| (11) TIM | DE= | -.169 | -.006 | -.180 | -.081 |
| | CE= | .082 | .121 | .198 | .314 |

Note: DE: Direct Elasticity CE: Cross Elasticity

**Table 7.6**
**Aggregate Elasticities for FEIU**

| | | 1. WALK | 2. CAR | 3. BUS | 4. RNT |
|---|---|---|---|---|---|
| (4) WDIST | DE= | -.185 | .000 | .000 | .000 |
| | CE= | .272 | .000 | .000 | .000 |
| (5) CINC | DE= | .000 | -.241 | .000 | .000 |
| | CE= | .000 | 12.008 | .000 | .000 |
| (6) CCOST | DE= | .000 | -.231 | .000 | .000 |
| | CE= | .000 | 12.526 | .000 | .000 |
| (7) BCAR | DE= | .000 | .000 | -.404 | .000 |
| | CE= | .000 | .000 | .364 | .000 |
| (8) BINC | DE= | .000 | .000 | 1.388 | .000 |
| | CE= | .000 | .000 | -1.817 | .000 |
| (9) BBOGL | DE= | .000 | .000 | -.622 | .000 |
| | CE= | .000 | .000 | .548 | .000 |
| (10) TIM | DE= | -.118 | -.004 | -.265 | -.280 |
| | CE= | .284 | .186 | .292 | .231 |
| (11) EXP | DE= | -.028 | -.005 | -.082 | -.143 |
| | CE= | .076 | .185 | .075 | .134 |

Note: DE: Direct Elasticity CE: Cross Elasticit

**Table 7.7**
**Aggregate Elasticities for FU**

| | | 1. WALK | 2. CAR | 3. BUS | 4. RNT |
|---|---|---|---|---|---|
| (4) WDIST | DE= | -.226 | .000 | .000 | .000 |
| | CE= | .281 | .000 | .000 | .000 |
| (5) CINC | DE= | .000 | -.323 | .000 | .000 |
| | CE= | .000 | 13.639 | .000 | .000 |
| (6) CCOST | DE= | .000 | -.323 | .000 | .000 |
| | CE= | .000 | 14.245 | .000 | .000 |
| (7) BCAR | DE= | .000 | .000 | -.554 | .000 |
| | CE= | .000 | .000 | .389 | .000 |
| (8) BBOGL | DE= | .000 | .000 | -.590 | .000 |
| | CE= | .000 | .000 | .456 | .000 |
| (9) TIM | DE= | -.035 | -.001 | -.075 | -.061 |
| | CE= | .069 | -.046 | .069 | .075 |
| (10) EXP | DE= | -.045 | -.008 | -.121 | -.169 |
| | CE= | .098 | .253 | .088 | .223 |

Note: DE: Direct Elasticity CE: Cross Elasticity

**Table 7.8**
**Aggregate Elasticities for MFU**

| | | 1. WALK | 2. CAR | 3. BUS | 4. RNT |
|---|---|---|---|---|---|
| (4) WDIST | DE= | -.015 | .000 | .000 | .000 |
| | CE= | .031 | .000 | .000 | .000 |
| (5) CINC | DE= | .000 | -.220 | .000 | .000 |
| | CE= | .000 | 13.737 | .000 | .000 |
| (6) CCOST | DE= | .000 | -.225 | .000 | .000 |
| | CE= | .000 | 14.879 | .000 | .000 |
| (7) BCAR | DE= | .000 | .000 | -.461 | .000 |
| | CE= | .000 | .000 | .287 | .000 |
| (8) BINC | DE= | .000 | .000 | 1.311 | .000 |
| | CE= | .000 | .000 | -1.180 | .000 |
| (9) BBOGL | DE= | .000 | .000 | -.344 | .000 |
| | CE= | .000 | .000 | .220 | .000 |
| (10) TIM | DE= | -.026 | -.001 | -.081 | -.807 |
| | CE= | .81 | .046 | -.061 | .59 |
| (11) EXP | DE= | -.027 | -.004 | -.104 | -.174 |
| | CE= | .88 | .199 | .064 | .126 |

Note: DE: Direct Elasticity CE: Cross Elasticity

A word of caution is warranted here. The elasticity formulation above is derived from partial differentiation of the choice function, on the assumption that any changes in X are marginal. The model itself should be used for forecasting.

### *7.1.2 Incremental Analysis Methods*

The incremental form of logit model is expressed as:

$$\hat{P}(i:A) = \frac{P(i:A)\ exp\ (\Delta U_i)}{\Sigma_{meA}\ P(m:A)\ exp\ (\Delta U_m)} \qquad (7.3)$$

Where

| | | |
|---|---|---|
| $\hat{P}(i:A)$ | = | revised market share of alternative i out of possible A alternatives available to a trip maker |
| $P(i:A)$ | = | original market share of alternative i. |
| $\Delta U_i$ | = | change in disutility (travel time or travel cost or both) |
| m | = | summation index |

For the School transport in Saudi Arabia, currently, there are four modes, i.e. Walk, Private car, School bus and Public bus. Assume that the

travel time and cost associated with these modes are changed, so that the changes in disutility associated with these modes are given by $\Delta U_{walk}$, $\Delta U_{private\ car}$, $\Delta U_{schoolbus}$, *and* $\Delta U_{public\ bus,}$ respectively.

Using the incremental form of the logit model, the revised market shares are then expressed as:

$$\hat{P}_{walk} = \frac{P_{walk}\ exp\ (\Delta U_{walk})}{P_{walk}\ exp\ (\Delta U_{walk}) + P_{p.c}\ exp\ (\Delta U_{p.c}) + P_{sb}\ exp(\Delta U_{auto}) + P_{PB}\ exp\ (\Delta U_{PB})} \quad (7.4a)$$

$$\hat{P}_{p.c} = \frac{P_{p.c}\ exp\ (\Delta U_{p.c})}{P_{p.c}\ exp\ (\Delta U_{p.c}) + P_{walk}\ exp\ (\Delta U_{walk}) + P_{SB}\ exp\ (\Delta U_{SB}) + P_{PB}\ exp\ (\Delta U_{PB})} \quad (7.4b)$$

$$\hat{P}_{SB} = \frac{P_{SB}\ exp\ (\Delta U_{SB})}{P_{SB}\ exp\ (\Delta\ U_{SB}) + P_{walk}\ exp\ (\Delta\ U_{walk}) + P_{SB}\ exp\ (\Delta U_{SB}) + P_{PB}\ exp\ (\Delta U_{PB})} \quad (7.4c)$$

$$\hat{P}_{PB} = \frac{P_{PB}\ exp\ (\Delta U_{PB})}{P_{PB}\ exp\ (\Delta\ U_{PB}) + P_{walk}\ exp\ (\Delta\ U_{walk}) + P_{PB}\ exp\ (\Delta U_{PB}) + P_{PB}\ exp\ (\Delta U_{PB})} \qquad (7.4d)$$

The changes in disutility expression due to changes in, say, travel time, cost, or both can be expressed as:

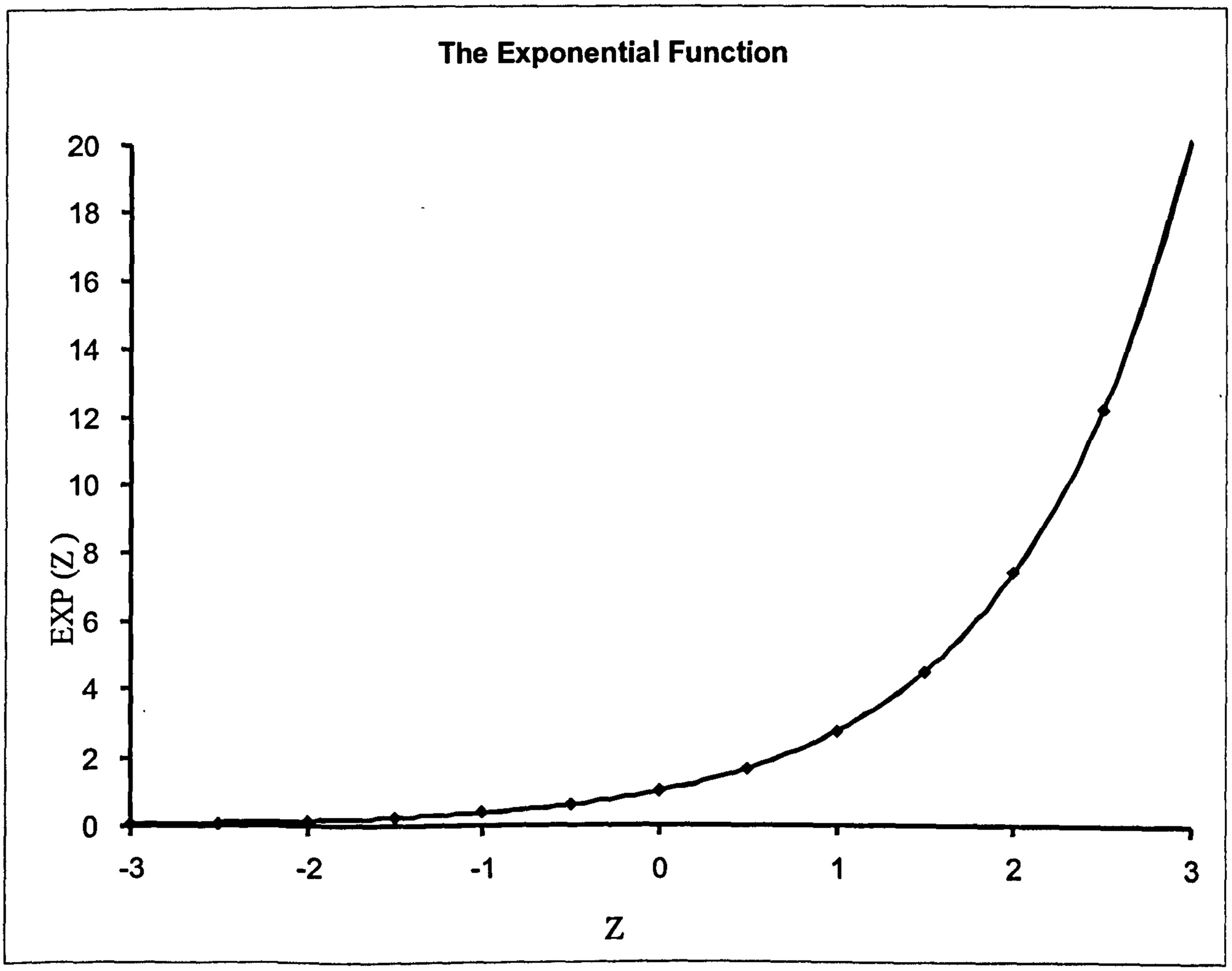
$\Delta\ U_i$ $= \Delta\ U_0$ x (change in cost) + $A_1$ x (change in vehicle travel time).

In order to use the incremental form of the logit model (equation 7.3), the existing market shares, the changes in travel time or cost, or both, and the weight coefficients $A_0$ , $A_1$ , etc., must all be specified. Existing market shares can usually be approximated by first estimating total person trips between O-D pair in question, and then using the results of recent On-Board Surveys, base year O-D Surveys, and any other data sources available for a study area on mode choice. Changes in travel time or cost, or both, can be easily related to systems management policy under consideration. If multinomial logit models have been calibrated for the study area under consideration, then values of weight coefficients $A_0$ , $A_1$ , etc. can be readily substituted in equation (7.3).

For exponential function, as shown in Figure 7.1 and as tabulated in Table 7.9, it can be seen from the figure and table that the exponential function is monotonic (i.e. its value increases when the value of its argument increases) and that its value is always positive, (Koppelman and Lerman, 1986).

# Figure 7.1

# The Exponential Function



## Table 7.9

## The Exponential Function

| Z | EXP(Z) |
|---|---|
| -3.0 | 0.050 |
| -2.5 | 0.082 |
| -2.0 | 0.135 |
| -1.5 | 0.223 |
| -1.0 | 0.368 |
| -0.5 | 0.607 |
| 0.0 | 1.000 |
| 0.5 | 1.649 |
| 1.0 | 2.718 |
| 1.5 | 4.482 |
| 2.0 | 7.389 |
| 2.5 | 12.183 |
| 3.0 | 20.086 |

The use of this technique is demonstrated with the following example.

***Example:***

Changing the starting time of the classes in elementary schools to avoid traffic congestion will improve travel times by car by 10 minutes and School bus travel times by 5 minutes. To offset the loss of market share, Public bus is thinking of reducing the bus fare by 20 SR. Assuming that the present mode shares for MEU are as follows:

| | |
|---|---|
| Walking: | 25% |
| Private Car: | 56% |
| School Bus: | 12% |
| Public Bus: | 7% |

Find the new market shares for each mode.

***Solution:***

The coefficients of time and cost are (as given in Table 7.10) as follows:

| | |
|---|---|
| Time | = -0.247 |
| Cost | = -0.161 |

The incremental values of utilities can be calculated as follows:

$$\Delta U_{Pb} = -0.161(-20) = +3.22$$

$$\Delta U_{bus} = -0.247(-5 \text{ min}) = +1.235$$

$$\Delta U_{auto} = -0.247(10) = +2.470$$

$$\Delta U_{walking} = -0.247(0) = 0$$

Increasing these values and the original probabilities in equations (7.4a), (7.4b) and (7.4c):

$$\hat{P}_{pb} = \frac{0.07 \exp(3.22)}{0 + 0.56 \exp(+2.470) + 0.12 \exp(+1.235) + 0.07 \exp(+3.22)}$$

$$= \frac{0.07 (25.028)}{0 + (0.56 \times 12.036) + (0.12 \times 3.690) + (0.07 \times 25.028)}$$

$$\hat{P}_{pb} = \frac{1.752}{6.740 + 0.443 + 1.752}$$

$$\hat{P}_{pb} = \frac{1.752}{8.935} = 0.196$$

$$\hat{P}_{auto} = \frac{6.740}{8.935} = 0.774$$

$$P_{sb} = \frac{0.443}{8.935} = 0.050$$

TOTAL =1.000

Note that Public bus share decreased by one %. To be sure whether a reduction of 20 SR is sufficient or not, in fact, we can find the exact reduction needed to keep the same market share as follows:

It is required that $\hat{P}_{pb} = P_{pb}$. Therefore using the probability function:

$$0.07 = \frac{0.07 \exp[-0.161(-\Delta C)]}{3.22 + 0.07 \exp[-0.161(-\Delta C)] + 6.740}$$

$$0.07 \exp[-0.161(-\Delta C)] = 0.697 + 0.07 \exp[-0.161(-\Delta C)]$$

Simplifying:

$$0.697 = 0.07 \exp(0.161\ \Delta C)$$

$$\exp(0.161\ \Delta C) = -9.957$$

or

$$0.161\ \Delta C = \ln(9.957)$$

$$\Delta C = \frac{2.298}{0.161}$$

$$\Delta C = 14.273$$

The advantage of this is that one does not have to deal with the whole utility function. It should be noted that this type of analysis is not suitable for estimation demand along a new transportation facility.

### *7.1.3 Quick Response Charts*

Simple charts can be developed which will enable the user to predict changes in model split easily. As an illustration, a chart will be developed for seeing the effect of the most critical service variable (cost) on Public bus share for all levels of education for both male and female.

First of all, since the sample for model calibration was based upon a choice-based sample, the alternative specific constants will not be consistent estimates. To obtain consistent estimates, they should be modified by subtracting ln $(H_g/W_g)$ from the exogenous sample estimate (see Manski and Lerman 1977), where $H_g$ is the sample fraction and $W_g$ is the population fraction.

**Table 7.10**

**Female Elementary Mode Choice Model (FEU)**

| Independent Variable | Explanation | Coefficient Estimate |
|---|---|---|
| ASC-WALK | Mode Specific Constant for Walk | 3.294 |
| ASC-CAR | Mode Specific Constant for Car | -6.212 |
| ASC-BUS | Mode Specific Constant for Bus | 0.827 |
| WDIST | Distance for Walk | -0.088 |
| CCOST | Cost for Car | -0.091 |
| CINC | Household Income for Car | 0.085 |
| BCAR | Number of Cars in Relation to Bus | -0.674 |
| BINC | Household Income in Relation to Bus | -0.432 |
| BBOGL | Number of Household Children in Relation to Bus | -0.195 |
| TIM | Total Travel Time | -0.247 |
| EXP | Total Expenses | -0.161 |

To demonstrate these corrections we will use the female elementary mode choice model (FEU), which is presented in Table 7.10 again for convenience. The estimates of the modal split for each trip purpose were calculated as shown in Table 7.11, using the data of the thesis. Table 7.11 gives the sample fraction and the estimated population fraction.

The true constants can now be estimated as follows:

| | | | |
|---|---|---|---|
| Revised Walk constant | = | 3.294 – 0.00 | = 3.294 |
| Revised Private car constant | = | -6.212 – (-0.04) | = -6.172 |
| Revised Public bus constant | = | 0.827 - 1.50 | = -0.673 |
| Revised School bus constant | = | 0.00 – 2.05 | = -2.05 |

The important thing to note in this example is that we treat the school bus alternative as having an implicit constant of zero, and we adjust it appropriately. Equivalently we could now modify the constants to have again a zero school bus constant by subtracting 2.05 from each, thereby preserving their differences. (It should be realized that one can add an arbitrary constant to all the systematic utilities without affecting the choice probabilities). This would yield the following estimates:

Revised Walk constant = 3.294 - (-2.05) = +5.344

Revised Private car constant = -6.172 - (-2.05) = -4.122

Revised Public bus constant = -0.673 - (-2.05) = +1.377

Revised School bus constant = -2.05 - (-2.05) = 0.00

With this revision, the model can be used with any random data for prediction.

**Table 7.11**

**Example of Adjustment of Alternative Specific Constant for Male Elementary Students' School Trips**

| | Sample | Sample Fraction ($H_g$) | Population | Population Fraction ($W_g$) | ln ($Hg/W_g$) |
|---|---|---|---|---|---|
| **WALK** | 44 | 0.25 | 238 | 0.25 | 0.00 |
| **PRIVATE CAR** | 98 | 0.56 | 564 | 0.58 | -0.04 |
| **PUBLIC BUS** | 20 | 0.12 | 75 | 0.08 | 1.50 |
| **SCHOOL BUS** | 12 | 0.7 | 88 | 0.09 | 2.05 |
| **TOTAL** | 174 | 100 | 965 | 100 | |

### *7.1.4 Investigating the Effect of Gasoline Price and Consequently Private Car Fare Increases*

The gasoline prices increased 15% and due to that private car costs increased by 30% (approximately). The effect of these changes on the market shares of Walking, Private Car, School Bus, and Public Bus can be easily investigated using the models developed in the thesis. This analysis will be performed for MFU, for which there are accurate aggregate travel statistics.

The MFU market share of modes is given again in Table 7.12 (Table 5.31 of the thesis) for convenience. The MFU mode-choice model was calibrated for school trip purpose and is given in Table 7.13 again for convenience (see Table 5.11 of the thesis).

For prediction of the new shares, the "Incremental Analysis Method" explained in section 7.1.2 of this chapter will be used. With this method, the revised market shares can be found as follows:

**Table 7.12**

**Number of Students and Their Split Between the Modes For MFU**

| Mode | Number of Students | Percentage |
|---|---|---|
| Walk | 238 | 24.7 |
| Private Car | 564 | 58.5 |
| School Bus | 72 | 7.5 |
| Public bus | 90 | 9.3 |

**Table 7.13**

**MFU Modal-Split Model**

| Independent Variable | Explanation | Coefficient Estimate |
|---|---|---|
| ASC-Walk | Mode-specific constant for Walk | 3.771 |
| ASC-Car | Mode-specific constant for Private Car | -1.847 |
| ASC-Bus | Mode –Specific Constant for School Bus | -1.074 |
| TIME | Total travel time in minutes | -0.036 |
| COST | Out-of-pocket total cost | -0.103 |
| WDIST | Distance for walking | -0.055 |
| CINC | Household Income for Private Car | 0.071 |
| CCOST | Cost for Private Car | -0.066 |
| BCAR | Family size of car for Bus | -0.494 |
| BINC | Household Income for Bus | -0.471 |
| BBOGL | Number of Family's pupils for Bus | -0.091 |

It should be noted that the model was calibrated in consideration that all travellers are non-captive.

The incremental monthly cost increases in Private Car and Bus travel have been calculated as follows:

$$\Delta COSTT_{BUS} = [(0.30\ SR/liter)/(6\ km/liter)]\ (7\ Km \times 22\ days)$$

$$= 7.7\ SR$$

$$\Delta COSTT_{CAR} = 8\ SR$$

With these, the incremental utilities can be calculated as follows:

$$\Delta U_{CAR} = -0.103\ (8) = -0.824$$

$$\Delta U_{BUS} = -0.103\ (7.7) = -0.7931$$

Inserting the incremental utilities and the original market shares into Equation 7.3 of the thesis, the new market shares can be obtained:

$$\hat{P}_{CAR} = \frac{0.585 \exp(-0.824)}{0.585 \exp(-0.824) + 0.075 \exp(-0.7931) + 0.093 \exp(0) + 0.247 \exp(0)}$$

$$\hat{P}_{CAR} = \frac{0.246}{0.0246 + 0.035 + 0.093 + 0.247}$$

$$\hat{P}_{CAR} = \frac{0.246}{0.621} = 0.39$$

$$\hat{P}_{SCHOOL\ BUS} = \frac{0.035}{0.621} = -0.06$$

$$\hat{P}_{PUBLIC\ BUS} = \frac{0.043}{0.621} = +0.07$$

$$\hat{P}_{WALK} = \frac{0.247}{0.621} = +0.40$$

For comparative purposes, these new market shares are tabulated with the previous market shares in Table 7.14.

As can be seen from this analysis, market shares of Walking and Public Bus were not affected much and Private Car and School Bus lost about 0.4% and 0.06% of their original shares only. This is mainly because auto and bus are the main competitors and since prices of both of the modes have been increased at the same time, they do not suffer much loss in their patronage.

Kingdom-wise, it is also expected that a similar result will prevail and modal shares will not change much with these simultaneous cost increases in Private Car and School Bus modes.

**Table 7.14**

**Changes in Modal Shares for Non-Captive Travellers After the Cost Increases**

| Mode | Before Changes | After Changes | % Change |
|---|---|---|---|
| Walking | 24.7 | 25.10 | 0.40 |
| Private Car | 58.5 | 58.09 | -0.41 |
| School Bus | 7.5 | 7.44 | -0.06 |
| Public Bus | 9.3 | 9.37 | 0.07 |

## 7.2 Aggregate Prediction Using Disaggregate Models

The choice models derived in Chapter 5 predict the probabilities with which any particular individual will take various actions. However, predictions for a specific individual are generally of little use in helping make investment

or planning decisions. Instead, most real-world decisions are based (at least in part) on the forecast of some *aggregated demand*, such as the number of trips of various types made in total by some population or the amount of freight shipped between different locations. Some linkage between the disaggregate level models described previously and the aggregate level forecasts of interest to planners and decision makers is obviously needed.

There are five procedures that can be employed in obtaining aggregate forecasts, which are explained in detail by Koppelman (1975) and summarized below.

1. Average individual. Constructs an "average individual" for the population and uses the choice probability for that average individual as an approximation for W (i).

2. Classification. Divides the population into G nearly homogeneous subgroups with sizes $N_1$, $N_2$, ...,$N_G$ and uses the choice probability of the average individual within each subgroup. $N_T$ (i) is estimated as the weighted sum of the G average individual forecasts, where the weights are the values of $N_g$, g = 1, ...., G.

3. Statistical Differentials. Approximates the distribution of attributes in the population by its moments and uses those moments in an approximation for W(i). Typically only the first and second central moments of the distribution are considered.

4. Explicit integration. Represents the distribution of the attributes in the population with an analytically convenient continuous distribution. This results in an equation as follows:

$$W(i) = \int_X P(i/x)\tilde{p}(x)dx$$

Where $\tilde{p}(x)$ is the approximate distribution of x across the population. Since x will in most applications include both continous and discrete elements, this integration should be thought of in the generalized sense, taking sums or integrals as appropriate. For some combinations of P(i / x) and $\tilde{p}(x)$, a closed-form solution to the integral can be found.

5. Sample enumeration. Uses a sample to represent the entire population. Model is then applied to the sample, and the resulting value of W(i) is used as an estimate of the population's value (Ben-Akiva and Lerman (1985)).

The W(i) mentioned above can be found using the following formula ( Ben-Akiva and Lerman,1985):

$$W(i) = \frac{1}{N_r} \sum_{n=1}^{N_r} P(i/Xn)$$

Where, ($P(i/X_n)$ = probability an individual n chooses an alternative i.

If the distribution of the attributes $X_n$, in the population is continuous and represented by the density function (x), the above equation can be expressed as (Formula 7.3, Ben-Akiva and Lerman,1985):

$$W(i) = \int_x P(i/x)p(x)dx$$

Of all the procedures, sample enumeration is the most flexible in forecasting how policies differentially impact various segments of the population. In contrast, classification-based forecasts can be disaggregated only for the groups originally defined as distinct classes. Unfortunately, the definition of classes that keep the errors of aggregation low is not necessarily the same as that which would provide information on the groups about which forecasts are needed. Explicit integration and statistical differentials do not permit easy disaggregation of population-level forecasts.

Empirical evidence suggests, as described by Hensher and Johnson, that the errors due to aggregation across individuals can be made relatively small without a great deal of difficulty.

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# 8

# *SUMMARY*

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# 8. SUMMARY

The main focus of this research is to study the attitudes (perceptions and feelings) of Saudi households towards different modes of school transport, to identify their preference of modes, to identify the constraints that impede them from choosing their preferred modes, and to examine the relationship between sociodemographic characteristics, attitudes, preferences and choices, as well as to develop potential modal split models.

The theoretical framework of this research was based on the available theoretical constructs of modal choice models and the expected Saudi family behavior. Data required to calibrate the models for school trips were collected by the questionnaire method. The collected data were divided into different files in order to fulfil the requirements of calibrating models for all educational levels for both male and female.

Saudi households use four modes for school transport out of the following six modes incorporated in the study: walking, private car, carpool, limousine/taxi, school bus, and rented bus. The four modes preferred are also the modes that the students are using right now. Saudi families evaluated those six modes in relation to five attributes; comfortability, convenience, security or safety, time, and cost. The highest scores were given to those four modes that are already in use, and are preferred. These four modes are:

1. Walking,
2. Private car,
3. Government school bus, and
4. Rented bus.

It was found that there are some specific and some generic variables more effective on mode choice than the others. These specific variables are: -

1. Distance (Dist).
2. Number of cars (Car),
3. Income (Inc),
4. Number of students- male (Boy),
5. Number of students- male and female (BoGl),
6. Cost (Cost), and
7. Total travel time (TTT).

and the generic variables are:

1. Comfortability
2. Time
3. Expense
4. Convenience, and
5. Safety.

It was found that the walking mode is used and preferred by those households who are near to the schools, mainly by the majority of elementary stage students due to the closeness of the elementary schools to houses. Private cars are preferred by those households who are using them, and mainly for male students in secondary schools, due to their ability to get driver's licence. Those who are using it, such as female students in intermediate and secondary stages, as well as those not served by school buses, such as all male students and elementary female students, prefer the government school bus. The rented school bus is preferred by those who are using it and have experience with it. It is also preferred by families who do not have government school bus availability or if they cannot provide a private car or they have many children going to school from their houses.

The respondents mentioned the following problems associated with the modes of transport they are using: loss of working time when transporting the students by family members, congestion and delay, lack of an organized bus transport system, insufficient number of bus transport vehicles, and crowding of female students inside the school bus.

The majority of the students prefer the government school bus, even though there are some obstacles hindering the students from using it. These obstacles are either the non-availability of this mode for male students, and

female students at elementary stages, or that the school bus cannot reach the house, or that these buses remain over-crowded.

When reviewing the problem of the school transport and the obstacles that hinder the use of preferred means, we observe the similarity and conformity of the obstacles. The major problem of the present school transport is the absence of an organized school bus and rented bus transport. This is the first problem, which constitutes 21.79% of all the problems specified by the families. The main obstacle that prevents the use of the preferred means is the non-availability of it. This obstacle constitutes 40.97% of all obstacles. Another problem that discourages the use of the preferred means is the congestion of female students inside the school bus. This problem constitutes 21% of all problems.

All this implies that if these problems are solved and the obstacles removed, Saudi families will be able to use the preferred means to transport their children to and from schools. This will then reduce the school transport problem by 40%. It is to be noted that 54.4% of the students' sponsors are government employees, and if many of them have to transport their children to and from school by private car at the cost of their office time, the cumulative loss of time is quite significant. Moreover, the traffic congestion will be multiplied remarkably at the beginning and the end of the school hours if the majority of the guardians have to transport their children by private car. Such traffic congestion problems increase the loss of time, as well as dissatisfaction

and discomfort of families. About 86.7% of the private cars' drivers are from the family: either the sponsor himself or one of the elder sons.

Employing a paid driver itself is a costly affair. This study shows that more than 13% of the drivers are paid employees who transport the children to school. If an extra car is to be maintained for the purpose of the school transport then cost of the car is involved.

As mentioned previously that 54.4% of the families are government employees, 45.6% of them transporting their children to schools, and in this case this is a loss of a total productivity of almost 13%, if we consider a daily seven working hours, subtracting one hour spent on school transportation. This is a big loss of national income, as illustrated clearly in the following example:

- Suppose the average income of an employee is 4000SR.
- 13% of the income is equal to 520SR.
- For one year the loss will be 520SR x 8 months = 4160SR

This is 4160SR lost yearly from just one employee, even though the government and private sectors do not recognize it. Let us take another example:

- Suppose the average school transportation cost by a mode such as public bus is 200SR to 300SR with an average of 250SR monthly.

- 520SR lost monthly could transport two students, with a 20SR saving.

For this, the government could provide sufficient school transport for the children of the government employees only with a little payment by pupils' families to help in having proper management and facilities to be compatible with the private companies. This would be to the benefit of the government in avoiding the loss of working hours by the employees, and to the benefit of the family's sponsors in not facing the problem of transporting their children, and to the benefit of all in terms of congestion and pollution due to using private cars for this purpose.

In addition to that, those employees don't feel relaxed, nor do the heads of their departments. Expanding daily working hours to eight hours, allowing one hour for school transportation, would be one solution just for those who like to

do the job of transportation, and this may also be applicable to the private sector, in consideration of more working hours.

Twenty-two types of models have been calibrated for the purpose of school trips at different educational levels. Each of those 22 types has an average of 8 models, as shown in Appendix C. The eleven best models according to goodness of fit measure rho-squared ($\rho^2$) have been chosen for school trips modal choice, by using four alternatives:

1. Walk,
2. Private Car,
3. Government School Bus, and
4. Rented bus.

These were found to be the most used and preferred modes for school trips. The overall prediction ratios for those models show good percentages correctly predicted by the models for the four modes. In addition, the aggregate elasticities of the estimated models are represented.

The estimated elasticities for school transport are interpreted as follows:

First: For the generic variables, comfortability, convenience, safety, time and expenses. All have the same interpretation for all school transport modes. The following is an explanation of direct elasticity for each variable:-

- Comfort, Convenience and Safety.

An increase of one percent of comfort / convenience / safety, of school transport mode, all else remaining constant, causes an increase in the overall probability of school transport mode choice.

- Time and Expense.

These two attributes have the same interpretations. An increase of one percent of actual time or expense of school transport mode, all else remaining constant, causes a decrease in the overall probability of school transport mode choice.

Second: For the specific variables, such as Student (STUDENT) (Number of students in the household), Household's Income (INCOME), Number of family cars (CARS), and Distance (DISTANCE).

All have different interpretation from one mode to another. For example: -

- Distant: An increase of one percent of the distance variable specific to walk mode, all else remaining constant, cause a decrease in the overall probability of the walk mode choice.

Where as, an increase of one percent of the distance variable specific to private car mode, all else remaining constant, cause an increase in the overall probability of the private car mode choice.

- Income: An increase of one percent of the household's income variable specific to school bus mode, all else remaining constant, cause a decrease in the overall probability of the school bus mode choice.

Where as, An increase of one percent of the household's income variable specific to private car mode, all else remaining constant, cause an increase in the overall probability of the private car mode choice.

Those all are clearly explained in the aggregate elasticities of the estimated models by exact percentage increase or decrease for each variable and each school transport mode.

It is found that the market demand for school transport is decreasing forwalking mode by all students, whereas for private car mode it is almost constant, even though there is a demand for private car by male secondary students due to the ability of those students to get a driving license.

For government school bus mode, there is no further demand by pupils to use this type of mode, even it is free of cost, but due to the problems associated with this mode.

Market demand for public bus mode is huge. It is better than any other mode, The demand for this mode by all students creates a big market for public bus companies.

The total percentage of market demand for other school transport modes than the one the households using for all general education levels are:-

**Table No. 8**

The Percentage Of Market Demand

| Educational Level | Percentage |
|---|---|
| Male Elementary | 27% |
| Male Intermediate | 33% |
| Male Secondary | -5% |
| Female Elementary | 20% |
| Female Intermediate | 20% |
| Female Secondary | 17% |
| All Male | 19% |
| All Female | 22% |
| All Male and Female | 21% |

The previous table shows a good market demand, mainly for private companies, either public buses or new transportation company, to share the market of school transport.

It is clear that male intermediate level has the highest market demand percentage, that 33% of the total number of students in the intermediate level are willing to alter to another school transport than the one the are using.

For market share, it is found that there are some variables more important than others affecting mode choice, and consequently affecting market share. Those attributes caused the pupils to favor one specific mode over another were such attributes as total travel time, cost, and income.

## Recommendations For Future Research

The basic recommendations for future research in the area are listed below:

1. This study was done in the city of Dammam. Another study could be done for other suburban areas. This is because the building and settlement layout in Dammam is representative of some settlements but it is not representative of all. Maybe old settlements are quite different.

2. This study took a long time to study all school transportation modes , whereas the used and preferred modes were only four. Another study for school transport may use these four modes: walk, private car, school bus, and public bus, saving time and money of the researcher.

3. This study found that the most important attribute for pupils to choose the mode is the total travel time (Time) and the expense (Exp. /Cost) of the school transport mode. A future study could concentrate only on these two attributes and measure precisely and accurately the amount of time in minutes causing the pupils to change from the used mode to another competitive mode.

4. To study the preference of Government employees as to whether an extra hour in their work or paying money for the job of school transport is acceptable as a solution for the convenience of the guardians, their children and the government for the purpose of school transport

# A

# *APPENDIX*

**Definition of Terms** **281**

# DEFINITION OF TERMS

**ASC** : Alternative Specific Constant.

**TIME A:** Actual travel time: travel time is one of the traditional variables which is used to build mode choice models. It is the time necessary for an individual to complete his trip starting from his origin and continuing to his final destination. In addition, the total travel time can be broken down into the following components:

- In-Vehicle Travel Time: the time spent in the mode.
- Waiting time: the time spent at the terminal before departure.
- Access Time: the time spent on the way to the mode of choice.
- Egress Time: the time spent between leaving the mode and arriving at the final destination.

**COM:** Comfort is a qualitative and attitudinal variable used to explain the behavior of the tripmaker in choosing a mode. It means:

Protection from weather

Cleanliness of vehicle and station

Fatigue felt when travelling

Control of immediate surroundings

Feeling of personal safety

Feeling of privacy

This variable was scaled from 1 to 5 in the questionnaire form, where 1 represents a perception of very good comfort of the mode, and 5 represents very poor comfort.

**CON:** Convenience is a qualitative and attitudinal variable used to explain the behavior of the tripmaker in choosing a mode. It means:

Ease of use

Reliability

Transfers required

Stops required

Frequency of service

Accessibility to means of travel.

Arrive on time

This variable is scaled from 1 to 5 in the questionnaire form, where 1 represents a perception of very good convenience of the mode, and 5 represents very bad convenience.

**TIME:** Time is a qualitative and attitudinal variable used to explain the behavior of the tripmaker in choosing a mode. This variable is scaled from 1 to 5 in the questionnaire form, where 1 represents a perception of very low in time in the mode, and 5 represents very high in time.

**SAFETY (SAF):** Safety is a qualitative and attitudinal variable used to explain the behavior of the tripmaker in choosing a mode. This variable is scaled from 1 to 5 in the questionnaire form, where 1 represents a perception of very safe in the mode, and 5 represents not safe at all.

**EXPENSE (EXP):** Expense is a qualitative and attitudinal variable used to explain the behavior of the tripmaker in choosing a mode. This variable is scaled from 1 to 5 in the questionnaire form, where 1 represents a perception of very expensive of the mode, and 5 represents very cheap.

**STUDENTS:** This represent the number of students in each household.

**INCOME (INC):** Household income is considered to be a major factor in deciding between different modes. This variable is the average monthly household income. Income is expressed in Saudi Riyals (SR).

**CARS:** Number of cars in the student's household. This variable is important as it shows whether the traveler has a complete set of mode choices or he is captive to other modes.

**DISTANCE (DIST):** This variable represents the distance in Km of the schools from the students' houses.

**BoGi:** Number of household's Boys and Girls.

**M:** Male students.

**F:** Female students.

**E:** Elementary stage.

**I:** Intermediate stage.

**S:** Secondary stage.

**W:** Walking Mode.

**C:** Private Car Mode.

**R:** Rented/Public Bus Mode.

**B:** School (Government) Bus Mode.

**(MEU):** Elementary male student used modes

**(MEP):** Elementary male student preferred modes

**(FEU):** Elementary female student used modes

**(FEP):** Elementary female student preferred modes

**(MIU):** Intermediate male student used modes

**(MIP):** Intermediate male student preferred modes

**(FIU):** Intermediate female student used modes

**(FIP):** Intermediate female student preferred modes

**(MSU):** Secondary male student used modes

**(MSP):** Secondary male student preferred modes

**(FSU):** Secondary female student used modes

**(FSP):** Secondary female student preferred modes

**(MEISU):** Male, Elementary, Intermediate, Secondary Used Modes

**(MEISP):** Male, Elementary, Intermediate, Secondary preferred Modes

**(MISU):** Male Intermediate, Secondary Used Modes

**(MISP):** Male Intermediate, Secondary preferred Modes

**(FEISU):** Female, Elementary, Intermediate, Secondary Used Modes

**(FEISP):** Female, Elementary, Intermediate, Secondary preferred Modes

**(FISU):** Female Intermediate, Secondary Used Modes

**(FISP):** Female Intermediate, Secondary preferred Modes

**( MFU):** Male and Female Used Modes

**(MFP):** Male and Female preferred Modes

**ASC –WALK (0)** = Alternative Specific Constant F or Walk Mode.

**ASC – CAR (0)** = Alternative Specific Constant F or Private Car Mode.

**ASC – BUS (0)** = Alternative Specific Constant F or School Bus Mode.

**WDIST (4)** = Distant Specific To Walk Mode.

**WCAR (35)** = Private Car Specific To Walk Mode.

**WINC (36)** = Income Specific To Walk Mode.

**WBOY (37)** = Number of Boys In the Households Specific To Walk Mode.

**WGIRL (38)** = Number of Girls In the Households Specific To Walk Mode.

**WBE (39)** = Number of Boys in Elementary Level Specific To Walk Mode.

**WBI (40)** = Number of Boys in Intermediate Level Specific To Walk Mode.

**WTIME (45)** = Total travel Time Specific To Walk Mode.

**CATIME** (46) = Total travel Time Specific To Private Car Mode.

**BTIME** (47) = Total travel Time Specific To School Bus Mode.

**RTIME** (48) = Total travel Time Specific To Rented Bus Mode.

**CCOST** (49) = Cost Specific To Private Car Mode.

**RCOST** (50) = Cost Specific To Private Car Mode.

**CINC** (51) = Income Specific To Private Car Mode.

**CDIST** (53) = Distant Specific To Private Car Mode.

**CCAR** (54) = Private Car Specific To Private Car Mode.

**CBOY** (56) = Number of Boys In the Households Specific To Private Car Mode.

**CGIRL** (57) = Number of Girls In the Households Specific To Private Car Mode.

**CBI** (59) = Number of Boys in Intermediate Level Specific To Private Car Mode.

**BDIST** (66) = Distant Specific To School Bus Mode.

**BCAR** (67) = Private Car Specific To School Bus Mode.

**BINC** (68) = Income Specific To School Bus Mode.

**BBOY** (69) = Number of Boys In the Houscholds Specific To School Bus Mode.

**WBOGL** (77) = Number of Boys and Girls In the Houscholds Specific To Walk Mode.

**CBOGL** (78) = Number of Boys and Girls In the Houscholds Specific To Private Car Mode.

**BBOGL** (79) = Number of Boys and Girls In the Houscholds Specific To School Bus Mode.

# B

# *APPENDIX*

**Questionnaire** **290**

# QUESTIONNAIRE
## (FOR FEMALE STUDENTS)

**Dear Student Guardians**

This questionnaire is designed to help provide information on attitudes and preferences of Saudi families towards using different transportation modes and evaluating them for the purpose of transporting students to and from schools. Your opinion is very important in this regard. We hope to be able to assist in planning a school transportation system, which would be more satisfactory and convenient for the students. So, please read the questionnaire and answer all questions.

After completing the questionnaire, please check it again to be sure that all items have been answered properly, as the study is a part of the requirements for the degree of Ph.D. in the City and Regional Planning Dept. at Newcastle University, U.K., with the co-operation of King Fahd University of Petroleum and Minerals.

Due to time limitation, would you please complete and return the questionnaire to the school through the student with in 5 days. Your true cooperation and positive participation in doing this research is greatly appreciated. With best regards,

Yours sincerely
**Khodran Al-Zahrani**

# QUESTIONNAIRE

## (FOR MALE STUDENTS)

**Dear Student Guardians**

This questionnaire is designed to help provide information on attitudes and preferences of Saudi families towards using different transportation modes and evaluating them for the purpose of transporting students to and from schools. Your opinion is very important in this regard. We hope to be able to assist in planning a school transportation system, which would be more satisfactory and convenient for the students. So, please read the questionnaire and answer all questions.

After completing the questionnaire, please check it again to be sure that all items have been answered properly, as the study is a part of the requirements for the Ph.D. degree in the City and Regional Planning Dept. at Newcastle University, U.K., with the co-operation of King Fahd University of Petroleum and Minerals.

Due to time limitation, would you please complete and return the questionnaire to the school through the student with in 5 days. Your true cooperation and positive participation in doing this research is greatly appreciated. With best regards,

Yours sincerely

**Khodran Al-Zahrani**

**School: ----------.Level of education: ----------**

## PART I

1. Please indicate the transportation modes used to transport your children to and from schools in all levels of education for both male and female students.

**(Please write only mode number in front of each level of education and the cost of each used mode).**

| Level of education | Male | monthly Cost(SR) | Time ( m) | Female | MonthlyCost (SR) |
|---|---|---|---|---|---|
| Elementary | | | | | |
| Intermediate | | | | | |
| Secondary | | | | | |

| NO | MODE |
|---|---|
| 1 | Walk |
| 2 | Private Car |
| 3 | Carpool |
| 4 | Limousine or Taxi |
| 5 | Public Bus |
| 6 | School Bus |

2. The modes you are using are:

Favorable ☐ Unfavorable ☐

3. In case of having a private car, who is the driver?

Family member ☐ Driver ☐

4. How far is the school from your house:

| Level of education | Boys schools | Girls schools |
|---|---|---|
| Elementary | km | km |
| Intermediate | km | km |
| Secondary | km | km |

5. Please tick ( ✓ )the problem (s) entailed by this existing school transport :

- ☐ The high cost
- ☐ Losing work hours
- ☐ Safety Problems
- ☐ Congestion problems
- ☐ Others (please specify) _____

6. Please tick ( ✓)the reason for not selecting the school bus for the school transport :

- ☐ Absence of govt. school transport bus.
- ☐ Insufficient school transport buses.
- ☐ Crowding in the bus
- ☐ Safety Problems.
- ☐ Others (please specify) _____

---

The questions below ask you to evaluate the different school transport modes with respect to different characteristics. Please circle one number in each row; in each question 1 represents very good and 5 represents a very poor level. You can select only one number from 1 to 5 in each question to indicate your feelings about different characteristics of different means of transportation.

7. Evaluate the following means of transportation with respect to **comfort.**

| | Very good | | | | Very poor |
|---|---|---|---|---|---|
| Walking | 1 | 2 | 3 | 4 | 5 |
| Private Car | 1 | 2 | 3 | 4 | 5 |
| Carpool | 1 | 2 | 3 | 4 | 5 |
| Limousine or Taxi | 1 | 2 | 3 | 4 | 5 |
| Public Bus | 1 | 2 | 3 | 4 | 5 |
| School Bus | 1 | 2 | 3 | 4 | 5 |

8. Evaluate the following means of transportation with respect to **Convenience**

| | Very good | | | | Very bad |
|---|---|---|---|---|---|
| Walking | 1 | 2 | 3 | 4 | 5 |
| Private Car | 1 | 2 | 3 | 4 | 5 |
| Carpool | 1 | 2 | 3 | 4 | 5 |
| Limousine or Taxi | 1 | 2 | 3 | 4 | 5 |
| Public Bus | 1 | 2 | 3 | 4 | 5 |
| School Bus | 1 | 2 | 3 | 4 | 5 |

---

9. Evaluate the following means of transportation with respect to Minimum Time **(walking, waiting, riding)**

| | Very low | | | | Very high |
|---|---|---|---|---|---|
| Walking | 1 | 2 | 3 | 4 | 5 |
| Private Car | 1 | 2 | 3 | 4 | 5 |
| Carpool | 1 | 2 | 3 | 4 | 5 |
| Limousine or Taxi | 1 | 2 | 3 | 4 | 5 |
| Public Bus | 1 | 2 | 3 | 4 | 5 |
| School Bus | 1 | 2 | 3 | 4 | 5 |

---

10. Evaluate the following means of transportation with respect to **Safety**

| | Very safe | | | | Not safe at all |
|---|---|---|---|---|---|
| Walking | 1 | 2 | 3 | 4 | 5 |
| Private Car | 1 | 2 | 3 | 4 | 5 |
| Carpool | 1 | 2 | 3 | 4 | 5 |
| Limousine or Taxi | 1 | 2 | 3 | 4 | 5 |
| Public Bus | 1 | 2 | 3 | 4 | 5 |
| School Bus | 1 | 2 | 3 | 4 | 5 |

11. Evaluate the following means of transportation with respect to **Expenses**

| | Very cheap | | | | Very expensive |
|---|---|---|---|---|---|
| Walking | 1 | 2 | 3 | 4 | 5 |
| Private Car | 1 | 2 | 3 | 4 | 5 |
| Carpool | 1 | 2 | 3 | 4 | 5 |
| Limousine or Taxi | 1 | 2 | 3 | 4 | 5 |
| Public Bus | 1 | 2 | 3 | 4 | 5 |
| School Bus | 1 | 2 | 3 | 4 | 5 |

Please indicate the transportation modes preferred to transport your children to and from schools in all levels of education for both males and females.

( Please write only mode number and the cost in front of each level of education ).

| Level of education | Male | monthly Cost(SR) | Time(m) | Female | monthly Cost(SR) | Time(m) |
|---|---|---|---|---|---|---|
| Elementary | | | | | | |
| Intermediate | | | | | | |
| Secondary | | | | | | |

| NO | MODE |
|---|---|
| 1 | walk |
| 2 | Private Car |
| 3 | Carpool |
| 4 | Limousine or Taxi |
| 5 | Public Bus |
| 6 | School Bus |

12. If your preferred mode(s) are different from the used mode(s), what are the constraints that impede you from using the preferred mode(s)?

(More than one answer can be chosen)

- ☐ High transport time.
- ☐ Non availability of preferred mode.
- ☐ The high expenses of the preferred modes.
- ☐ Non availability of safety procedures.
- ☐ Crowding in the bus.

Others (please specify)_____

## Part II

13. Please mention or tick (  ) as appropriate.

---

14. Family sponsor's Age_____ years.

---

15. Level of education of the family sponsor

    Elementary ☐  Intermediate ☐  Secondary ☐

---

16. Job field in :

    ☐ Government sector ☐ Private sector.

---

17. Number of cars owned by the family, _____ Car(s)

---

18. Household monthly income :

☐ Less than 2000 SR.

☐ 2001 - 4,000 SR.

☐ 4,001 - 6000 SR.

☐ 6001 -8,000 SR.

☐ 8001 - 10000 SR.

☐ 10001 - 12,000 SR.

☐ 12,001 -14000 SR.

☐ More than 14000 SR.

---

19. What is the location of your home ? Plan _____, Section _____.

20. Number of the children in the family?

_____ Male. _____ Female.

21. Educational level of the children :

| Level of education | No.of Males | No. of Females |
|---|---|---|
| Elementary | | |
| Intermediate | | |
| Secondary | | |

22. Please write any other additional remarks or recommendations you may have on the school transportation :

A. _____.

B. _____.

C. _____.

_____

_____

At the end of this questionnaire, I would like to thank you for your cooperation, which will help in improving school transport, hoping that this questionnaire is returned by the student to the school.

## استفتاء للعوائل السعودية بشأن نقل الأباء من وإلى المدارس

عزيزي ولي أمر الطالبة

السلام عليكم ورحمة الله وبركاته

إن الهدف من هذا الاستبيان هو التعرف علـــى رغبـــات العائلـــة السعودية وتفضيلهم لوسيلة نقل الأبناء (طـــلاب وطالبـــات) مـــن والـــى المدارس وذلك من خلال تقييم وسائل المواصلات المختلفة ، وحيـــث أن رأيكم ومساهمتكم في هذا الموضوع يساعد على التخطيط الســـليم لنظـــام النقل المدرسي والذي تعود منفعته لأبناءنا الطلاب والطالبات . لذا نرجـــو قراءة الاستبيان والإجابة على جميع أسئلته.

راجياً الالتزام بالدقة في الإجابة حيث أن هـــذه المعلومـــات وهـــذه الدراسة مهمة وجزء من رسالة الدكتوراه من إدارة التخطـــيط الحضـــري والإقليمي من جامعة نيوكاسل ببريطانيا بالتعاون مع جامعة الملـــك فهـــد للبترول والمعادن.

كما أرجو أن تتم تعبئة الاستبيان وإعادته إلى إدارة المدرسة بواسطة الطالبة في اليوم الثاني من استلامه ، علماً بأن مساهمتكم سوف يكون لها كل التقدير للوصول إلى راحة الطلاب والطالبات .

شاكرين ومقدرين تعاونكم

ولكم خالص تحياتي،،،

المهندس

خضران بن علي القفعي الزهراني

اسم المدرسة : _____موقعها : _____
المرحلة : _____

## الجزء الأول

**1-ما هي وسيلة النقل المستخدمة حالياً لنقل ابناء العائلة من وإلى المدرسة وما هي تكلفة تلك الوسيلة مع ذكرالزمن المستغرق للرحلة .**

| الرقم | الوسيلة |
|---|---|
| 1 | المشي |
| 2 | سيارة خاصة |
| 3 | سيارة تعاونية |
| 4 | ليموزين/تاكسي |
| 5 | حافلة مستأجرة |
| 6 | حافلة المدرسة |

| المرحلة الدراسية | رقم وسيلة النقل للطلاب | التكلفة (بالريال) | الزمن (دقيقة) | رقم وسيلة النقل للطالبات | التكلفة (ريال) | الزمن (دقيقة) |
|---|---|---|---|---|---|---|
| الابتدائية | | | | | | |
| المتوسطة | | | | | | |
| الثانوية | | | | | | |

(فضلاً إختر رقم الوسيلة من خلال الجدول الموضح)

**2- هل الوسيلة / الوسائل المستخدمة حالياً : مرضية ☐ غير مرضية ☐**

**3-في حالة وجود سيارة خاصة لدى العائلة من يتولى قيادتها ؟**

**أحد أفراد الأسرة ☐ سائق ☐**

**4-كم تبعد المدرسة عن المنزل ؟**

| المرحلة الدراسية | مدارس البنين | مدارس البنات |
|---|---|---|
| الابتدائية | كم | كم |
| المتوسطة | كم | كم |
| الثانوية | كم | كم |

**5-من فضلك أشر بعلامة (✓) على المشاكل الحالية للنقل المدرسي:**

- ☐ التكلفة المرتفعة.
- ☐ إهدار ساعات العمل لموظف.
- ☐ عدم توفر وسائل السلامة .
- ☐ الزحام داخل الحافلة .
- ☐ أخرى (من فضلك أذكرها) .....

6-من فضلك أشر بعلاة(✓) على اسباب عدم إستخدام حافلة النقل المدرسي:

- ☐ قلة عدد الحافلات المدرسيـــة.
- ☐ ازدحام الطالبات داخل الحافلة .
- ☐ عدم تفر انقل المدرسي المنظم .
- ☐ عدم توفر وسائل الســـلامة .
- ☐ أخــرى (من فضلك أذكرها) .....

---

عزيزي ولي أمر الطالبة:

الأسئلة التالية تتطلب مقارنة وسائل النقل المختلفة لعملية النقل المدرسي ، فضلاً ضع دائرة واحدة في كل سطر حول الإجابة المناسبة لك( يلاحظ أن رقم واحد هو الأفضل ورقم خمسة هو للأسوأ).

7-فضلاً قارن بين وسائل النقل المختلفة من حيث :

الراحة(comfortable) : مريح بالنسبة للطالبة خلال الرحلة

| | الأفضل | | | | الأسوأ |
|---|---|---|---|---|---|
| المشي | 1 | 2 | 3 | 4 | 5 |
| السيارة الخاصة | 1 | 2 | 3 | 4 | 5 |
| الليموزين أو التاكسي | 1 | 2 | 3 | 4 | 5 |
| حافلة تعاونية | 1 | 2 | 3 | 4 | 5 |
| حافلة المدرسة | 1 | 2 | 3 | 4 | 5 |
| حافلة مستأجرة | 1 | 2 | 3 | 4 | 5 |

---

8- الملائمة (convenience) : المقدرة على استخدام وقت الحاجة اليه في اي وقت مع سهولة الوصول إليه.

| | الأفضل | | | | الأسوأ |
|---|---|---|---|---|---|
| المشي | 1 | 2 | 3 | 4 | 5 |
| السيارة الخاصة | 1 | 2 | 3 | 4 | 5 |
| الليموزين أو التاكسي | 1 | 2 | 3 | 4 | 5 |
| حافلة تعاونية | 1 | 2 | 3 | 4 | 5 |
| حافلة المدرسة | 1 | 2 | 3 | 4 | 5 |
| حافلة مستأجرة | 1 | 2 | 3 | 4 | 5 |

**9- الوقت الإجمالي (total travel time) : للرحلة بما في ذلك وقت الانتظار ووقت ركوب الوسيلة.**

| | الأقل وقت | | | | الأكثر وقت |
|---|---|---|---|---|---|
| المشي | 1 | 2 | 3 | 4 | 5 |
| السيارة الخاصة | 1 | 2 | 3 | 4 | 5 |
| الليموزين أو التاكسي | 1 | 2 | 3 | 4 | 5 |
| حافلة تعاونية | 1 | 2 | 3 | 4 | 5 |
| حافلة المدرسة | 1 | 2 | 3 | 4 | 5 |
| حافلة مستأجرة | 1 | 2 | 3 | 4 | 5 |

---

**10-السلامة( safety) :**

| | الأفضل من حيث السلامة | | | | الأسوأ من حيث السلامة |
|---|---|---|---|---|---|
| المشي | 1 | 2 | 3 | 4 | 5 |
| السيارة الخاصة | 1 | 2 | 3 | 4 | 5 |
| الليموزين أو التاكسي | 1 | 2 | 3 | 4 | 5 |
| حافلة تعاونية | 1 | 2 | 3 | 4 | 5 |
| حافلة المدرسة | 1 | 2 | 3 | 4 | 5 |
| حافلة مستأجرة | 1 | 2 | 3 | 4 | 5 |

---

**11- التكلفة الإجمالية (expenses)**

| | الأقل تكلفة | | | | الأكثر تكلفة |
|---|---|---|---|---|---|
| المشي | 1 | 2 | 3 | 4 | 5 |
| السيارة الخاصة | 1 | 2 | 3 | 4 | 5 |
| الليموزين أو التاكسي | 1 | 2 | 3 | 4 | 5 |
| حافلة تعاونية | 1 | 2 | 3 | 4 | 5 |
| حافلة المدرسة | 1 | 2 | 3 | 4 | 5 |
| حافلة مستأجرة | 1 | 2 | 3 | 4 | 5 |

**12-ما هي وسيلة النقل المفضلة لنقل أبناء العائلة من والى المدرسة؟ وما هي تكلفة تلك الوسيلة مع ذكر الزمن المستغرق للرحلة .**

(فضلاً اختر رقم الوسيلة من خلال الجدول الموضح)

| الرقم | الوسيلة |
|---|---|
| 1 | المشي |
| 2 | سيارة خاصة |
| 3 | سيارة تعاونية |
| 4 | ليموزين/تاكسي |
| 5 | حافلة مستأجرة |
| 6 | حافلة المدرسة |

| المرحلة الدراسية | رقم وسيلة النقل للطلاب | التكلفة (بالريال) | الزمن (دقيقة) | رقم وسيلة النقل للطالبات | التكلفة (ريال) | الزمن (دقيقة) |
|---|---|---|---|---|---|---|
| الابتدائية | | | | | | |
| المتوسطة | | | | | | |
| الثانوية | | | | | | |

---

**13-هل وسيلة النقل المفضلة تختلف عن الوسيلة المستخدمة حالياً؟**

نعم ☐ لا ☐

ـ في حالة الإجابة بلا يرجى الانتقال إلى الجزء الثاني من الاستبيان ، أما في حالة الإجابة بنعم ، فما هي العوائق التي تمنع اختيار الوسيلة المفضلة ( ضع علامة (✓)على الإجابة مع ملاحظ أنه بالإمكان إختيار أكثر من إجابة ) .

☐ عدم توفر الوسيلة المفضلة .

☐التكلفة المرتفعة للوسيلة المفضلة .

☐ عدم إمكانية وصول الوسيلة المفضلة إلى المنزل .

☐ازدحام الطالبات في الوسيلة المفضلة .

☐ أخرى ( من فضلك أذكرها).

## الجزء الثاني

**من فضلك أجب على الأسئلة أو ضع علامة (✓) على الإجابة المناسبة .**

14-عمر رب الأسرة ـــــــــ سنة .

15-المستوى التعليمي لرب الأسرة : ـــــــــــــــــــ

عدد سنوات الدراسة : ـــــــــ سنة .

16-عمل رب الأسرة:

☐ القطاع الحكومي ☐ القطاع الخاص

17-عدد السيارات التي تملكها العائلة ـــــــــ سيارة .

18-الدخل الشهري للعائلة :

- ☐ أقـــل مـــن 2000 ريـــــــال ســـــــعودي.
- ☐ 2001- 4000 ريـــــــال ســـــــعودي.
- ☐ 4001- 6000 ريـــــــال ســـــــعودي .
- ☐ 6001- 8000 ريـــــــال ســـــــعودي .
- ☐ 8001- 10000 ريـــــــال ســـــــعودي .
- ☐ 10001- 12000 ريـــــــال ســـــــعودي .
- ☐ 12000 - 14000 ريـــــــال ســـــــعودي .
- ☐ أكثـــر مـــن 14000 ريـــــــال ســـــــعودي .

19-أين يقع منزلك؟ في مخطط ـــــــــ في حي ـــــــــ أقرب قاطع ـــــــــ

20- ما هو عدد أبناء العائلة ؟

ـــــــ ذكور ـــــــ إناث

21-حدد عدد الأبناء في كل مستوى تعليمي .

| المرحلة الدراسية | عدد الطلاب | عدد الطالبات |
|---|---|---|
| الابتدائية | | |
| المتوسطة | | |
| الثانوية | | |

22- من فضلك أكتب أي معلومات أخرى أو توصيات حول النقل المدرسي ؟

أ ) _____

ب) _____

ج) _____

_____

وفي نهاية هذا الاستبيان أود أن أتقدم إليكم بالشكر على مشاركتكم التي سوف يكــون لها الاثُر المباشر في تطوير وسيلة النقل المدرسي التي سوف تعود بالمنفعة لــىالطلاب بنــين وبنات . راجياً أن ترد هذا الاستبيان عبر الطالبة إلى إدارة المدرسة .

# C APPENDIX

**Coding and Data Program** 305

# TABLE 1 CODING AND DATA PROGRAM ABBREVIATION

| FIELD | QUESTION NUMBER | VARIABLE NAME | INSTRUCTION | DATA PROGRAM COMPUTER ABBREVIATION |
|---|---|---|---|---|
| 1 | None | Level of education | 1. Boys Elementary, | BE |
| | | | 2. Boys Intermediate, | BI |
| | | | 3. Boys Secondary, | BS |
| | | | 4. Girls Elementary, | GE |
| | | | 5. Girls Intermediate, | GI |
| | | | 6. Girls Secondary. | GS |
| 2 | None | Modes | 1=Walking, | W |
| | | | 2= Private Car, | C |
| | | | 3= Carpool, | CP |
| | | | 4= Limousine or Taxi, | LT |
| | | | 5= Rented Public Bus, | RB |
| | | | 6= School Bus, | SB |
| | | | 0=Undefined. | |

| FIELD | QUESTION NUMBER | VARIABLE NAME | INSTRUCTION | DATA PROGRAM COMPUTER ABBREVIATION |
|---|---|---|---|---|
| 3-6 | Q1 | Cost | Cost for each Chosen Mode, for the level of education, for both boys and girls. | COST |
| 7-10 | | Time | Time for each Chosen Mode, for the level of education, for both boys and girls. | TIME |
| | | Distance | Distance for each Chosen Mode, for the level of education, for both boys and girls. | Dist |
| 56 | Q2 | Satisfaction | 0,1=Favorable;<br>0,1=Un-favorable | Satis(1,0) |
| 57 | Q3 | Driver | 1=Family Member, 1=Driver<br>0=Undefined | Driver(1,1,0) |
| 9-12 | Q5 | Use Modes Problems | 1=for each of the assigned problems, 0=for each of the un-decided problems<br>1,0=high cost<br>1,0=losing work hours<br>1,0=safety problems<br>1,0= congestion problems<br>1,0= others | <br><br><br>Problem1<br>Problem2<br>Problem3<br>Problem4<br>Problem5 |
| 13-18 | Q6 | None use of school bus | 1 for each of the assigned problem, 0=for each of the un-decided problem<br>1,0=high cost<br>1,0=losing work hours<br>1,0=safety problems<br>1,0= congestion problems<br>1,0= others | <br><br><br>Note1<br>Note2<br>Note3<br>Note4<br>Note5 |

| FIELD | QUESTION NUMBER | VARIABLE NAME | INSTRUCTION | DATA PROGRAM COMPUTER ABBREVIATION |
|---|---|---|---|---|
| 19-24 | Q7 | Comfort | The scale value for each of the modes,<br>Walking,<br>Private Car,<br>Carpool,<br>Limousine or Taxi,<br>Rented (Public) Bus, and<br>School Bus.<br><br>For Each Mode, one number from the scale<br>(1,2,3,4,5) or<br>0=for each undecided | <br><br>Com 1<br>Com 2<br>Com 3<br>Com 4<br>Com 5<br>Com 6 |
| 25-30 | Q8 | Convenience | The scale value for each of the modes,<br>Walking,<br>Private Car,<br>Carpool,<br>Limousine or Taxi,<br>Rented (Public) Bus, and<br>School Bus.. | <br><br>Con 1<br>Con 2<br>Con 3<br>Con 4<br>Con 5<br>Con 6 |
| | | | For Each Mode, one number from the scale<br>(1,2,3,4,5) or<br>0=for each undecided | |

| FIELD | QUESTION NUMBER | VARIABLE NAME | INSTRUCTION | DATA PROGRAM COMPUTER ABBREVIATION |
|---|---|---|---|---|
| 31-37 | Q9 | Time | The scale value for each of the modes,<br><br>Walking,<br>Private Car,<br>Carpool,<br>Limousine or Taxi,<br>Rented (Public)Bus, and<br>School Bus..<br><br>For Each Mode, one number from the scale<br>(1,2,3,4,5) or<br>0=for each undecided | <br><br>Time 1<br>Time 2<br>Time 3<br>Time 4<br>Time 5<br>Time 6 |
| 38-43 | Q10 | Safety | The scale value for each of the modes,<br>Walking,<br>Private Car,<br>Carpool,<br>Limousine or Taxi,<br>Rented (Public) Bus, and<br>School Bus.. | <br>Safe 1<br>Safe 2<br>Safe 3<br>Safe 4<br>Safe 5<br>Safe 6 |
| | | | For Each Mode, one number from the scale<br>(1,2,3,4,5) or<br>0=for each undecided | |

| FIELD | QUESTION NUMBER | VARIABLE NAME | INSTRUCTION | DATA PROGRAM COMPUTER ABBREVIATION |
|---|---|---|---|---|
| 44 -59 | Q11 | Expense | The scale value for each of the modes,<br>Walking,<br>Private Car,<br>Carpool,<br>Limousine or Taxi,<br>Rented (Public)Bus, and<br>School Bus.<br><br>For Each Mode, one number from the scale<br>(1,2,3,4,5) or<br>0=for each undecided | <br>Exp 1<br>Exp 2<br>Exp 3<br>Exp 4<br>Exp 5<br>Exp 6 |
| 55-58 | Q12 | Cost | Cost for Preferred Mode, for the level of education | COST |
| 59-62 | | Time | Time for Preferred Mode, for the level of education | TIME |
| 59-62 | | Preferability of used mode | 1=Yes, 2=N0, 0=Undecided | yes |
| 40 | Q13 | Constraints | 1=Yes, 2=N0, 0=Undecided<br>1=for each assigned problem<br>0=for undecided | |
| 41-44 | Q13 | | 1,0=Non availability of Preferred mode<br>1,0=The higher expenses of the preferred Mode<br>1,0=Inappropriate routing for the house<br>1,0=Crowding in the bus<br>1,0=Safety Problems | Conn1<br>Conn2<br>Conn3<br>Conn4<br>Conn5 |

| FIELD | QUESTION NUMBER | VARIABLE NAME | INSTRUCTION | DATA PROGRAM COMPUTER ABBREVIATION |
|---|---|---|---|---|
| 45 | Q14 | Age | Age # Years | Age |
| 46 | Q15 | Education | # Years | Edu. |
| 47 | Q16 | Employment | 1=Govt-Sector, 2=Private Sector | Pvt |
| | Q17 | Cars | Number of cars | Cars |
| 48 | Q18 | Household Income (in SRs) | 1=<2000,<br>2=2001-4000<br>3=4001-6000,<br>4 =6001-8000<br>5=8001-10000,<br>6 = 10001-12000<br>7=12001-14000,<br>8 = >14001 | Income |
| 49 | Q20 | | Numer of boys in the family | Boys |
| 50 | Q20 | | Numer of girls in the family | girls |
| 51 | Q21 | | # of Males in Elementary | be |
| 52 | | | # of Females in Elementary | ge |
| 53 | | | # of Males in Intermediate | bi |
| 54 | | | # of Females in Intermediate | gi |
| 55 | | | # of Males in Secondary<br># of Females in Secondary | bs<br>gs |
| 57 | | Used modes | Used mode's number for each level of education | Mode |
| 57 | | Preferred modes | Preferred mode's number for each level of education | Pmode |

**TABLE ( 1 )**
**MODEL RESULTS FOR MODE CHOICE MODELS FOR MALE INTERMEDIATE PREFFERED**
**(ESTIMATED VARIABLE COEFFICIENTS CT- STATISTICS)**

| IND. VARIABLE | | MODEL 1 | MODEL 2 | MODEL 3 | MODEL 4 | MODEL 5 |
|---|---|---|---|---|---|---|
| ASC –WALK | (0) | 2.227(2.256) | 1.084(1.500) | 3.386(2.996) | 1.069(1.487) | 3.434(1.848) |
| ASC – CAR | (0) | -2.171(-1.787) | -1.772(-1.323) | 3.443(3.215) | -2.461(-2.568) | -0.302(-0.133) |
| ASC – BUS | (0) | -4.445(-2.005) | -0.163(-0.158) | -4.848(-0.978) | -2.501(-2.162) | -1.200(-0.288) |
| WDIST | (4) | -0.096(-0.656) | -0.086(-0.789) | 6.007(4.234) | -0.076(-0.700) | 5.202(2.819) |
| WCAR | (35) | 0.263(0.695) | 0.353(1.070) | | 0.631(1.572) | 0.123(0.247) |
| WINC | (36) | -0.138(-0.751) | | -0.087(-0.609) | -0.119(-0.804) | |
| WBOY | (37) | | -0.235(-1.476) | 0.024(0.143) | -0.209(-1.451) | |
| WGIRL | (38) | | | | | |
| WBE | (39) | | | | | |
| WBI | (40) | -0.181(-0.334) | | | | |
| WTIME | (45) | -0.106(-2.556) | | | | |
| CATIME | (46) | 0.995(3.694) | 1.059(4.291) | | | 0.941(3.028) |
| BTIME | (47) | 0.863(1.638) | | 2.712(4.295) | | 2.336(2.954) |
| RTIME | (48) | | | 2.323(4.460) | | 2.027(2.961) |
| CCOST | (49) | -0.024(-4.451) | -0.024(-4.769) | -0.044(-2.890) | -0.024(-4.664) | -0.027(-3.235) |
| RCOST | (50) | | | | | |
| CCOSTU | (51) | 0.015(4.138) | 0.016(4.418) | 0.049(3.336) | 0.016(4.388) | 0.022(2.914) |
| CTIMEU | (52) | | | | | |
| CDIST | (53) | 0.185(0.696) | | 7.243(4.425) | 0.410(0.889) | 5.669(2.874) |
| CCAR | (54) | | | | | |
| CINC | (55) | 0.147(0.654) | | | | |
| CBOY | (56) | | | | | |
| CGIRL | (57) | | | | | |
| CBI | (59) | -0.731(-0.958) | | | | |
| BDIST | (66) | -1.937(-1.413) | | | | |
| BCAR | (67) | | | | | -3.829(-1.424) |
| BING | (68) | 0.096(0.206) | | | 0.197(0.811) | 0.682(0.871) |
| BBOY | (69) | | | | | |
| WBOGL | (77) | | | | | -0.018(-0.076) |
| CBOGL | (78) | | -0.017(-0.117) | | | 0.173(0.643) |
| BBOGL | (79) | | -0.281(-1.632) | 0.078(0.184) | | |
| COM | (82) | | -0.308(-1.741) | | -0.222(-1.560) | |
| CON | (83) | | 0.086(0.610) | | 0.060(0.440) | |
| TIM | (84) | -0.162(-1.222) | -0.055(-0.410) | -0.037(-0.227) | | -0.021(-0.107) |
| SAF | (85) | | 0.160(1.119) | 0.192(1.003) | | |
| EXP | (86) | -0.087(-0.532) | -0.069(-0.463) | | | 0.207(0.849) |
| RHO SQUARED | | 0.639 | 0.538 | 0.714 | 0.531 | 0.817 |

**TABLE ( 2 )**
**MODEL RESULTS FOR MODE CHOICE MODELS FOR GIRLS 450 PREFFERED**
**(ESTIMATED VARIABLE COEFFICIENTS CT- STATISTICS**

| IND. VARIABLE | MODEL 1 | MODEL 2 | MODEL 3 | MODEL 4 | MODEL 5 | MODEL 6 | MODEL 7 |
|---|---|---|---|---|---|---|---|
| ASC-WALK (0) | 0.603(0.956) | 0.987(1.930) | -0.482(-1.104) | -0.3569-0.760) | 0.112(0.164) | 0.353(0.595) | |
| ASC – CAR (0) | 0.7164(1.138) | 0.676(0.923) | 0.951(2.855) | 0.757(1.777) | 0.536(1.824) | 2.343(5.243) | |
| ASC – BUS (0) | 1.082(1.908) | 1.028(1.743) | -0.110(-0.254) | -0.532(-0.867) | -0.046(-0.078) | 0.784(1.441) | |
| WDIST (4) | 0.019(0.373) | 0.038(0.701) | 0.170(2.604) | 0.069(1.216) | -0.043(-0.786) | 0.085(1.562) | |
| WCAR (35) | | -0.004(-0.019) | | | | | |
| WINC (36) | 0.007(0.081) | | 0.23(0.295) | -0.023(-0.265) | -0.061(-0.720) | 0.048(0.589) | |
| WBOY (37) | 0.070(0.719) | | | | | 0.110(1.219) | |
| WGIRL (38) | | | | | | | |
| WTIME (45) | | | | | -0.095(-3.952) | | |
| CATIME (46) | 0.609(5.442) | 0.591(5.321) | | 0.055(4.055) | | | |
| BTIME (47) | | 0.030(1.615) | 0.086(3.948) | 0.051(2.999) | 0.217(3.939) | 0.046(2.451) | |
| RTIME (48) | 0.191(6.491) | 0.204(6.506) | 0.124(7.724) | 0.084(7.927) | | 0.235(7.205) | |
| CCOST (49) | -0.020(-8.301) | -0.020(-8.453) | | | | -0.018(-7.766) | |
| CCOSTU (51) | 0.018(8.748) | 0.018(8,778) | 0.010(7.954) | 0.011(8.114) | 0.009(7.576) | 0.020(8.763) | |
| CDIST (53) | 0.584(3.424) | 0.584(3.757) | 0.203(4.564) | | | 1.003(5.368) | |
| CCAR (54) | | | -0.040(-0.351) | | | | |
| | -0.140(-1.431) | | | -0.110(-1.886) | | | |
| CINC (55) | | | | | | | |
| CBOY (56) | | | | | | | |
| CGIRL (57) | | | | | -0.092(-2.561) | | |
| BTIMEU (65) | | | | | -0.546(-3.914) | | |
| BDIST (66) | | -0.611(-2.368) | -0.379(-1.775) | | -0.482(-2.036) | | |
| BCAR (67) | | 0.161(1.667) | | -0.012(-0.131) | | | |
| BINC (68) | | | | | | | |
| BBOY (69) | | | | | 0.072(1.248) | | |
| WBOGL (77) | | -0.051(-0.759) | -0.025(-0.689) | -0.009(-0.237) | | | |
| CBOGL (78) | -0.24(-0.374) | | | -0.025(-0.392) | 0.038(0.588) | 0.003(0.046) | |
| BBOGL (79) | 0.052(0.606) | 0.049(0.487) | | 0.006(0.097) | -0.019(-0.287) | | |
| COM (82) | | 0.062(0.666) | | | | | |
| CON (83) | -0.139(-1.547) | -0.168(-1.809) | | -0.054(-0.862) | -0.052(-0.823) | -0.164(-2.120) | |
| TIM (84) | | | | | 0.083(1.240) | 0.129(1.613) | |
| SAF (85) | -0.021(-0.251) | | -0.125(-2.222) | -0.100(-1.755) | -0.103(-1.942) | | |
| EXP (86) | | | | | | | |
| RHO SQUARED | 0.575 | 0.583 | 0.213 | 0.207 | 0.189 | 0.499 | |

TABLE ( 3 )

MODEL RESULTS FOR MODE CHOICE MODELS FOR MIU

(ESTIMATED VARIABLE COEFFICIENTS CT- STATISTICS

| IND. VARIABLE | | MODEL 1 | MODEL 2 | MODEL 3 | MODEL 4 | MODEL 5 |
|---|---|---|---|---|---|---|
| ASC-WALK | (0) | 0.883(1.186) | 1.575(2.622) | 0.936(1.579) | 0.830(1.734) | |
| ASC – CAR | (0) | -1.488(-1.420) | 1.188(2.541) | 1.920(3.004) | 0.857(1.845) | |
| ASC – BUS | (0) | -0.494(-0.449) | 0.189(0.203) | -0.694(-0.767) | -0.988(-1.128) | |
| WDIST | (4) | 0.146(1.818) | 0.210(2.391) | | -0.009(-0.228) | |
| WCAR | (35) | -0.043(-0.176) | | 0.159(0.654) | 0.208(0.908) | |
| WINC | (36) | 0.137(1.042) | -0.067(-0.764) | -0.098(-1.074) | -0.112(-1.381) | |
| WBOY | (37) | | -0.013(-0.120) | 0.089(0.765) | | |
| WGIRL | (38) | | | | | |
| WTIME | (45) | | | | | |
| CATIME | (46) | 0.697(4.206) | | | | |
| BTIME | (47) | 0.066(1.682) | 0.092(2.259) | | | |
| RTIME | (48) | 0.072(2.459) | 0.095(2.970) | 0.020(1.543) | | |
| CINC | (49) | -0.020(-5.344) | -0.020(-5.591) | -0.020(-4.695) | | |
| CCOST | (51) | 0.018(5.055) | 0.019(5.690) | 0.021(5.116) | 0.004(2.823) | |
| CDIST | (53) | 0.435(1.928) | 1.422(4.787) | | -0.013(-0.315) | |
| CCAR | (54) | | | 0.426(1.692) | 0.263(1.302) | |
| | | 0.283(1.526) | | | | |
| CCOSTU | (55) | | | | | |
| CGIRL | (57) | | | | | |
| BTIMEU | (65) | | | 0.062(0.088) | 0.008(0.107) | |
| BDIST | (66) | -0.255(-0.481) | | -0.241(-0.458) | -0.208(-0.403) | |
| BCAR | (67) | 0.217(0.922) | | -0.012(-0.057) | -0.040(-0.207) | |
| BINC | (68) | 0.019(0.218) | | | | |
| WBOGL | (77) | -0.033(-0.300) | | -0.039(-0.512) | | |
| CBOGL | (78) | -0.149(-0.860) | -0.208(-1.446) | | | |
| BBOGL | (79) | | | | | |
| COM | (82) | -0.117(-1.177) | | -0.022(-0.304) | -0.078(-1.033) | |
| CON | (83) | 0.233(2.211) | 0.123(1.456) | | 0.142(1.732) | |
| TIM | (84) | | -0.015(-0.172) | | 0.021(0.257) | |
| SAF | (85) | 0.163(1.442) | 0.075(0.801) | 0.067(0.791) | | |
| EXP | (86) | | | | | |
| RHO SQUARED | | 0.511 | 0.350 | 0.232 | 0.471 | |

TABLE ( 4 )

MODEL RESULTS FOR MODE CHOICE MODELS FOR MIP

(ESTIMATED VARIABLE COEFFICIENTS CT- STATISTICS

| IND. VARIABLE | MODEL 1 | MODEL 2 | MODEL 3 | MODEL 4 | MODEL 5 |
|---|---|---|---|---|---|
| ASC-WALK (0) | -0.954(-1.044) | 2.399(2.429) | -0.412(-0.491) | 0.553(0.799) | -0.614(-0.665) |
| ASC – CAR (0) | 0.551(0.445) | 2.192(3.733) | 0.761(0.554) | 1.593(2.137) | 0.892(0.698) |
| ASC – BUS (0) | -0.819(-0.662) | -0.763(-0.487) | -1.273(-1.475) | -1.148(-0.973) | -0.785(-0.675) |
| WDIST (4) | -0.114(-1.556) | 0.042(0.595) | -0.050(-0.746) | -0.100(-1.048) | -0.061(-0.860) |
| WCAR (35) | | -0.505(-1.771) | | | 0.065(0.182) |
| WINC (36) | 0.156(1.091) | 0.207(1.581) | | 0.149(1.436) | 0.224(1.381) |
| WBOY (37) | 0.491(2.201) | 0.331(2.103) | 0.949(2.441) | | 0.942(2.269) |
| WGIRL (38) | | | | | |
| WTIME (45) | | -0.152(-3.475) | | | |
| CATIME (46) | | 0.020(0.737) | | | |
| BTIME (47) | | -0.071(-0.878) | | | |
| RTIME (48) | -0.018(-0.499) | 0.052(1.818) | | -0.015(-0.355) | |
| CINC (49) | -0.022(-3.629) | | -0.025(-3.437) | | -0.024(-3.702) |
| CCOST (51) | 0.021(3.552) | | 0.023(3.436) | 0.017(3.932) | 0.022(3.632) |
| CDIST (53) | 1.351(2.511) | | 1.430(2.635) | -0.191(-2.058) | 1.553(2.697) |
| CCAR (54) | | | -0.808(-2.359) | | |
| | | | 0.251(1.045) | | |
| CCOSTU (55) | | | | | 0.323(1.114) |
| CBOY (56) | | | | | |
| CGIRL (57) | | 0.069(0.909) | | | |
| BTIMEU (65) | | 0.327(1.871) | 0.034(0.493) | 0.049(0.503) | 0.046(0.623) |
| BDIST (66) | | -0.351(-0.449) | | | |
| BCAR (67) | -0.040(-1.057) | -0.449(-0.858) | | | |
| BINC (68) | | | | | -0.237(-0.567) |
| BBOY (69) | | | -0.234(-1.062) | | -0.346(-1.595) |
| WBOGL (77) | 0.224(1.528) | | 0.345(1.880) | 0.027(0.385) | |
| CBOGL (78) | 0.092(0.450) | | | -0.090(-0.535) | |
| BBOGL (79) | | -0.087(-0.707) | | -0.102(-0.837) | 0.058(0.336) |
| COM (82) | | | | | 0.099(0.581) |
| CON (83) | 0.018(0.116) | -0.048(-0.375) | | | |
| TIM (84) | 0.076(0.481) | | | 0.163(1.356) | |
| SAF (85) | | | | | |
| EXP (86) | | | | | |
| RHO SQUARED | 0.552 | 0.228 | 0.568 | 0.193 | 0.555 |

**TABLE ( 5 )**
**MODEL RESULTS FOR MODE CHOICE MODELS FOR BOYS PREFERRED**
**(ESTIMATED VARIABLE COEFFICIENTS CT- STATISTICS**

| IND. VARIABLE | MODEL 1 | MODEL 2 | MODEL 3 | MODEL 4 | MODEL 5 | MODEL 6 | MODEL 7 |
|---|---|---|---|---|---|---|---|
| ASC-WALK (0) | -0.423(-0.445) | -0.046(-0.041) | 0.603(0.757) | 4.847(6.231) | 4.116(5.136) | 4.075(5.183) | 3.281(4.391) |
| ASC – CAR (0) | 1.535(1.448) | 1.589(1.416) | 2.001(1.839) | 0.507(0.669) | -2.147(-0.910) | 0.861(0.586) | 4.168(4.344) |
| ASC – BUS (0) | 0.990(1.217) | 0.74590.696) | 1.305(1.481) | 0.698(0.918) | 0.786(0.984) | 0.603(0.792) | 1.014(1.284) |
| WDIST (4) | 0.110(1.042) | 0.125(1.143) | 0.105(1.023) | -1.324(-5.654) | -0.931(-3.701) | -0.958(-3.524) | |
| WCAR (35) | | -0.103(-0.776) | -0.179(-0.612) | -0.192(-0.611) | -0.214(-0.749) | | -0.290(-1.173) |
| WINC (36) | -0.109(-0.428) | | | 0.069(0.518) | | -0.133(-0.952) | -0.107(-0.763) |
| WBOY (37) | | | | | | 0.238(1.891) | 0.148(1.373) |
| WGIRL (38) | | | | | | | |
| WBI (40) | | | | | | | |
| WTIME (45) | | | | | | | |
| CATIME (46) | | | | | 1.322(2.884) | | |
| BTIME (47) | 0.152(3.846) | 0.154(3.944) | | | 0.017(1.030) | -.016(0.863) | |
| RTIME (48) | -0.031(-4.207) | -0.031(-4.242) | 0.157(3.886) | | 0.047(2.323) | 0.036(1.892) | 0.071(4.518) |
| CCOST (49) | 0.036(5.190) | 0.036(5.215) | -0.031(-4.180) | | -0.064(-2.858) | -0.082(-3.859) | -0.106(-5.277) |
| CCOSTU (51) | 1.145(2.576) | 1.089(2.493) | 0.036(5.188) | 0.03698.627) | 0.069(3.254) | 0.094(4.510) | 0.134(6.550) |
| CDIST (53) | -0.456(-1.494) | -0.542(-1.714) | 1.142(2.567) | -0.139(-1.821) | | 1.796(2.514) | |
| CCAR (54) | | | -0.541(-1.624) | -0.076(-0.245) | | | -0.201(-0.484) |
| CINC (55) | | | | | | | |
| CBOY (56) | | | | | | | |
| CGIRL (57) | | | | | | | |
| CBI (59) | 0.071(0.647) | 0.080(0.728) | | | | | |
| BTIMEU (65) | -0.729(-1.836) | -0.925(-2.066) | 0.067(0.613) | 0.092(-1.442) | | | 0.114(1.888) |
| BDIST (66) | 0.142(0.970) | 0.110(0.700) | -0.908(-2.148) | -0.428(-1.185) | -0.487(-1.399) | | -0.553(-1.759) |
| BCAR (67) | 0.145(0.838) | 0.121(1.028) | 0.149(1.028) | 0.321(2.177) | 0.348(2.486) | 0.172(1.151) | 0.293(1.793) |
| BINC (68) | | | | | | | |
| BBOY (69) | 0.093(0.798) | 0.145(1.083) | | | 0.096(1.292) | | |
| WBOGL (77) | | 0.121(0.912) | 0.054(0.494) | | 0.334(1.505) | 0.205(1.313) | -0.048(-0.385) |
| CBOGL (78) | 0.235(1.544) | 0.158(1.078) | | | | | |
| BBOGL (79) | | | 0.210(1.387) | | 0.267(1.830) | 0.263(1.833) | |
| COM (82) | -0.234(-1.710) | -0.026(-1.885) | -0.093(-0.725) | -0.083(-0.091) | -0.272(-2.226) | -0.265(-2.215) | -0.268(-3.114) |
| CON (83) | | 0.057(0.4440 | -0.198(-1.454) | 0.028(0.300) | | | |
| TIM (84) | -0.147(-1.152) | -0.153(-1.203) | | -0.187(-1.882) | -0.263(-2.110) | -0.265(-2.182) | |
| SAF (85) | | | -0.158(-1.245) | | | | -0.128(-1.217) |
| EXP (86) | | | | | | | |
| RHO SQUARED | 0.502 | 0.504 | 0.501 | 0.651 | 0.779 | 0.763 | 0.695 |

# TABLE( 6 )

## MODEL RESULTS FOR MODE CHOICE MODELS FOR ELEMENTARY GIRLS USED (ESTIMATED VARIABLE COEFFICIENTS CT- STATISTICS

| IND. VARIABLE | | MODEL 1 | MODEL 2 | MODEL 3 | MODEL 4 | MODEL 5 | MODEL 6 | MODEL 7 |
|---|---|---|---|---|---|---|---|---|
| ASC-WALK | (0) | 4.008(2.773) | 4.606(3.855) | 3.294(4.089) | 4.957(4.509) | 3.922(3.029) | 4.492(3.176) | 3.549(3.040) |
| ASC – CAR | (0) | -1.110(-0.416) | 1.065(1.009) | -6.212(-1.559) | 1.377(1.357) | -7.108(-0.639) | -0.456(-0.187) | -1.138(-1.173) |
| ASC – BUS | (0) | 1.213(0.875) | 1.572(1.384) | 0.827(0.842) | 1.685(1.584) | 0.857(0.628) | 1.444(1.026) | -0.014(-0.019) |
| WDIST | (4) | -0.978(-2.767) | -1.182(-3.163) | -0.088(-0.162) | -1.037(-2.681) | -1.080(-2.769) | -1.037(-2.914) | -0.134(-0.224) |
| WINC | (36) | -0.124(-0.599) | -0.195(-1.073) | | -0.260(-1.373) | | -0.131(-0.678) | |
| WBOY | (37) | | -0.053(-0.252) | | | | | |
| WGIRL | (38) | | | | | | | -0.155(-2.087) |
| WTIME | (45) | | | -0.141(-2.001) | | | | 0.117(2.121) |
| CATIME | (46) | | 0.015(0.657) | 3.625(2.053) | | | | |
| BTIME | (47) | 0.175(2.875) | | | 0.079(1.657) | 0.173(2.832) | 0.178(2.959) | |
| RTIME | (48) | | 0.038(1.426) | | 0.078(2.090) | | | |
| CINC | (49) | -0.034(-2.212) | | -0.091(-2.240) | | -0.065(-1.183) | -0.033(-2.191) | |
| CCOST | (51) | 0.076(3.089) | 0.039(5.872) | 0.085(2.408) | -0.041(5.834) | 0.143(1.166) | 0.075(3.301) | 0.039(5.793) |
| CDIST | (53) | 2.396(1.693) | -0.105(-1.064) | | 0.104(0.679) | 5.471(1.096) | 2.333(1.658) | -0.173(-2.245) |
| CCAR | (54) | | | | -0.727(-2.001) | -4.216(-0.838) | | |
| | | 0.080(0.169) | | | | 1.518(0.699) | | -0.045(-0.248) |
| CCOSTU | (55) | | | | | | | |
| CGIRL | (57) | | | | | | | -0.006(-0.135) |
| BTIMEU | (65) | -0.478(-2.816) | | | | -0.504(-3.006) | -0.503(-3.016) | -0.415(-2.563) |
| BDIST | (66) | -0.846(-1.956) | -0.313(-0.810) | -0.674(-1.793) | -0.616(-1.506) | -0.737(-1.725) | -0.820(-1.940) | -0.343(-0.814) |
| BCAR | (67) | 0.674(2.584) | 0.329(1.870) | 0.432(2.268) | 0.370(2.064) | 0.699(2.817) | 0.648(2.535) | 0.433(2.095) |
| BINC | (68) | -0.076(-0.526) | | | | -0.155(-1.066) | -0.107(-0.747) | 0.154(1.362) |
| WBOGL | (77) | -0.662(-1.745) | -0.400(-2.683) | | -0.281(-2.074) | -0.898(-1.137) | -0.626(-2.201) | |
| CBOGL | (78) | -0.424(-2.286) | -0.253(-1.852) | -0.195(-1.566) | -0.272(-2.197) | -0.437(-2.317) | -0.440(-2.322) | -0.120(-0.882) |
| BBOGL | (79) | | | | | -0.319(-1.942) | | -0.057(-0.365) |
| COM | (82) | | | | | | | |
| CON | (83) | -0.173(-1.083) | -0.199(-1.544) | -0.247(-1.664) | -0.193(-1.427) | | | -0.153(-1.045) |
| TIM | (84) | -0.219(-1.427) | -0.266(-1.919) | | -0.318(-2.157) | | -0.252(-1.682) | -0.221(-1.468) |
| SAF | (85) | | 0.057(0.411) | -0.161(-1.030) | 0.116(0.790) | -0.080(-0.470) | | 0.109(0.783) |
| EXP | (86) | | | | | | | |
| RHO SQUARED | | 0.740 | 0.604 | 0.740 | 0.621 | 0.745 | 0.736 | 0.611 |

**TABLE( 7 )**
**MODEL RESULTS FOR MODE CHOICE MODELS FOR GIRLS INTERMEDIATE USED**
**(ESTIMATED VARIABLE COEFFICIENTS CT- STATISTICS)**

| IND. VARIABLE | | MODEL 1 | MODEL 2 | MODEL 3 | MODEL 4 | MODEL 5 | MODEL 6 |
|---|---|---|---|---|---|---|---|
| ASC –WALK | (0) | 4.383(3.2340 | 4.380(3.222) | 4.228(3.198) | 5.151(4.719) | 5.269(3.798) | 2.815(2.915) |
| ASC – CAR | (0) | 2.108(1.286) | -6.638(-1.579) | 2.266(1.385) | 1.186(1.208) | -6.039(-1.467) | -3.254(-1.952) |
| ASC – BUS | (0) | -5.934(-1.997) | -12.308(-3.023) | -5.771(-1.953) | 2.063(2.521) | -0.763(-0.830) | -4.505(-2.302) |
| WDIST | (4) | -2.262(-3.717) | -1.334(-3.468) | -2.511(-3.824) | -1.395(-3.426) | | -2.110(-1.608) |
| WCAR | (35) | | | | -0.212(-0.526) | | |
| WINC | (36) | -0.065(-0.322) | -0.181(-0.798) | | -0.314(-1.678) | -0.370(-1.822) | |
| WBOY | (37) | | | | | | |
| WGIRL | (38) | | | | | | |
| WBE | (39) | | | | | | |
| WBI | (40) | | | | | | |
| WTIME | (45) | | -0.151(-1.909) | | | -0.224(-2.792) | -0.045(-0.311) |
| CATIME | (46) | | 1.887(2.093) | | | 1.871(1.915) | 1.104(2.710) |
| BTIME | (47) | 0.129(2.120) | 0.050(0.896) | -0.123(2.038) | | 0.111(2.026) | |
| RTIME | (48) | | 0.215(3.143) | | | 0.066(1.814) | |
| CINC | (49) | -0.046(-3.811) | -0.076(-2.001) | -0.050(-3.929) | | -0.076(-2.005) | -0.050(-3.592) |
| RCOST | (50) | | | | | | |
| CCOST | (51) | 0.061(4.522) | 0.073(2.210) | 0.062(4.646) | 0.041(5.874) | 0.069(2.255) | 0.055(3.738) |
| CTIMEU | (52) | | | | -0.126(-1.623) | | |
| CDIST | (53) | 0.958(1.549) | 2.128(1.410) | 1.109(1.720) | -0.808(-2.127) | 1.871(1.283) | |
| CCAR | (54) | | | -0.238(-0.462) | | | |
| CCOSTU | (55) | | | | | | |
| CBOY | (56) | | | | | | |
| CGIRL | (57) | | | | | | |
| CBI | (59) | | | | | | |
| BDIST | (66) | -0.300(-1.941) | 0.604(2.359) | -0.284(-1.806) | | -0.234(-1.269) | |
| BCAR | (67) | -0.625(-1.330) | -1.740(-2.408) | -0.639(-1.388) | | -0.097(-0.274) | -0.688(-1.620) |
| BING | (68) | 1.364(2.916) | 2.434(3.273) | | | | 1.064(3.317) |
| BBOY | (69) | | | | | | |
| WBOGL | (77) | -0.169(-1.237) | | -0.230(-1.762) | | | |
| CBOGL | (78) | -0.363(-1.787) | | -0.348(-1.656) | -0.324(-2.252) | | |
| BBOGL | (79) | -0.375(-1.596) | | -0.433(-1.771) | -0.285(-2.456) | | -0.234(-1.266) |
| COM | (82) | -0.327(-1.859) | | -0.311(-2.109) | -0.137(-0.828) | -0.185(-1.020) | |
| CON | (83) | 0.026(0.153) | -0.198(-1.117) | | -0.164(-1.164) | 0.071(0.417) | |
| TIM | (84) | | -0.140(-0.732) | | -0.101(-0.743) | 0.161(0.898) | -0.158(-0.995) |
| SAF | (85) | | | | -0.256(-1.725) | -0.153(-0.831) | |
| EXP | (86) | | | -0.301(-1.435) | 0.113(0.790) | -0.135(-0.708) | -0.266(-1.432) |
| RHO SQUARED | | 0.714 | 0.811 | 0.720 | 0.610 | 0.728 | 0.740 |

TABLE( 8 )

MODEL RESULTS FOR MODE CHOICE MODELS FOR FIU

(ESTIMATED VARIABLE COEFFICIENTS CT- STATISTICS)

| IND. VARIABLE | MODEL1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| ASC- WLK(0) | 3.26(2.953) | 3.640(2.847) | 3.946(3.650) | 3.303(3.176) | 3.163(3.304) |
| ASC-CAR(0) | -0.986(-0.911) | -9.121(-1.433) | 0.030(0.037) | -0.516(-0.691) | -0.315(-0.409) |
| ASC- BUS(0) | -4.045(-1.913) | -5.706(-1.985) | -3.594(-2.066) | -5.728(-3.536) | -3.828(-2.216) |
| WDIST 4 | -2.045(-3.565) | -2.544(-3.614) | -2.249(-3.705) | -2.190(-3.675) | -2.142(-3.593) |
| WCAR 35 | 0.273(0.795) | 0.308(0.695) | | 0.268(0.717) | 0.176(0.552) |
| WING 36 | -0.111(-0.540) | -0.155(-0.699) | -0.158(-0.824) | -0.111(-0.557) | -0.240(-1.246) |
| WBOY 37 | | | -0.206(-1.247) | -0.241(-1.427) | |
| WBI 40 | | | | | |
| WTIME 45 | | | | | |
| CATIME 46 | 0.108(1.899) | 2.088(1.898) | | | |
| BTIME 47 | 0.098(1.899) | 0.116(1.869) | | | |
| RTIME 48 | | | | | |
| CINC 49 | -0.011(-4.092) | -0.088(-2.131) | | | |
| RCOST | | | | | |
| CCOST 51 | 0.027(6.106) | 0.083(2.508) | 0.027(6.347) | 0.027(6.464) | 0.027(6.322) |
| CTIMEU | | | | | |
| CDIST 53 | -0.251(-2.214) | 2.150(1.260) | -0.060(-1.372) | | -0.058(-1.292) |
| CCAR 54 | | | | 0.103(0.371) | 0.099(0.358) |
| CCOSTU 55 | 0.184(1.278) | 0.340(0.512) | | | |
| CBOY 56 | | | | | |
| BCOSTU | | | | | |
| BTIMEU | | | | | |
| BDIST 66 | -0.271(-1.790) | -0.246(-1.584) | | | |
| BCAR 67 | -0.770(-1.621) | -0.697(-1.417) | | | |
| BING 68 | 1.133(3.239) | 1.321(2.859) | 0.822(3.420) | 0.800(3.347) | 0.832(3.400) |
| BBOY 69 | | | | | |
| WBOGL 77 | -0.134(-1.084) | -0.205(-1.391) | | | |
| CBOGL 78 | -0.275(-2.418) | -0.186(-0.623) | -0.288(-2.717) | -0.261(-2.399) | -0.255(-2.392) |
| BBOGL 79 | -0.371(-1.890) | -0.448(-1.792) | -0.314(-2.036) | | -0.289(-1.881) |
| COM 82 | | | | -0.169(-1.151) | |
| CON 83 | -0.235(-1.784) | -0.177(-1.049) | -0.195(-1.568) | -0.162(-1.247) | -0.158(-1.345) |
| TIM 84 | -0.055(-0.387) | -0.074(-0.411) | -0.070(-0.471) | | |
| SAF 85 | | | -0.216(-1.542) | | -0.233(-1.835) |
| EXP | 0.052(420) | -0.433(-1.766) | | | |
| RHO.SQUARE | 0.558 | 0.785 | 0.532 | 0.515 | 0.528 |

TABLE( 9 )

MODEL RESULTS FOR MODE CHOICE MODELS FOR FIP

(ESTIMETED VARIABLE COEFFIAENTS CT- STAISTITS)

| IND. VARIABLE | MODEL1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| ASC- WLK(0) | 6.387(3.371) | 5.883(3.523) | 6.446(4.680) | 6.145(3.477) | 5.044(3.538) |
| ASC-CAR(0) | 1.276(0.723) | -1.318(-0.767) | 2.623(2.285) | -1.197(-0.680) | -2.174(-1.910) |
| ASC- BUS(0) | 0.473(0.284) | 0.831(0.675) | 0.871(0.743) | 0.868(0.679) | 0.405(0.402) |
| WDIST 4 | -1.248(-1.488) | -2.382(-3.463) | -2.227(-5.627) | -2.441(-3.456) | -2.286(-3.455) |
| WCAR 35 | -0.131(-0.183) | 0.065(0.146) | 0.024(0.075) | 0.012(0.028) | 0.209(0492) |
| WING 36 | -0.064(-0.142) | -0.428(-1.717) | -0.252(-1.975) | -0.490(-1.879) | -0.435(-1.835) |
| WBOY 37 | | 0.102(0.245) | 0.111(0.476) | | 0.213(0.526) |
| WBI 40 | 0.807(1.012) | | | | |
| WTIME 45 | -0.119(-1.208) | | | | |
| CATIME 46 | 0.419(3.685) | | | | |
| BTIME 47 | 0.070(1.667) | | | | |
| RTIME 48 | | | | | |
| CINC 49 | -0.011(-4.092) | | | | |
| RCOST | | | | | |
| CCOST 51 | | 0.057(4.160) | | 0.059(4.233) | 0.058(4.367) |
| CTIMEU | | | | | |
| CDIST 53 | -0.078(-0.458) | -0.089(-0.698) | -0.0787(-2.074) | -0.086(-0.675) | |
| CCAR 54 | 0.172(0.247) | | 0.168(0.641) | -1.073(-1.194) | |
| CCOSTU 55 | 0.230(0.535) | | | | |
| CBOY 56 | | | | | |
| BCOSTU | | | | | |
| BTIMEU | | | | | |
| BDIST 66 | -0.274(-1.929) | | | | |
| BCAR 67 | -0.104(-0.150) | | | | |
| BING 68 | 0.465(1.040) | | | | |
| BBOY 69 | | | | | |
| WBOGL 77 | -0.043(-0.150) | 0.104(0.360) | -0.037(-0.172) | | 0.269(1.518) |
| CBOGL 78 | 0.040(0.143) | -0.058(-0.247) | 0.011(0.062) | 0.111(0.396) | |
| BBOGL 79 | -0.040(-0.142) | 0.036(0.190) | 0.026(0.151) | 0.029(0.147) | 0.074(0.513) |
| COM 82 | 0.146(0.865) | 0.454(1.571) | 0.104(0.765) | 0.457(1.580) | 0.182(0.805) |
| CON 83 | -0.446(-2.880) | -0.379(-1.910) | -0.311(-2.666) | -0.409(-1.580) | -0.329(-1.583) |
| TIM 84 | -0.102(-0.639) | -0.135(-0.553) | -0.048(-0.371) | -0.156(-0.644) | -0.171(-0.721) |
| SAF 85 | -0.113(-0.692) | -0.491(-1.918) | | -0.504(-1.953) | |
| EXP | -0.031(-0.211) | -0.379(-0.910) | -0.136(-1.154) | -0.431(-2.032) | -0.340(-1.860) |
| RHO.SQUARE | 0.556 | 0.777 | 0.381 | 0.781 | 0.759 |

TABLE( 10 )

MODEL RESULTS FOR MODE CHOICE MODELS FOR FSU

(ESTIMATED VARIABLE COEFFICIENTS CT- STATISTICS)

| IND. VARIABLE | MODEL1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| ASC- WLK(0) | 4.284(3.018) | 4.642(4.192) | 3.088(3.802) | 5.151(4.719) | 2.550(2.707) |
| ASC-CAR(0) | 2.322(1.762) | 0.711(0.706) | 1.652(2.809) | 1.186(1.208) | -1.857(-2.676) |
| ASC- BUS(0) | 1.433(1.010) | 1.975(2.244) | 0.125(0.316) | 2.063(2.521) | 0.512(0.740) |
| WDIST 4 | -0.556(-0.766) | -1.334(-3.468) | -0.597(-4.378) | -1.395(-3.426) | -1.288(-3.345) |
| WCAR 35 | -0.424(-1.054) | | -0.170(-0.503) | -0.212(-0.526) | |
| WING 36 | -0.067(-0.033) | -0.307(-1.889) | -0.079(-0.575) | -0.314(-1.678) | -0.207(-1.354) |
| WBOY 37 | | -0.032(-0.153) | 0.188(0.926) | | 0.077(0.256) |
| WBI 40 | | | | | |
| WTIME 45 | -0.108(-1.439) | | | | |
| CATIME 46 | 0.479(4.227) | | | | |
| BTIME 47 | 0.129(2.415) | | | | |
| RTIME 48 | | | | | |
| CINC 49 | -0.098(-4.457) | | | | |
| RCOST | | | | | |
| CCOST 51 | | 0.039(5.969) | | 0.041(5.874) | 0.034(6.041) |
| CDIST 53 | -0.171(-1.193) | -0.130(-1.886) | | -0.126(-1.623) | |
| CCAR 54 | -0.458(-1.384) | | -0.204(-0.997) | -0.808(-2.127) | |
| CCOSTU 55 | 0.112(0.641) | | | | |
| CBOY 56 | | | | | |
| CBI 59 | 0.040(0.129) | | | | |
| BCOSTU | | | | | |
| BTIMEU | | | | | |
| BDIST 66 | -0.386(-2.429) | | | | |
| BCAR 67 | -1.017(-2.236) | | | | |
| BING 68 | 0.542(2.558) | | | | |
| BBOY 69 | | | | | |
| WBOGL 77 | -0.052(-0.370) | | 0.022(0.169) | | 0.149(0.810) |
| CBOGL 78 | -0.183(-1.376) | -0.428(-2.894) | -0.032(-430) | -0.324(-2.252) | |
| BBOGL 79 | -0.333(-2.044) | -0.269(-2.194) | | -0.285(-2.456) | -0.038(-0.379) |
| COM 82 | | -0.071(-0.460) | -0.094(-0.814) | -0.137(-0.828) | -0.081(-0.585) |
| CON 83 | | -0.169(-1.251) | -0.308(-3.041) | -0.164(-1.164) | -0.163(-1.258) |
| TIM 84 | | -0.124(-0.9320 | -0.051(-0.507) | -0.101(-0.743) | -0.136(-1.014) |
| SAF 85 | | -0.234(-1.648) | | -0.256(-1.725) | |
| EXP 86 | -0.082(-0.759) | 0.082(0.578) | -0.015(-0.162) | 0.113(0.790) | 0.061(0.464) |
| RHO SQUARED | 0.395 | 0.596 | 0.236 | 0.610 | 0.558 |

TABLE ( 11 )

MODEL RESULTS FOR MODE CHOICE MODELS FOR FSP

(ESTIMATED VARIABLE COEFFICIENTS CT- STATISTICS

| IND. VARIABLE | MODEL 1 | MODEL 2 | MODEL 3 | MODEL 4 | MODEL 5 |
|---|---|---|---|---|---|
| ASC-WALK (0) | 3.157(8.092) | 4.219(9.765) | 3.807(9.114) | 3.633(8.515) | |
| ASC – CAR (0) | 1.810(2.476) | 0.538(1.429) | 0.283(0.756) | 1.648(2.420) | |
| ASC – BUS (0) | -0.239(-1.174) | 0.846(2.117) | 0.290(0.816) | 0.270(0.751) | |
| WDIST (4) | -1.516(-8.661) | -1.271(-7.555) | -1.426(-8.963) | -1.4197(-8.047) | |
| WCAR (35) | | 0.014(0.117) | 0.003(0.025) | 0.084(0.632) | |
| WINC (36) | | -0.154(-2.353) | -0.0158(-2.413) | -0.194(-2.893) | |
| WBOY (37) | | | | | |
| WGIRL (38) | | | | | |
| WTIME (45) | | | | | |
| CATIME (46) | | | | | |
| BTIME (47) | | | | | |
| RTIME (48) | | 0.051(3.416) | | | |
| CINC (49) | -0.086(-5.482) | | | -0.090(-5.677) | |
| CCOST (51) | 0.096(6.260) | 0.029(15.088) | 0.028(14.869) | 0.100(6.361) | |
| CDIST (53) | 0.927(2.674) | 0.045(0.769) | -0.099(-3.563) | 0.982(2.743) | |
| CCAR (54) | 0.116(0.436) | | -0.039(-0.318) | | |
| | -0.098(-0.742) | | | | |
| CCOSTU (55) | | | | | |
| CGIRL (57) | | | | | |
| BTIMEU (65) | -0.023(-0.854) | 0.100(1.739) | | | |
| BDIST (66) | | | | | |
| BCAR (67) | | | | | |
| BINC (68) | -0.006(-0.157) | -0.034(-0.702) | -0.021(-0.443) | -0.015(-0.310) | |
| WBOGL (77) | -0.038(-0.472) | -0.166(-3.549) | -0.158(-3.168) | | |
| CBOGL (78) | | -0.111(-2.284) | -0.096(-1.999) | -0.109(-1.375) | |
| BBOGL (79) | -0.055(-0.856) | 0.012(0.215) | 0.037(0.559) | -0.036(-0.555) | |
| COM (82) | -0.060(-0.967) | | -0.090(-1.665) | -0.089(-1.422) | |
| CON (83) | | | 0.032(0.577) | | |
| TIM (84) | | -0.169(-3.044) | -0.0156(-2.796) | | |
| SAF (85) | | | | | |
| EXP (86) | | | | | |
| RHO SQUARED | 0.655 | 0.521 | 0.514 | 0.660 | |

**TABLE ( 12 )**
**MODEL RESULTS FOR MODE CHOICE MODELS FOR GIRLS 450 PREFFERED**
**(ESTIMATED VARIABLE COEFFICIENTS CT- STATISTICS**

| IND. VARIABLE | MODEL 1 | MODEL 2 | MODEL 3 | MODEL 4 | MODEL 5 | MODEL 6 | MODEL 7 |
|---|---|---|---|---|---|---|---|
| ASC-WALK (0) | 0.603(0.956) | 0.987(1.930) | -0.482(-1.104) | -0.3569-0.760) | 0.112(0.164) | 0.353(0.595) | |
| ASC – CAR (0) | 0.7164(1.138) | 0.676(0.923) | 0.951(2.855) | 0.757(1.777) | 0.536(1.824) | 2.343(5.243) | |
| ASC – BUS (0) | 1.082(1.908) | 1.028(1.743) | -0.110(-0.254) | -0.532(-0.867) | -0.046(-0.078) | 0.784(1.441) | |
| WDIST (4) | 0.019(0.373) | 0.038(0.701) | 0.170(2.604) | 0.069(1.216) | -0.043(-0.786) | 0.085(1.562) | |
| WCAR (35) | | -0.004(-0.019) | | | | | |
| WINC (36) | 0.007(0.081) | | 0.23(0.295) | -0.023(-0.265) | -0.061(-0.720) | 0.048(0.589) | |
| WBOY (37) | 0.070(0.719) | | | | | 0.110(1.219) | |
| WGIRL (38) | | | | | | | |
| WTIME (45) | | | | | -0.095(-3.952) | | |
| CATIME (46) | 0.609(5.442) | 0.591(5.321) | | 0.055(4.055) | | | |
| BTIME (47) | | 0.030(1.615) | 0.086(3.948) | 0.051(2.999) | 0.217(3.939) | 0.046(2.451) | |
| RTIME (48) | 0.191(6.491) | 0.204(6.506) | 0.124(7.724) | 0.084(7.927) | | 0.235(7.205) | |
| CCOST (49) | -0.020(-8.301) | -0.020(-8.453) | | | | -0.018(-7.766) | |
| CCOSTU (51) | 0.018(8.748) | 0.018(8,778) | 0.010(7.954) | 0.011(8.114) | 0.009(7.576) | 0.020(8.763) | |
| CDIST (53) | 0.584(3.424) | 0.584(3.757) | 0.203(4.564) | | | 1.003(5.368) | |
| CCAR (54) | | | -0.040(-0.351) | | | | |
| | -0.140(-1.431) | | | -0.110(-1.886) | | | |
| CINC (55) | | | | | | | |
| CBOY (56) | | | | | | | |
| CGIRL (57) | | | | | -0.092(-2.561) | | |
| BTIMEU (65) | | | | | -0.546(-3.914) | | |
| BDIST (66) | | -0.611(-2.368) | -0.379(-1.775) | | -0.482(-2.036) | | |
| BCAR (67) | | 0.161(1.667) | | -0.012(-0.131) | | | |
| BINC (68) | | | | | | | |
| BBOY (69) | | | | | 0.072(1.248) | | |
| WBOGL (77) | | -0.051(-0.759) | -0.025(-0.689) | -0.009(-0.237) | | | |
| CBOGL (78) | -0.24(-0.374) | | | -0.025(-0.392) | 0.038(0.588) | 0.003(0.046) | |
| BBOGL (79) | 0.052(0.606) | 0.049(0.487) | | 0.006(0.097) | -0.019(-0.287) | | |
| COM (82) | | 0.062(0.666) | | | | | |
| CON (83) | -0.139(-1.547) | -0.168(-1.809) | | -0.054(-0.862) | -0.052(-0.823) | -0.164(-2.120) | |
| TIM (84) | | | | | 0.083(1.240) | 0.129(1.613) | |
| SAF (85) | -0.021(-0.251) | | -0.125(-2.222) | -0.100(-1.755) | -0.103(-1.942) | | |
| EXP (86) | | | | | | | |
| RHO SQUARED | 0.575 | 0.583 | 0.213 | 0.207 | 0.189 | 0.499 | |