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THE DETERMINANTS OF DEMAND FOR PUBLIC TRANSPORT IN SOUTH AFRICA

BY

TSHEGOFATSO PRISCILLA SELESENG

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ABSTRACT

This study analyses the determinants of demand for public transport in South Africa, using quarterly data covering the period from 1990-2009. The study initially provides an overview of the South African public transport system and population trends. Based on the review of the theoretical and empirical literature on transport, the study specifies a model of public transport demand in South Africa. Tests for stationarity and unit roots in the series (both informal and formal tests), and co-integration test have been performed. The co-integration test is done using the Johansen (1990, 1995) methodology. A vector error correction model is run to provide robust determinant variables on public transport. The results revealed that in the short run, the demand for public transport depends positively and significantly on GDP per capita growth and negatively on prices for public transport and fuel prices. However, over the long run, the demand for public transport depends negatively on GDP per capita growth as expected, but positively on the other variables including the growth in employment levels. To check for robustness of the VECM results the diagnostic tests were performed. The AR Roots Graph reports the inverse roots of the characteristics AR polynomial. The graph showed that all roots lie inside the unit circle which is an indication that VAR is stable. Some of the results found in this the study, such as the short run and long run impact of income growth on public demand, are supported by findings from other studies.

Keywords: Public transport, demand, South Africa, determinants, growth and population.

DECLARATION

I, Tshegofatso Seleseng with student number 200603329, do hereby declare that this dissertation is my original work except for cited material, which has been acknowledged to the respective author. This dissertation has not been previously submitted or presented at any University for a similar or any other degree award.

Signature……………………………….. Date…23/March/2012……………

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DEDICATION

I dedicate this research paper to my father, Ps L.A Seleseng for always giving me the support and the encouragement to go further in education, to keep pressing through and for his prayers. And also to my sisters (Mmathapelo and Lorato) who have taught me to always hold my head up regardless of any situations. And to my younger sister Kelebogile, who was always in my mind. And not forgetting my little nephew (Onkabetse), so that he should also write a dissertation in his interested field of study in the not so distant future.

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CHAPTER ONE

Introduction to the Research Issue

1.1 Background of the study

Transportation is the movement of people and freight (Button, 1993), to their desired destinations, which can be places of employment, places of residence, holiday destinations or just to places where they can interact with other economic agents. The South African government has recently implemented policy measures no road construction and the provision of better public transport services i.e.; taxi recapitalization, bus rapid transport system and the Gautrain.

The land public transport incorporates road public transport (that is taxis and buses) and the rail public transport. The transport sector has been highlighted by the government as a key contributor to South Africa's competitiveness in global markets. It is increasingly being seen as a crucial engine for economic growth and social development. South Africa's total road network is about 754 000 kilometers, 9 600km of which are surfaced national roads. The drive from Musina on South Africa's northern border to Cape Town in the south is a 2 000km journey on well-maintained roads. While the Department of Transport is responsible for overall policy, road-building and maintenance is the responsibility of the South African National Roads Agency as well as the nine provinces and local governments (Department of Transport, 2008).

South Africa has an extensive rail network - the 10th longest in the world - connecting with networks in the sub-Saharan region. State-owned Transnet Freight Rail is the largest railroad and heavy hauler in southern Africa, with about 22 000km of rail network, of which about 1 500km are heavy haul lines. According to the Department of Transport (2008), the company's rail infrastructure, which connects the ports with the rest of South Africa, represents about 80% of Africa's total. The government has embarked on a project to improve rail safety and revive train travel as a viable public transport option. In 2008, the government said it would spend R19.5-billion a year over four years on upgrading its ports and rail infrastructure, with nearly half of this going towards the freight rail industry (Department of Transport, 2008). The South African Rail Commuter Corporation operates the Metro rail commuter services in the Western Cape, the Eastern Cape, KwaZulu Natal and the Gauteng province, focusing mainly on poorer South African commuters. Tourists and well-heeled passengers can travel on the Blue Train, one of the world's most famous luxury trains, while

Shosholoza Meyl transports about four million passengers a year between the country's major cities. Services also connect to other southern African destinations in Zimbabwe, Mozambique and Swaziland.

Transport, therefore, still has a key role to play in modern society. This importance is further reflected in the link between transport levels and economic growth. In the past, this link was very strong; as both passenger and freight transport play a vital role in the functioning of the economy, with strong growth normally associated with innovative transport solutions. It is, thus, no great surprise that transport issues continue to feature strongly in the public domain. Issues such as congestion and the role of road pricing, the impact of traffic on the environment, the organisation of public transport services, the rise of low-cost airlines, the capacity of the rail network, or indeed the 'problem on the railway' and so on, are constantly mentioned.

Land transport is the most widely used mode of transporting freight and passengers. This includes the use of road transportation and rail transportation for both freight and passengers. Minibus taxis are responsible for 65% of the 2.5 billion annual passenger trips in urban areas, as well as a high percentage of rural and intercity transport. Buses and trains account for 21% and 14% respectively of all public transport (Department of Transport, 2008). According to the National Household Travel Survey (2003), about 26% of households in South Africa have access to a motor car. At 108 cars per 1000 of the population, car ownership in South Africa remains in its infancy. In a thriving economy like South Africa, a greater proportion of the population is absorbed in the formal sector and becomes automobile dependent (Litman and Laube, 2002) while the rest, which holds the majority of the population, finds itself in the informal sector and again dependent on public transport. Public transport in South Africa is vital as it plays a key role in providing the population with better access to employment, education, shopping and health services. However, to achieve these objectives nationally can be a difficult task, as the transport system must be efficient. An efficient and accommodative transport system is one, according to (Tiwari, 2003), that meets the mobility needs of the most valuable groups of the society without which, all users face sub-optimal conditions of operation. Inefficient transport provision does not result in the intended mobility, safety and environmental benefit.

The above implies that there is a growing demand for public transportation in the country. This, in turn, requires a continual analysis of the public transportation system. When this is done frequently, we are able to assess and respond to the rising cost of public transport and to analyse whether there is a need to construct new roads, to repair the fast deteriorating roads and, decaying railways, maintain train stations or to divert the excess demand for transport to rail transport, knowing that the pressure put on road transport is too high.

1.2 Statement of the problem

The demand for travel continues to increase, while capacity constraints are widespread. Economics provides the analytical basis for making the best use of such limited resources. In many countries the transport sector has experienced major restructuring for more than a decade, often delivering important efficiency gains. Whether considering options for future restructuring or seeking to make the existing structure work better, policy makers and regulators are increasingly drawing on economic techniques to develop and appraise transport policies, and to contain subsidies to operators whilst ensuring appropriate levels of service quality and investment. Dissatisfaction with the administration and the enforcement of the current passenger transport policy has been expressed by users, operators and the Department of Transport (White Paper on National Transport Policy, 1996).

Due to the preparation for the 2010 FIFA World Cup, the South African government decided to extend and further develop the transport infrastructure. This was done by allocating more resources and investing in the construction of public transport infrastructure for both roads and railways. The demand for land transport was considered to have been significantly increased and that the provision for the supply of land transportation would catch up with the growing demand.

The main concern, which this study intends to address, is to identify what the factors are that determine the need to sustain the public transport even in the post-World Cup era. Is the seemingly excess supply of public transport infrastructure going to remain idle, or be under-utilised due to limited use of land transportation?

1.3 Objectives

The main objective of the study is to examine the various factors that determine the demand for public transport (both road and rail public transport) in South Africa. The sub-objectives of the study are the following:

- To examine the structure and trend of the public transport in South Africa.
- To identify and assess the significance of factors such as fares, income level, fuel prices, GDP per capita and employment levels that, determine the demand for public transport in South Africa.

- To reach conclusions and make recommendations based on the result of the study.

1.4 Hypotheses of the study

The hypotheses to be tested are as follows:

a) The demand for public transport is inversely related to public transport fares, prices of fuel and positively related to GDP per capita and employment levels, in the short run.

b) The demand for public transport is inversely related to the growth in GDP per capita in the long run.

1.5 Justification of the Study

This study will be a significant endeavour in policy formulations that involve public transport systems in South Africa. There is now a general realization that public transport has a significant role to play in enhancing urban mobility, reducing road congestion, decreasing the impact on the environment through harmful emissions and better serving the economy (Walters, 2008). Furthermore, this research will be a valuable source of information for policy makers in the Department of Transport, in order to improve the public transport system stance by proving the efficiency, reliability and affordability of public transport system. This can be achieved in ways that can support economic prosperity, whilst also promoting technological advances that can mitigate the impacts of high levels of mobility on the environment and society.

Policy makers need information on the precise factors that affect public transport use. Therefore, by explaining the determinants and the behaviour of demand for public transport in South African context, this study will help policy makers to design potent policies. Moreover, this research will provide recommendations on how to facilitate with the steering of demand for public transport use for both long and short terms to meet with the supply side of the public transport.

In addition, this study will act as a good source of information for researchers, as a result will inform debates on this subject. This research will also contribute to empirical literature on the factors that drive public transport growth in South Africa. Public transport has a key role to play in the modern society.

1.6 Layout of the Study

This study will consist of the following five chapters:

- Chapter 1- Introduction to the research issue to be investigated
- Chapter 2- Background and Overview of Public Transport in South Africa
- Chapter 3- Literature Review
- Chapter 4- Research Methodology
- Chapter 5- Presentation and Analysis of Empirical Results
- Chapter 6- Summary, Conclusions, Policy Implication and Recommendation

CHAPTER TWO

An Overview of the Public Transport System in South Africa

2.1 Introduction

South Africa has a population size of over 48 million people. The country has shown remarkable resilience in coming out of the turmoil that was caused by 40 years of Apartheid. One of the remaining scars of the Apartheid policy, however, is a settlement pattern characterized by inefficiencies and inequalities. Its form and structure impose undue and unavoidable costs on all inhabitants, especially the poor.

Land use planning was aimed at isolating people and entrenching the principles of separation of race groups. Throughout the country, in both rural and urban areas, there are still people who are unable to access even the most basic services because of inadequate public transport and poverty. In larger urban areas, public transport is generally seen as unsafe, unreliable, inconvenient and offering little choice particularly for trips outside of working hours. This has resulted in an ever-increasing reliance on and growth in private vehicle use, with an inevitable increase in congestion, delays and environmental deterioration. There is now a general realization that public transport has a significant role to play in enhancing urban mobility, reducing road congestion, decreasing the impact on the environment through harmful emissions and better serving the economy (Walters, 2008).

The legacy of apartheid is the main phenomenon that explains the structure and performance of South Africa's public transportation system. Apart from the undesirable effects that the apartheid policies brought about, South Africa retains a well developed and extensive transport industry (consisting of a road network, and rail system) which plays a significant role in economic activity. The aim of this chapter is to review and reflect on the developments and factors affecting public transport use in South Africa.

2.2 History and Development of Public Transport in South Africa

2.2.1 The minibus taxi industry

Starting from the 1960s, the apartheid government moved black people away from the commercial and industrial centers of the country's cities. So black people lived far away from the best work opportunities and needed public transport more badly than other groups, but the available public transport was not convenient enough. It was expensive and it also operated only at peak times and along set routes. Furthermore, most black people were too poor to own private passenger cars. The minibus-taxi industry started in the late 1970s to meet the demand of people for transport. However, it was difficult to get the operating permits, so many operators worked illegally, without permits. They were punished through fines or by having their vehicles confiscated. Thus, during the boycotts of bus services in the 1980's pressure to allow minibus taxis to operate came from both black commuters and from white businesses which wanted their workers to be able to travel to work cheaply and more easily. After a number of investigations, in 1986 government made it legal to operate 16-seater taxis, although they restricted the number of permits. By 1989, around 50 00 minibus-taxis were operating nationally. And then, in 1990 the taxi 'wars' began in which different taxi owners' associations fought over routes. These wars resulted in the deaths of hundreds or even thousands of owners, drivers and commuters over the following years (Walters, 2008).

In 2002, the Gauteng Department of Transport estimated that there were about 16 000 unregistered taxis in the province and, until recently, about 127 000 operating in the whole country. This just shows how the industry grew rapidly in an uncontrollable manner. Today, the minibus-taxi industry transports approximately 65% percent of daily commuters. This market share has steadily increased over the last twenty years or so, as rail services and bus services have deteriorated, despite large government subsidies. The minibus taxi industry represented a community-based industry that provided a service in defiance of the apartheid government. Post 1994, the new democratic government has placed a high priority on improving the mobility and access to opportunities of all commuters. The vital role that the minibus taxi industry plays in the transport arena could not be ignored, nor could the inadequacies and inefficiencies of minibus-taxi services and operations (Walters, 2008).

2. 2. 2. The Commuter Bus Industry

The commuter bus industry is responsible for the transportation of about 1.5 million commuters per day in South Africa (SABOA, 2009). The bus industry has for many years made a vital contribution to the economic and social development of the country. As a provider of bus services it has and continues to provide mobility to millions of people who are dependent on public transport, for example, learners who require transport to and from school, workers who require transport to and from work, and individuals who are seeking employment or access to hospitals and other services. These commuter bus services are rendered country-wide by about 70 bus companies operating about 8500 buses. These services are offered in urban and rural areas and are often the only form of public transport available to many daily commuters.

In order to ensure that services are affordable government subsidies the services between 40% and 60% on average (Walters, 2008). For example, if 50% subsidy was applicable to a particular ticket valued at R10 the real cost would have been R20 for the commuter if there had been no subsidization, which makes the cost of travel more affordable for the lower income earners. The South African Bus Operators Association (SABOA) is the credible voice of an inclusive, efficient, sustainable and transforming bus industry, which plays a role in an integrated transport system through safe, reliable and affordable bus services that add value and are attractive to stakeholders.

2. 2. 3 Commuter Rail Services

The commuter rail network in the country is a reflection of the political past of South Africa, where labour was conveyed between distant dormitory townships on the outskirts of the cities and jobs in and around the cities. The new dispensation in South Africa brought about very different development behaviour, with settlements and travel patterns changing drastically over the past decades. The rapidly changing spatial developments and the lack of the required land-use/transport integration, together with low levels of rail development and investments over a number of years, have left the rail mode as a declining choice of public transport. The minibus-taxi industry has eroded rail and bus patronage levels (Walters, 2008).

In 1990, the responsibility for commuter rail transport was transferred from Transnet, a state owned enterprise and the national rail carrier responsible for general freight, bulk rail transport and long distance passenger rail services to a government agency, as indicated by the South African Rail Commuter Corporation, (SARCC), reporting to the Department of Transport (DoT). All rail commuters related assets (infrastructure, rolling stock and land) were transferred to the SARCC. The functions of the SARCC include investment planning and, subsidy management. Until recently, PRASA (Passenger Rail Agency of South Africa) dealt with the operations, personnel and assets of the South African Rail Commuter Corporation, Metrorail, Intersite Property Management Services, Shosholoza Menly and the long distance bus company, Autopax (Translux and City-to City).

The rail commuter business is subsidised by National government to the extent of 65% of its total operating costs and capital renewal costs, representing an annual capital subsidy of R700 million and an operating subsidy of R2 billion, all of which are managed through SARCC (South African Rail Commuter Corporation) as the Department of Transport's national rail commuter agency. The system is operated in 6 metropolitan areas, transporting 2.2 million passengers daily. Three of the major metropolitan commuter networks – Johannesburg, Cape Town and Pretoria (Tshwane), are together responsible for about 2 million of these movements. The majority of passengers (84%) are of working age and are male black people (South African Rail Commuter Corporation, 2007). In socio-economic terms, rail users are amongst the lowest income groups and least able to exercise modal choice. Rail transportation is unreliable as it's always delayed and rarely arrives on time, when compared to the other modes of public transport (bus and taxi). This will lead to a continuing decline in the number of users (National Household Travel Survey, 2003).

2. 2. 4 Further Developments of the Land Public Transport System in South Africa

The rising number of passenger cars on the Gauteng highways, has resulted in a rapid increase in highways maintenance, which can be very costly for the municipality and the resulting negative externalities (e.g. congestion and pollution) experienced are the following: in February 2000, the Gauteng Provincial Government announced the development of a rapid-rail system linking Johannesburg with Tshwane (Pretoria) and the OR Tambo International Airport. The construction of the R25 billion Gautrain started in September 2006. The first phase of the construction, which is the link between Sandton and OR Tambo International Airport, has been completed and the second phase of the construction will be completed by the end of 2011, which is the link between Johannesburg and Tshwane. Three anchor stations plus seven other stations will be linked by the 80 kilometres of rail along the planned route. The three anchor stations include the following: OR Tambo international Airport; Tshwane (Pretoria train station) and the Johannesburg (Park Station). Seven other stations will be located at Rosebank, Sandton, Marlboro, Midrand, Centurion, Hatfield and Rhodesfield (Kempton Park) (Walter, 2008).

The operation specifications for the Gautrain include maximum travelling speeds of between 160 to 180 kilometers per hour, reaching Tshwane from Johannesburg in less than 40 minutes. The frequency between Johannesburg and Tshwane will initially be six trains per hour per direction and it will operate approximately 18 hours per day with a maximum peak hour seating capacity of 1 926 passengers per direction. There are also road-based public transport services which include dedicated bus services to transport passenger to and from stations (www.gautrain.co.za).

The second major development of the public transport system is the Bus Rapid Transit (BRT). The Rea Vaya BRT is intended provide a feeder system for the rapid transit railway system. The BRT comprises a middle lane for large, high-tech buses which will move comfortably and quickly around Johannesburg using specific designated routes, enclosed bus stations along the routes and a high-tech control centre. The BRT transport services also operate in the Nelson Mandela Bay Municipality, Soweto and Johannesburg and the system is still to be introduced in Cape Town and Tshwane.

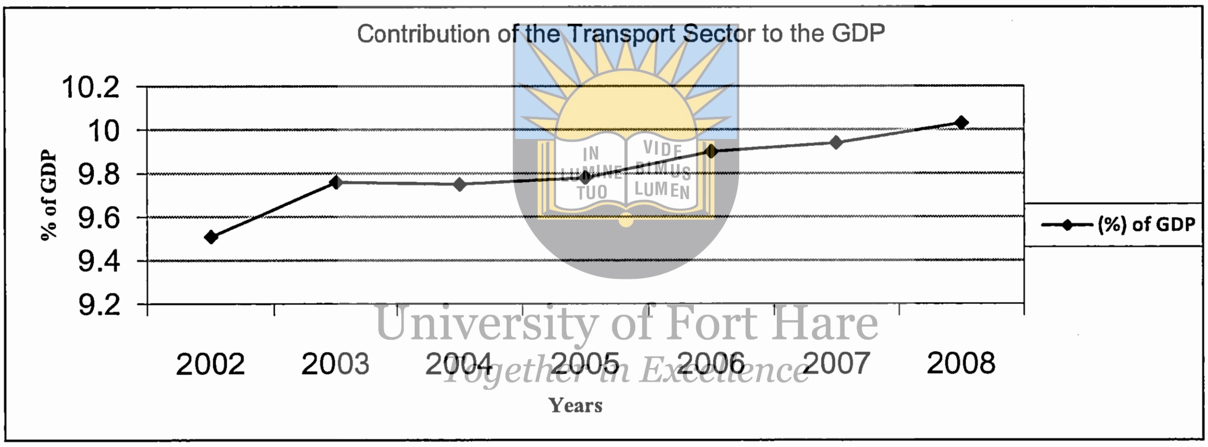
Buses run in exclusive, dedicated lanes in the centre of the existing roads. Smaller feeder buses bring people from the outer areas to the stations on the trunk routes. Bus capacity rangers between 75-112 passengers and approximately 150 stations will be operating. These are positioned half a kilometre apart, with running times from 5 am to midnight.

2.3 An overview of Transport and the Economy

2.3.1 Contribution of the transport sector to the economy

The transport sector comprises all infrastructure and participants in roads, aviation, railway and maritime transportation etc. It makes significant contribution to the economy as illustrated in Figure 2.1 below.

Figure 2.1: Contribution of the transport sector to the gross domestic product 2002 – 2008.

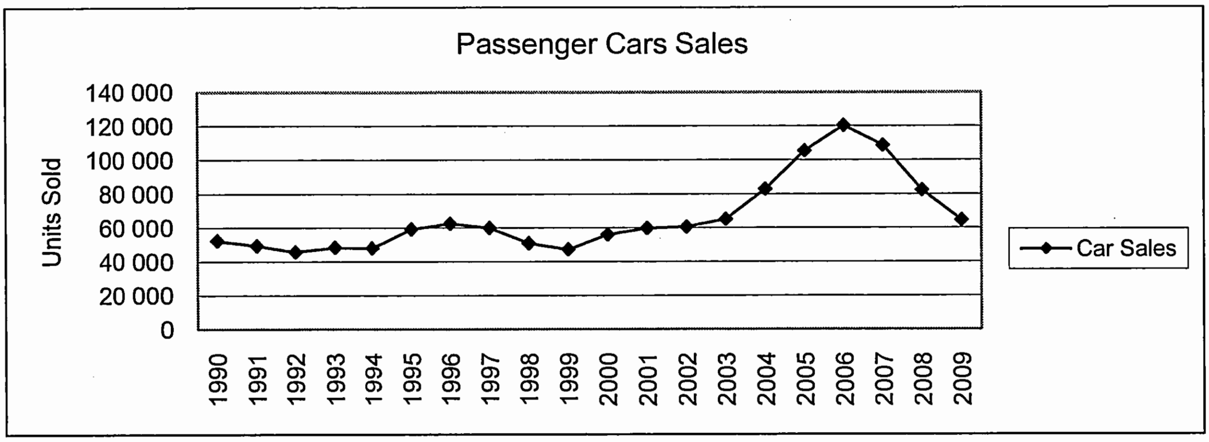


Source: Annual Transport Statistics Bulletin (2008) – Republic of South Africa

Over this short period of time, the percentage contribution of the transport sector towards the GDP has been over 9% and on the rise. But between 2003 and 2004 there was a slight decline of about 0, 1%. This was due to the rising price of oil, which did slow down productivity in this sector. Since then the trend has been a 5, 5% increase on a yearly basis.

It is generally considered that the determinants of demand for public transport are the people's willingness and the affordability of private cars. It's expected that there will be a positive relationship between income levels of individuals and passenger car sales units. This means that the more income people earn, the more they decide to buy cars instead of using public transport, and this, in turn, reduces the demand for public transport.

Figure 2.2: Units sold of Passenger Cars



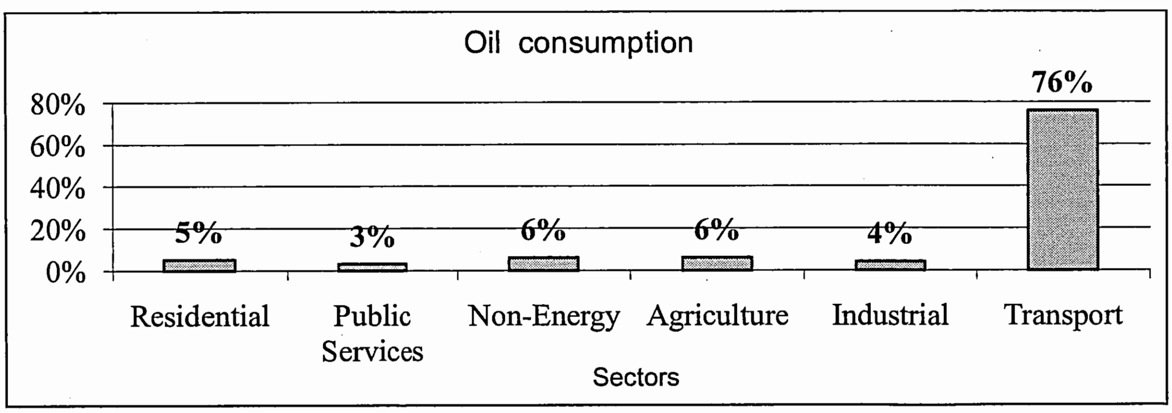
Source: Response Group Trendline (2010)

Figure 2.2, shows that it has not been an easy time for the consumers of passenger cars in general, over the years. However, from 1999 till 2006, there was a rise in the number of passenger car units sold from 50 000 to 130 000 units. This was a result of the thriving economy and the availability of easy credit. But from 2006 till 2009 there was a decrease in the number of units sold. This was due to the credit crunch, better known as the effects of the financial crises.

2. 3. 2 Oil Consumption in the South African Sectors

South Africa is an oil importing country and imported oil makes up about 65 per cent of South Africa's annual petroleum consumption. The remainder comes from domestic production of oil in which about 5 per cent of domestic needs and the well-developed fuels industry supply nearly 30 per cent of domestic consumption. South Africa processes imported crude oil into liquid petroleum fuels. A large part of petroleum products are used for road transport. Graph 2.3, shows the sizes of the oil consuming sectors in the economy.

Figure 2.3: Sectorial Shares of Oil Consumption in South Africa

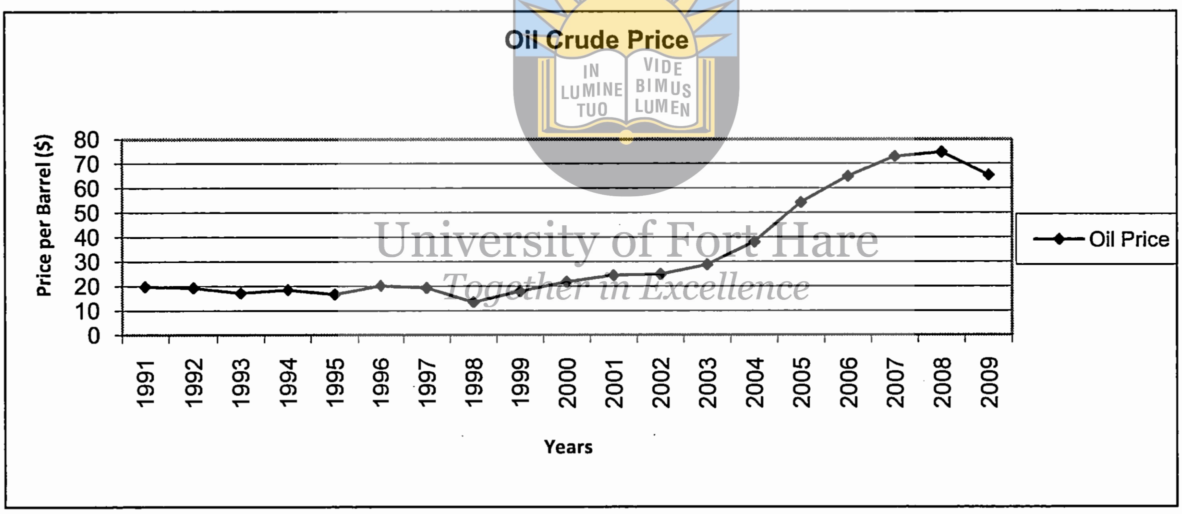


Source: Key World Energy Statistics (2009)

As showed in figure 2.3, the transport sector takes up more than 3 quarters of the consumption of oil in the country. It takes up to 76% while other sectors just take up small percentages. The transport sector includes usage from motor cars, light commercial vehicles and also heavy vehicles both in the public and private sectors for transporting both passenger and freight, all of which need fuel derived from crude oil to operate.

Both motoring and rail transportation are depended on fuel to ensure efficiency in transporting both passengers and freight. And as fuel prices rise, it becomes costly to transport both passengers and freight. As a result, public transport users are obliged to pay higher travelling fares. In this way, production of goods and services within the country is affected negatively as it becomes more costly to commute to places of work and to deliver goods to places where there is most demand.

Figure 2.4: Prices of Brent Crude Oil



Source: South African Reserve Bank Database (2010)

Figure 2.4 clearly depicts that the trend line for oil prices was not stable during the last few years of the apartheid regime and a little after the new dispensation (post 1994) of the government. This was a result of the Gulf war, which decreased oil consumption globally. And during 1996 and 1998, there was a decrease in price of crude oil. This meant that a typical consumer would have paid less for fuel usage in the country, and this influenced the South African markets to perform relatively well. According to the South African Reserve Bank Database (2010), from 1998 to 2008, the price of oil rose and the financial crisis as well as the war in Afghanistan and Iraq also influenced the price of fuel to keep rising.

2.5 Trends on Demand for Public Transport

It is generally considered in the economics literature that there are a number of factors that influence the demand for a commodity. Likewise, according to the literature on travel demand, the demand for public transport is affected by factors such as demography and income (Jolly et al, 2004). These factors are discussed in the context of South Africa below:

2.5.1 Demographic factors affecting transport

According to Statistics South Africa, as referred to by Mokonyama *et al*, 2006, the South African population increased from 40.5 million people in 1996 to 44.8 million in 2001, an average growth rate of 10.4%. According to Statistics South Africa, the mid-year estimates of the South African population during 2001-2003 decreased by 3.5%. This is evidenced in Table 2.1 below.

Table 2.1: Population of South Africa 1996 to 2003

Province	1996 Census	2001 Census	% Growth 1996 - 2001	2003 Mid Year Estimates	% Change 2001-2003
W. Cape	3 956 875	4 524 335	14.3	4 733 00	4.6
E. Cape	6 302 525	6 436 763	2.1	6 485 000	0.7
N. Cape	840 321	822 727	-2.1	888 000	7.9
Free State	2 633 504	2 706 775	2.8	2 737 000	1.1
K.Z.N	8 417 021	9 426 017	12.0	9 806 000	4.0
North West	3 354 423	3 669 349	9.4	4 217 000	14.9
Gauteng	7 348 423	8 837 178	20.3	9 806 000	1.0
Mpumalanga	2 800 711	3 122 990	11.5	3 326 000	6.5
Limpopo	4 929 368	5 273 642	7.0	5 283 000	0.2
Total	40 583 573	44 819 776	10.4	46 401 000	3.5

Source: Mokonyama *et al.* (2007)

Table 2.1 above, shows varying population growth rates among the different provinces from 1996-2001 and from 2001-2003. During this period the Northern Cape experienced a negative growth rate of -2.1%. The highest growth rate during 1996-2001 was experienced by the Gauteng Province with a 20.3% growth rate, followed by the Western Cape Province at 14.3% and KwaZulu Natal at a 12% growth rate. In contrast, during the 2001-2003 periods, the highest increases were experienced by the Northern Cape and Mpumalanga, respectively, with Gauteng now showing increases of only 1%.

Table 2.2 below shows varying trends in South Africa's population from 2004 till 2010.

Table 2.2: Population of South Africa 2004 to 2010

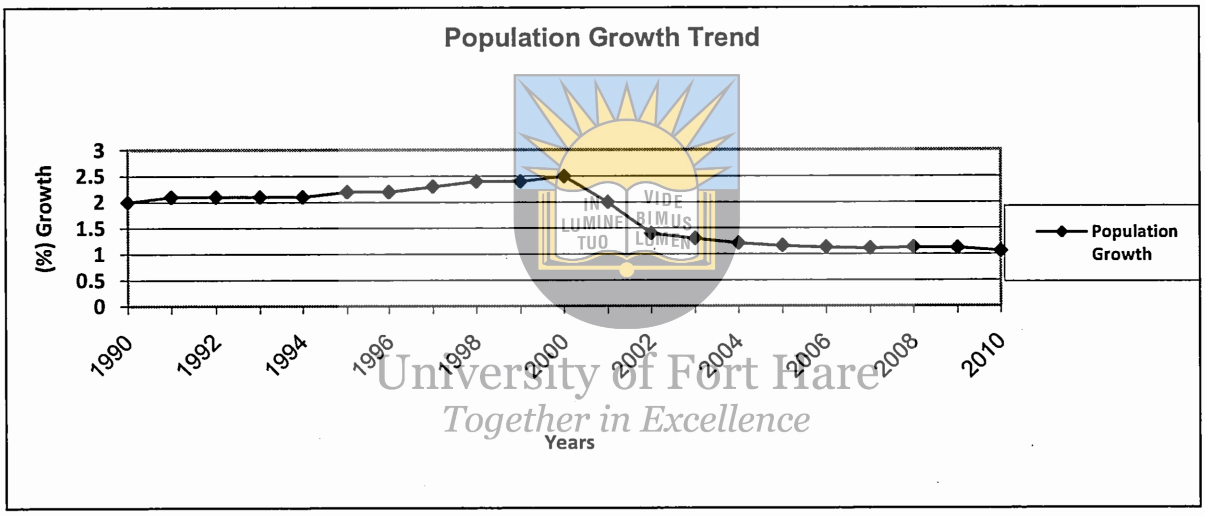
Province	2004 Mid Year Estimates	2009 Mid Year Estimates	% Growth 2004 - 2009	2010 Mid Year Estimates	% Change 2009 – 2010
W. Cape	4 570 696	5 356 900	17.2%	5 223 900	-2.5%
E. Cape	7 088 547	6 648 600	-6.6%	6 743 800	1.4%
N. Cape	899 349	1 147 600	27.6%	1 103 900	-3.8%
Free State	2 950 661	2 902 400	-1.6%	2 824 500	-2.7%
KZN	9 665 875	10 449 300	8.1%	10 645 400	1.9%
North West	3 807 469	3 450 400	-9.3%	3 200 900	-7.2%
Gauteng	8 847 740	10 531 300	19.0%	11 191 700	6.3%
Mpumalanga	3 244 306	3 606 500	11.1%	3 617 600	0.3%
Limpopo	5 511 946	5 227 200	-5.2%	5 439 600	4.1%
Total	46 586 607	49 320 500	5.8%	49 991 300	1.4%

Source: Statistics South Africa, 2004-2010 Publications

According to table 2.2, from 2004 to 2009, there was a 5.8% growth in the whole country's population. The highest population growth was experienced in the Northern Cape Province during this period, a 27.6% growth, which was higher than Gauteng's growth rate at 19% and the Western Cape at a lower rate of 17.2%. It is expected that as the population increases the need to travel will also increase, as there is the need to travel to the economic hubs or to places of other activities. These may include places for shopping, for education, for medical attention and even to places of work. This will lead to an increase in the demand for transport infrastructure (assignment infrastructure *see in Chapter 3*) and consequently the demand for public transport will rise.

In figure 2.5, the population growth trend for the whole country is depicted. This includes figures before and after of the country's new democratic dispensation.

Figure 2.5: Population Growth Trend in South Africa



Source: World Bank Database (2011)

Figure 2.5 shows the growth trend of the population of South Africa as being characterized by a gradual increase from 1990 to 2000, from a 2% growth rate to 2, 6 %. Then there was a sharp decline from 2000 to 2002, with a sudden decrease from 2, 6% to 1.3%. From there onwards, there was a gradual decline till 2010. This gradual decrease in the population trend may have been accompanied by the corresponding decline in the demand for public transport. Another way of looking at the implication of population for transportation is in terms of population densities in different parts of South Africa. Figure 2.6 shows the population density in the six South African metropolitan cities. As the figure shows, there is a close association between the size of the city and its overall population density. Thus, Johannesburg, which is larger than the others, has a higher population density. By contrast, Nelson Mandela which is regarded as a smaller metropolitan city has a lower population density. The fact that a given city like Johannesburg has a higher population density than the others implies that its demand for public transportation will be greater.

Source: Mokonyama *et al.* (2007)

According to Mokonyama *et al.* (2007), by world standards, the population densities in the South African metropolitan cities are low. It is believed that "this factor it impacts negatively on the viability of public transport and leads to longer travel distances and times, than in cities in the other parts of the world" (Mokonyama *et al,* 2007: 10). This is evidenced in table 2.3 which shows the contrasts between Tshwane's population density and average trip length and those of four other world cities.

Table 2.3: The impact of development density on trip lengths

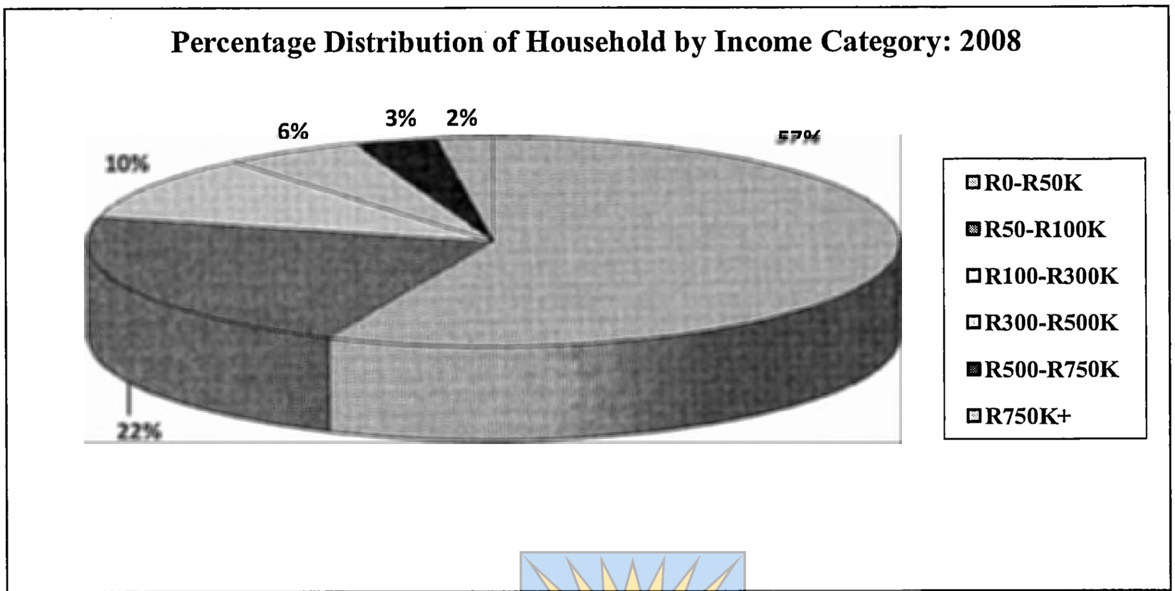
Metropolitan City	**Density urban pop/km^2**	**Average trip length (km)**
Moscow	14 626	7.7
Singapore	9353	8.0
Tokyo	8768	10.8
London	5907	8.6
Tshwane car users	1276	17.6
Tshwane public transport users	1276	25.4

Sources: Cameron, JWM et.al. Transport performance indicators: benchmarking Tshwane against world cities; Southern African transport Conferences, Pretoria, July 2005, as presented in Mokonyama et *al.* (2007).

2.5.2 Income Distribution Pattern

Figure 2.6a and 2.6b provide information on the income distribution pattern in South Africa during 2008 and 2009, respectively. This is based on the findings of the Bureau of Market Research at the University of South Africa, during 2008-2010.

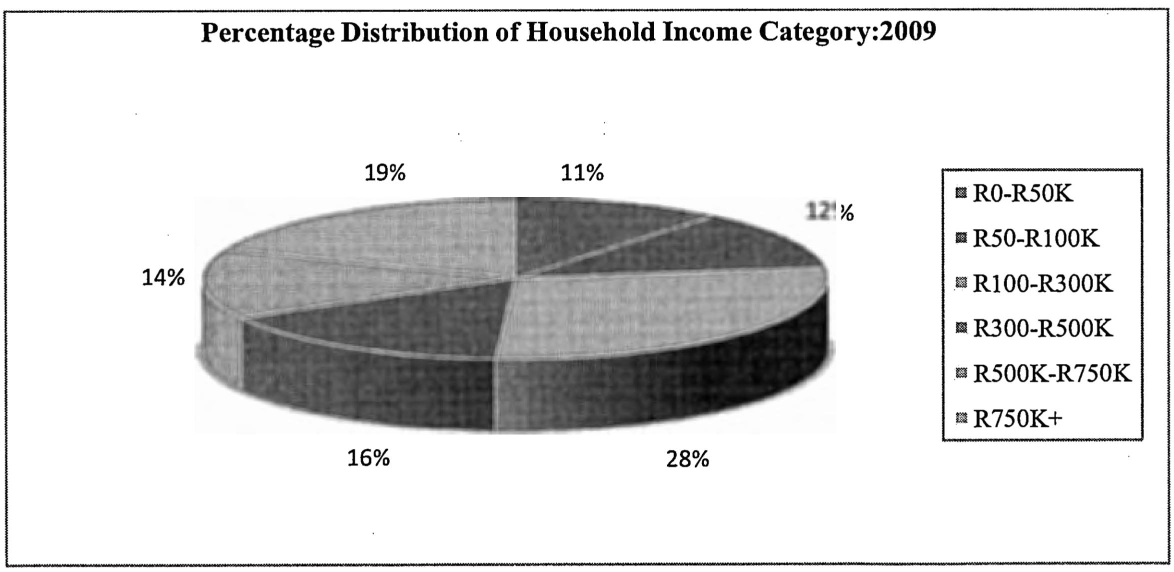
Figure 2.6a: Income Distribution Category in 2008



Source: Masemola and Van Wyk (2009)

In figure 2.6a, more than half (57%) of 13 390 919 million households are found in the lowest income group (R0 – R50K) in which most of these income earners are African (Black) people. While (22%) of all households are found to be in the income group of (R50-R100K). The highest income, that is, R750K and more is actually earned by only 2% of the 13 390 919 million households. 81% of the highest income earners are white people and only 10% are African (black) people. This shows the extent of the income inequality within the country.

Figure 2.6b: Income Distribution Category in 2009

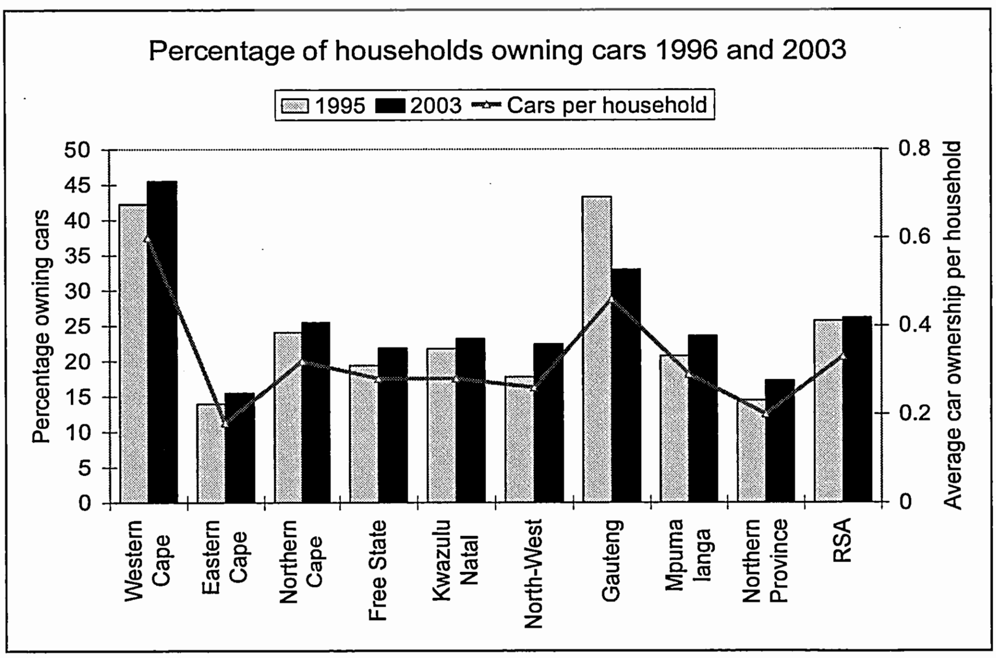


Source: Masemola and Van Wyk (2009)

In 2009, there were dramatic changes in the level of income per category. According to the findings of the Bureau of Market Research, in 2009, there were 13 654 416 million households in South Africa and they had a combined income of R1 631 billion as compared to the R1 531 billion in 2008 representing a 6.5% increases in household income in nominal terms during the period 2008 and 2009. Accordingly, 28% of these households are found in the middle income group of R100-R300K. 11% of the country's households earned between R0-R50K, and 16% of the total number of households earned between R300-R500K. Moreover, 19% of households earn more than R750K, in which 79% of those earners are white people, and 11% are Africans (Black people).

Turning to the car ownership picture in South Africa, Figure 2.7 below shows the percentage of households owning cars in 1996 and 2003. From figure 2.7, we see that the Gauteng and the Western Cape Provinces have the highest rates of proportion of households owning cars at about 45% and 33% respectively. Between these years Gauteng is the only province that had a decline in household car ownership figures while the figure for the other provinces grew. But in respect of the proportion of households with cars, the Western Cape tops Gauteng.

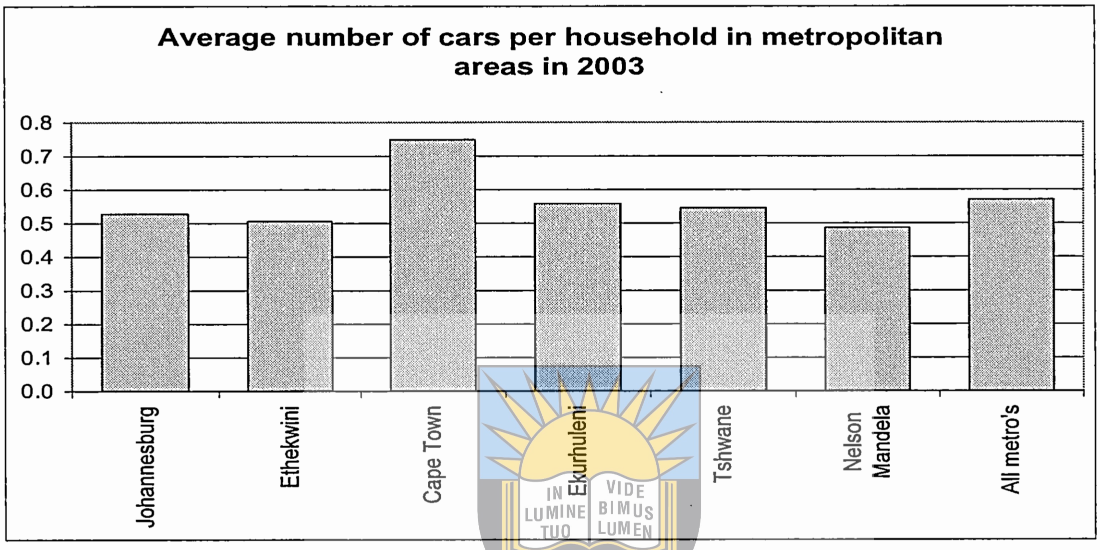
Figure 2.7: Relative increase in car ownership, compared with the increase in population in the period 1996 to 2003.



Source: Mokonyama *et al.* (2007)

The average car ownership per household is highest in the Western Cape and Gauteng at roughly 0.6 and 0.5 cars per household respectively. This is double the rate of car ownership in all the other provinces. The reason for the differences in the proportion of households owning cars and the average car ownership rate in Western Cape and Gauteng is that the Gauteng has more multiple-car households and lower average household size.

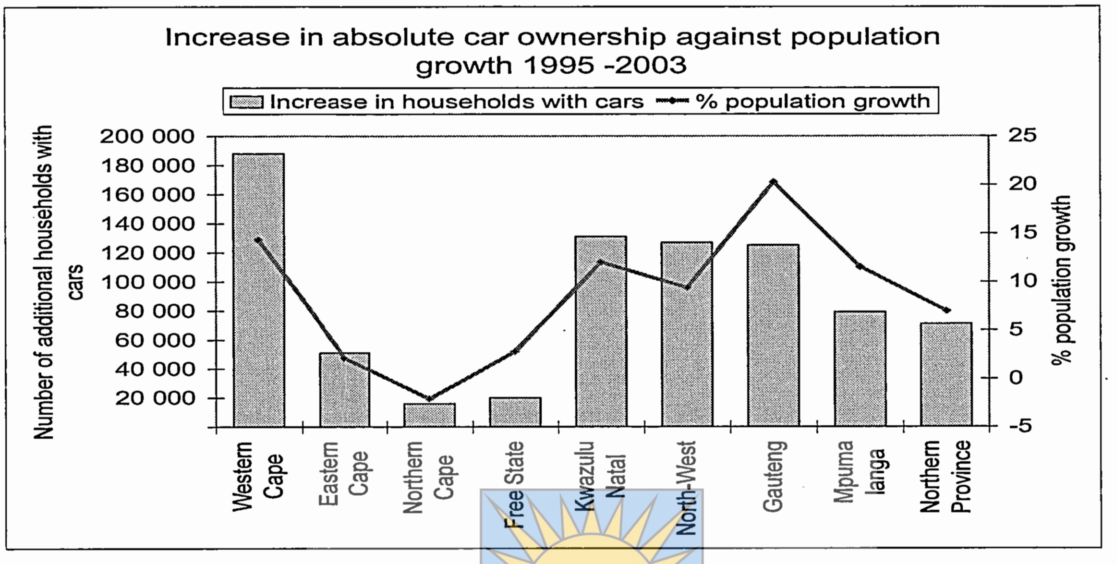
Figure 2.8: Household car ownership in 2003.



Source: Mokonyama *et al.* (2007)

Unfortunately the data sources did not allow a trend comparison between 1995 and 2003. However, comparing Figure 2.8 with the provincial trend shown in Figure 2.7, the results in the two figures are very consistent in respect of Gauteng and Western Cape which are dominated by metropolitan populations. We can assume that the trends in figure 2.7 are likely to complement those in the metropolitan areas. This could be because these areas have a large number of in-migration of poor households, resulting in a drop in household car ownership, even though the numbers of cars in the metropolitan areas are likely to have increased significantly, as is clearly depicted in figure 2.9.

Figure 2.9: Increase in absolute car ownership against population growth between 1995 and 2003.

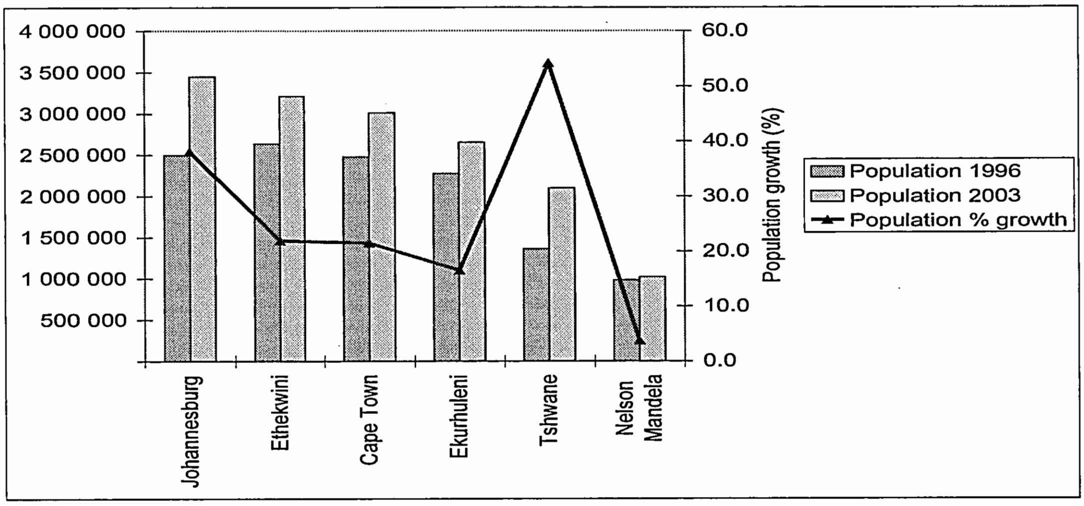


Source: Mokonyama *et al.* (2007)

Figure 2.9 shows the Western Cape has the largest growth with around 190 000 new car-owning households. The Northern Cape has the lowest growth at around 20 000 new car-owning households and also has the lowest figures for population growth. Gauteng has the highest percentage figure for population growth at around 20%, but the proportion of households owning cars in Gauteng dropped below the level of the Western Cape. The number of new households owning cars in Gauteng has risen by about 120 000, but the province has experienced the most rapid population growth. Most of the arrivals are from other provinces and the rural areas, increasing the proportion of non-car-households.

Figures 2.7 to 2.9 should be examined concurrently in order to form an impression of what might have been happening to household car ownership in the metropolitan areas. The large increase in the number of car-owning households in the North West is surprising and could be a combination of the migration of the poor to neighbouring provinces and increased affluence occasioned by the strong mining and agricultural activities in the province Mokonyama *et al.* (2007).

Figure 2.10: Population change and growth in the metropolitan areas (1996 to 2003).



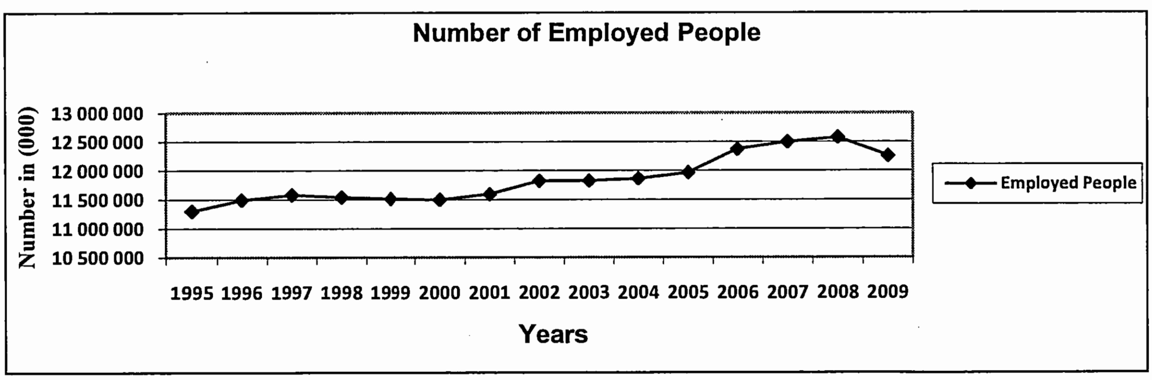
Source: Mokonyama *et al.* (2007)

Figure 2.10 above shows the population growth in the metropolitan areas during 1996 and 2003. The extent of the population growth, particularly in Johannesburg and Tshwane (mostly low-income urbanizing migrants) helps to explain why car ownership rates have declined in some of the metropolitan provinces. The Nelson Mandela metropolis has the lowest population growth figures, while Tshwane has the highest population growth percentage figures at over 50 percent.

2.6 Trends in travel to work

One of the factors determining the demand for public transport is the number of workers and their transport mode, that is, whether they travel by their own car or public transport. In this section we look at the trends for employed people and the types of mode frequently used, in travelling to work.

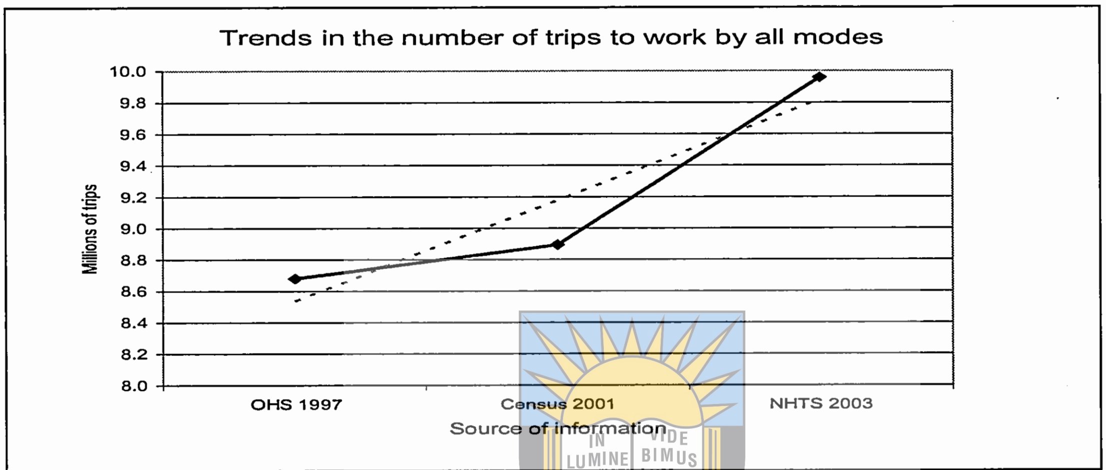
Figure 2.11: Number of Workers in South Africa



Source: South African Economic Data Indicators Database

As previously stated in figure 2.10, the population percentage growth declined in the metropolitan areas except in the Tshwane area. Figure 2.11 shows that the employment figures were on a gradual rise. This rise in employment may depend on the type of work available, e. g. contractual jobs that have been on the rise due to government trying to make schemes that can create jobs. Also, during the preparation of the 2010 World Cup, many jobs were created.

Figure 2.12: Growth in the number of trips to work

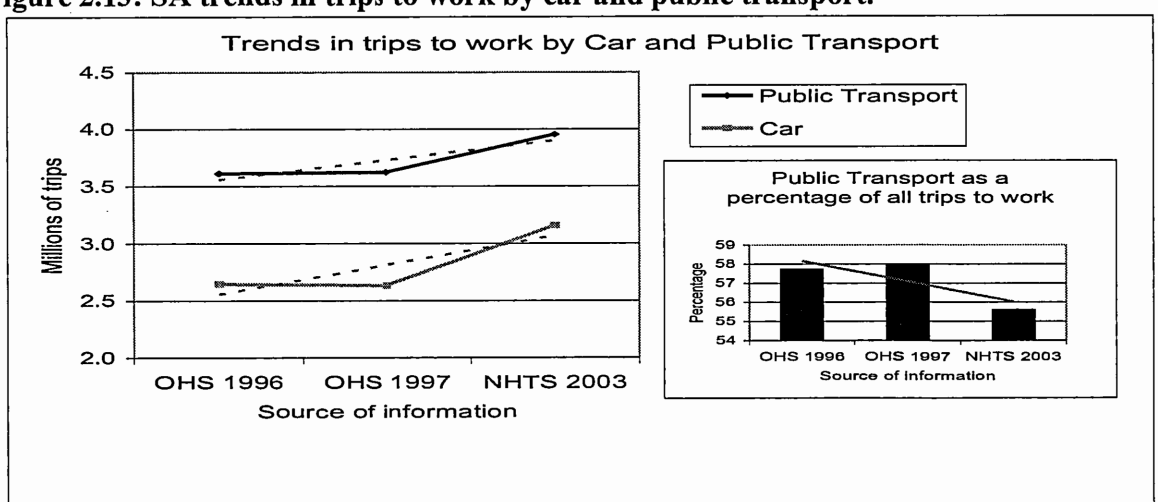


Source: Mokonyama *et al.* (2007)

In figure 2.12, the trend in the trip to work by all modes of travel between 1997 and 2003, can be seen. The trend shows that the number of trip increased substantially from about 8.7 million trips to work per day in 1997 to about 9.9 million in 2003. The trend in work trips matches the growth in the working population.

In figure 2.13, the graph shows the national transportation mode share trends and the percentages that show the type of public transport used for all trips to work.

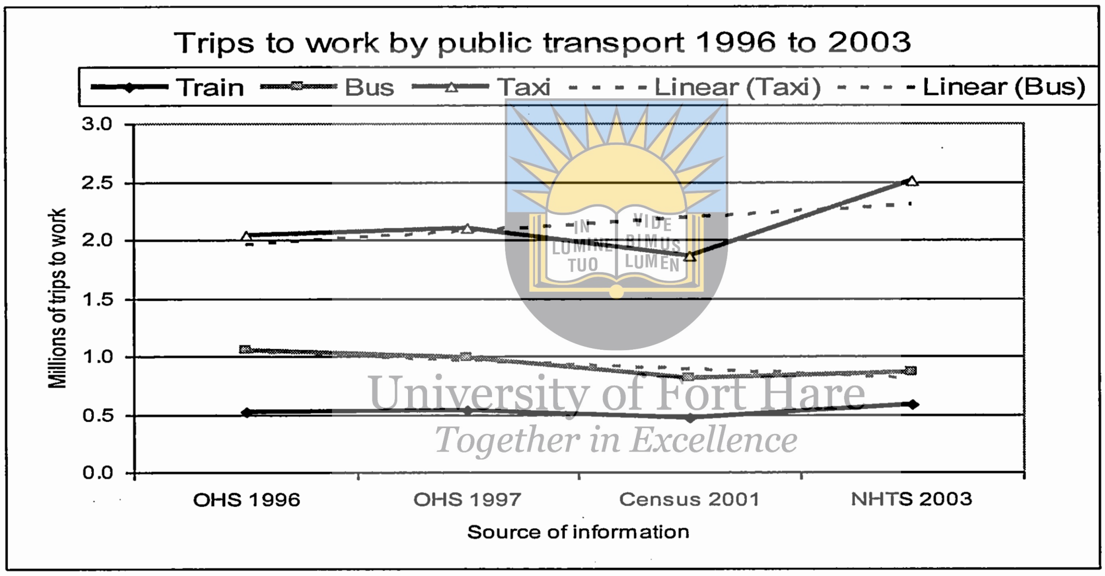
Figure 2.13: SA trends in trips to work by car and public transport.



Source: Mokonyama *et al.* (2007)

In figure 2.13, between 1996 and 2003 there was a general increase in the country's population and employment levels, which led to increases in the absolute number of trips for both car and public transport. It is apparent though, that the rate of growth was higher for car use than for public transport. The reason for this is that people opt to purchase private cars when their income increases, perhaps because of status or for the mere fact that they are dissatisfied with the South African public transport system. The bar chart in figure 2.13 indicates that public transport is in relative decline with its market share dropping from 58 to 56 percent.

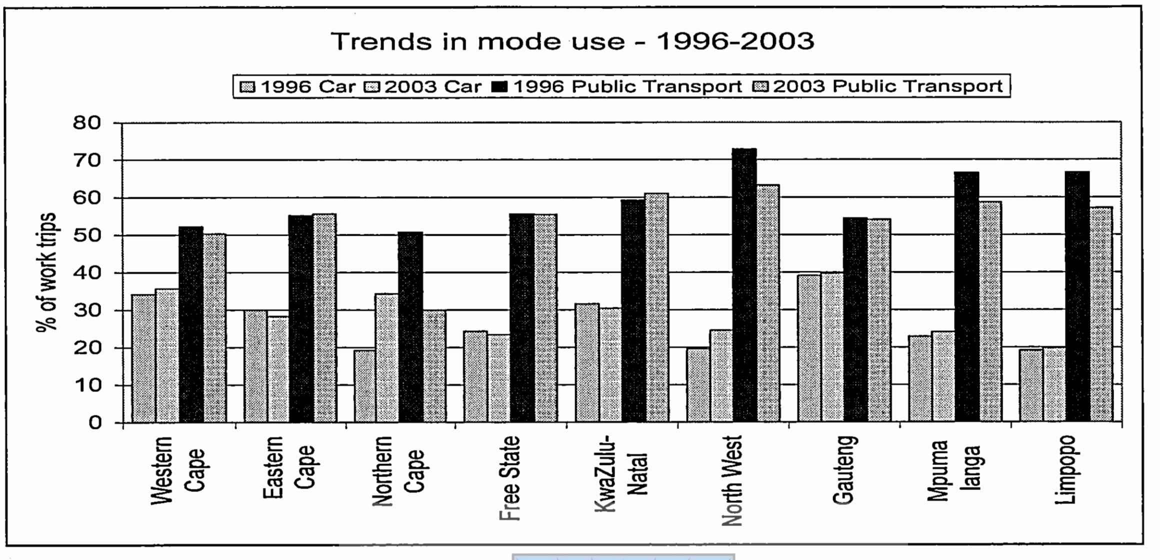
Figure 2.14: Public transport mode share for work trips



Source: Mokonyama *et al.* (2007)

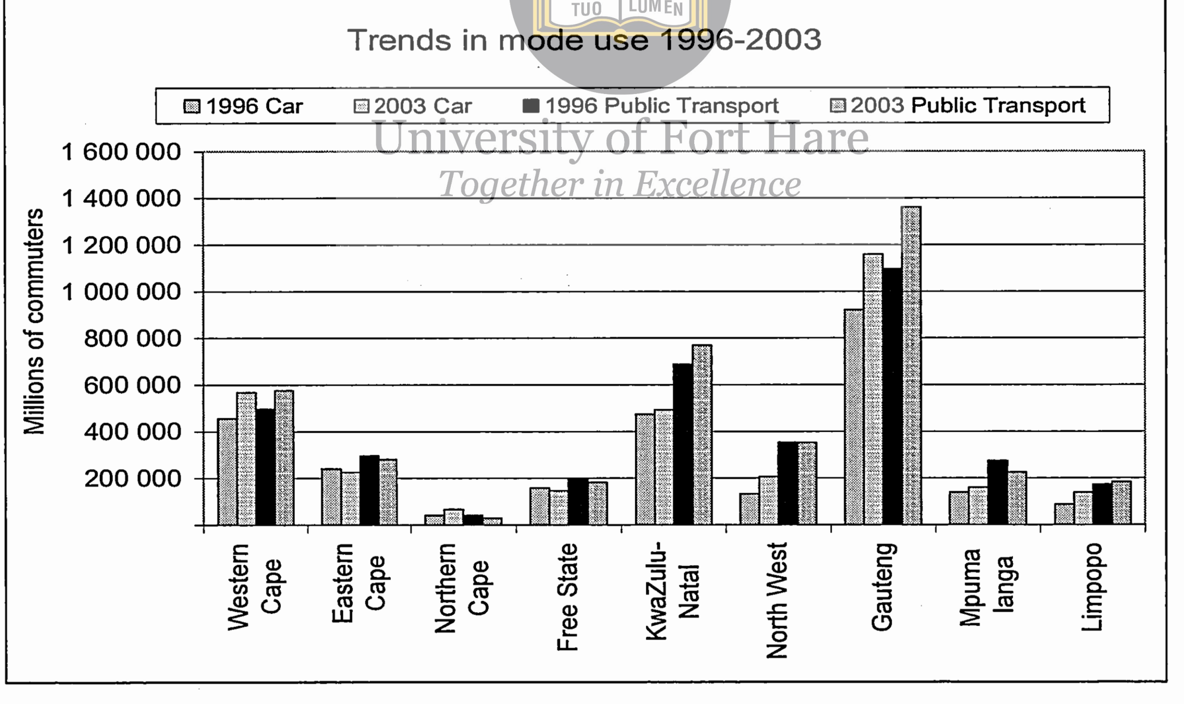
Changes in the number of trips to work by public transport between 1996 and 2003 are depicted in figure 2.14. Minibus-taxi use continued to increase from about 2 million to 2.5 million trips to work per day. Bus usage dropped from over one million to about 850 000 while train use remained fairly constant at around 500 000.

Figure 2.15a: Relative trends in mode use - 1996 to 2003



Source: Mokonyama *et al.* (2007)

Figure 2.15b: Absolute trends in mode use - 1996 to 2003

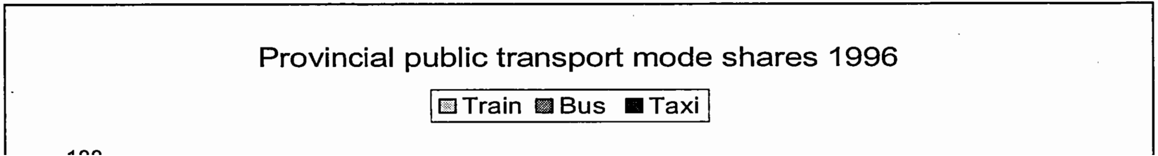


Source: Mokonyama *et al.* (2007)

Relative and absolute trends in the use of public transport and modes for work trips are shown in figure 2.15a and b respectively. In relative terms, the increase in car use for trips to work was most significant in the Northern Cape. The only provinces where there was a relative decline in the proportion of work trips by car are the Eastern Cape and the Free State. Public transport use declined significantly in relative terms in the Northern Cape, the North West, Mpumalanga and Limpopo.

In absolute terms, it is clear that the largest growth in work trip travel occurred in Gauteng, KwaZulu Natal and the Western Cape. The number of car trips appears to have increased significantly in the North West and to a lesser extent in Limpopo.

Figure 2.16: Trends in public transport mode share for work trips - 1996 to 2003

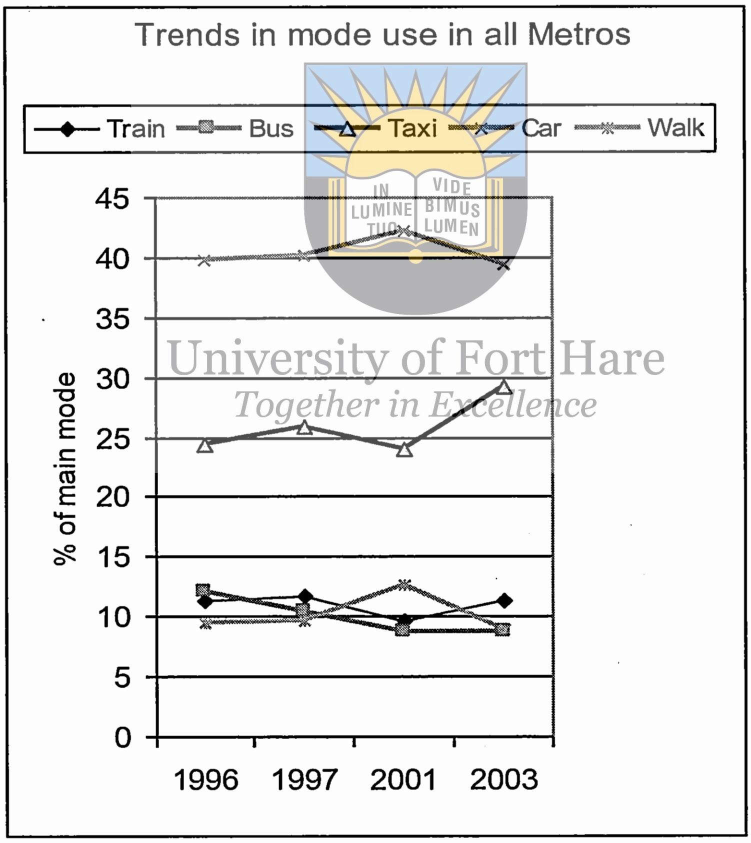


gains were largely at the expense of bus transport. In every province, the bus market share declined significantly in contrast to train services, which generally retained their market share, except in the Western Cape.

2.7 Metropolitan Trends on transportation

According to Mokonyama *et al.* (2007), the number of work trips in metropolitan areas increased fairly dramatically; but the market share of the travel modes remained fairly constant. Only minibus-taxis have had a significant increased its market shares as seen in figure 2.17 (from 24 to 29 per cent).

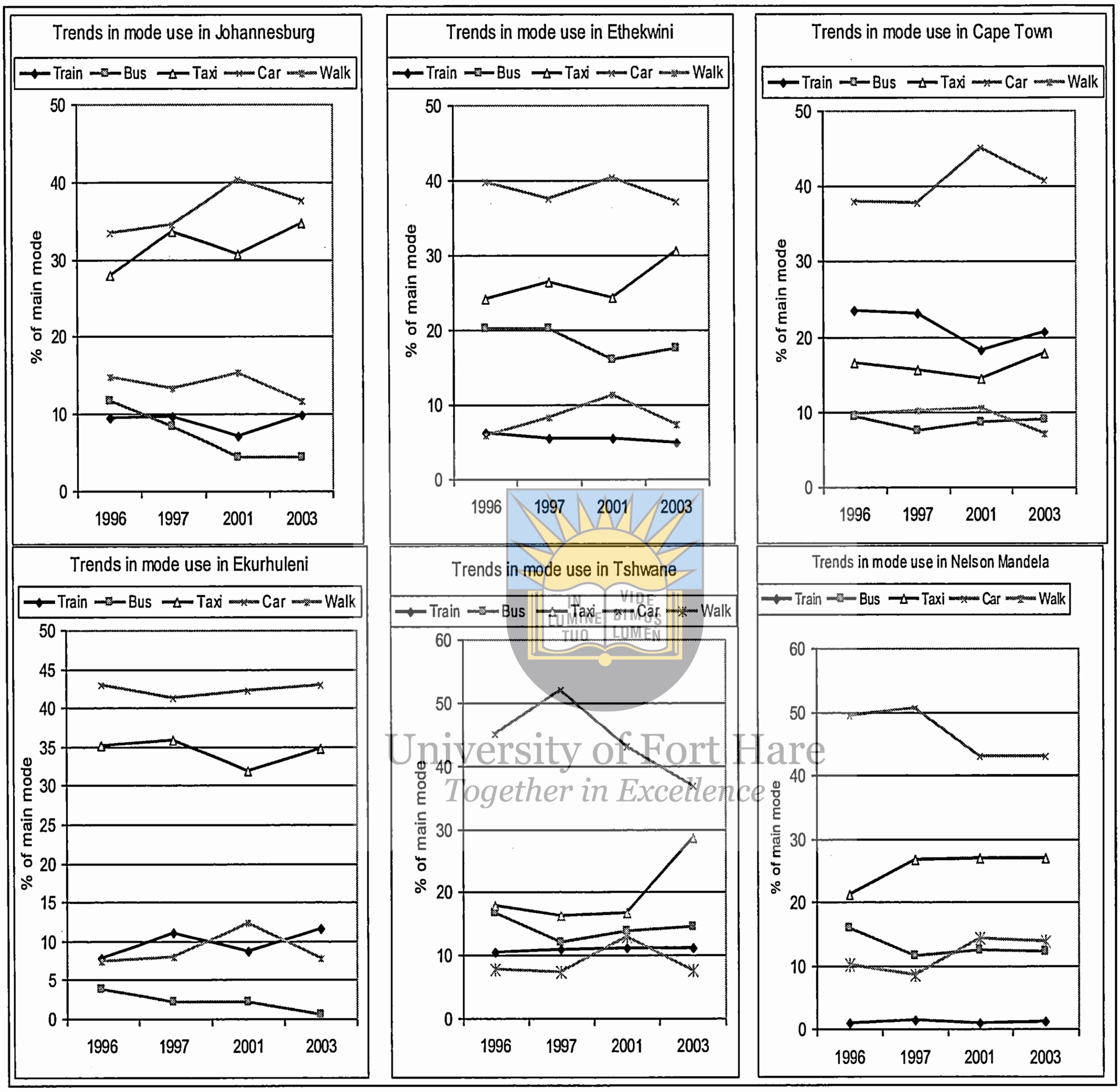
Figure 2.17: Mode shares of trips to work in metropolitan areas - 1996 to 2003



Source: Mokonyama *et al.* (2007)

The minibus-taxi market size, however, rose from 928 000 in 1996 to 1.36 million in 2003 which is a 47 per cent increase. The car share remained fairly constant at around 40 per cent, train and bus services were at around 10 per cent and walking, on average, accounted for about 10 per cent of trip to work in the metropolitan areas.

Figure 2.18: Metropolitan trends in mode share for work trips: 1996 - 2003



Source: Mokonyama *et al.* (2007)

In figure 2.18, car use increased significantly in the Johannesburg and Cape Town areas, while it remained stable in the Ekurhuleni areas. In other cities, the market share decreased, particularly in the Tshwane and Nelson Mandela metropolitan areas. These changes were probably due to demographic and income changes in the cities mentioned. Train use declined everywhere except for the Tshwane and the Ekurhuleni metropolitan areas.

Minibus-taxi use increased in Johannesburg, Ethekwini, and Cape Town and most notably in Tshwane, where the mode share rose from about 18% in 1996 to 28% in 2003. In all these metropolitan cities the gap between the minibus-taxi market share, and those of other public transport modes widened except in Cape Town, where the gap between trains, the leading mode, and taxis progressively narrowed. The mode share of minibus-taxis remained fairly constant in Ekurhuleni and Nelson Mandela. In the latter between 1996 and 1997 there was an upward adjustment in the minibus-taxi share, also reflecting a downward adjustment affecting bus services. According to Mokonyama *et al* (2007) both remained constant in 1997.

2.8 Transport Safety

The number of accidents in different modes of transport does affect consumer choice of transport mode.

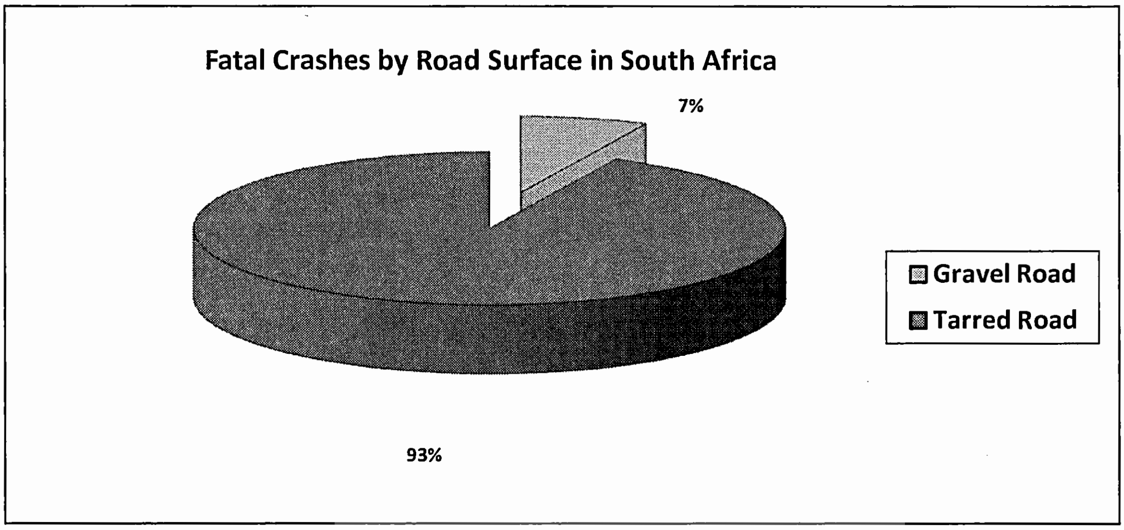
Table 2.4: Annual Number of Fatal Crashes by Province

Province	Years						
	2002	2003	2004	2005	2006	2007	**2008**
Gauteng	1675	2078	2107	2178	2419	2458	1884
Kwa-Zulu Nata	1385	1812	1997	1865	1514	1317	1129
Western Cape	869	984	925	913	948	1311	883
Eastern Cape	662	840	846	950	996	1189	763
Free State	609	550	522	640	671	622	425
Mpumalanga	664	853	728	785	631	992	676
North West	701	793	787	830	851	837	600
Limpopo	582	778	770	763	587	823	916
Northern Cape	273	274	247	219	249	220	112
South Africa	**7420**	**8962**	**8929**	**9143**	**8866**	**9769**	**7388**

Source: Annual Transport Statistics Bulletin (2008)

As can be seen from Table 2.4 above, Gauteng had the highest number of fatal crashes in the whole country followed by the Kwa-Zulu Natal, the Western Cape and the Eastern Cape. Gauteng led because of the high number of people who are constantly on the move. Also, it is a place where there is serious traffic congestion on a daily basis. This increases the chances of being involved in a fatal accident. The Northern Cape has the least number of fatalities because; the province itself is not densely populated and most roads in the province are not tarred roads but gravel roads.

Figure 2.19: Share of Fatal Crashes by Road Surface, 2008



Source: Annual Transport Statistics Bulletin (2008)

Figure 2.19, shows that fatalities that happen on South African roads are usually on tarred roads. This is because drivers travel much slower on gravel roads. Also because of the loud noise of the gravel and the bumpy ride, drivers are unlikely to fall asleep behind the steering wheel, unlike on the tarred roads. Many pedestrians are hit on the road by motor way users in the rural areas. This is because on gravel roads pedestrians can identify a car while it is still far off and can estimate the speed of oncoming cars, due to the loud noise. But with the tarred roads, they cannot do this, because the noise from on-coming cars is greatly reduced and the heat shimmering off the surface distorts the vision in the estimation of how far away on-coming traffic is (Annual Transport Statistics Bulletin, 2008).

2.9 Summary of the Chapter

Safety does not generally count as a contributing factor when choosing the mode of public transport, according to commuters. Road public transport, over the years, has had many crash fatalities, but that has not stopped people from using taxis and buses for transportation. Based on the review of this chapter, car ownership and the level of income are to be taken as factors determining the demand for public transport.

Additional factors include population growth and also the number of employed people. As the more the number of people increases, the more the country gets pressured to absorb additional people into the labour market. This leads to an increase in the number of employed people, which, in turn, results in a rise in income levels. All this increases the demand for public transport, as more people will need to travel to their various places of work.

Moreover, the more people get a rise in their income, the more they turn to private passenger cars for transportation, resulting in a decrease in the demand for public transport.

CHAPTER THREE

Literature Review

3.1 Introduction

The purpose of this literature review is to convey the knowledge and ideas that have been established on the topic of the demand for public transport and what its strengths and weaknesses are. This review covers the theoretical literature review, empirical literature review and assessment of the literature.

3.2 Theoretical Literature Review

In general, most individuals travel because they wish to benefit from the social, recreational, education, employment and other opportunities that become accessible with movement. According to Thompson (1974), there are several reasons why people in the modern world desire to transport themselves. Without transport, social relationships and contacts are normally very restricted. Transport permits social intercourse, and with it may come a greater understanding of the problems and attitudes of various geographically distant groups. The second reason is that, modern transport has widened cultural opportunities, permitting people to examine the artistic treasures of other parts of cities. And finally, transport is desired to permit people to live and work apart. Especially, it permits the geographical separation of employment from leisure. It increases the life-style options open to people, giving them a choice among residential locations away from cities but involving a heavy commitment to travel, or ones, much closer to the main employment centre but involving short commuting journeys. Transport, quite simply, widens the location choices open to households (Button, 2010).

Modelling is an important part of any large scale decision making process in any system. In the context of transportation, the first generation of travel demand models were developed in the late 1950's. That period was characterised by a rapid increase in car use followed by major investments in new road infrastructure. To assess the impact of the investments, models that could be used to predict travel demand in the long run were needed. In order to plan for transportation facilities, it is necessary to forecast how heavily they will be used. In order to price them rationally and determine the best operating policies, it is necessary to know how users respond to prices and services characteristics. To be able to evaluate whether a project would be worthwhile, it is necessary to have a measure of the benefits it will produce. All these requirements are in the province of travel demand analysis (Heertjie and Polak, 2001).

In the most general terms, the literature (especially the literature on passenger travel) distinguishes between three types of models: the classical four-stage models, often used in urban transport studies, which predominantly uses aggregate data; the microeconomic approach of travel-choice behaviour, which is underpinned by the random utility theory, in which traveller behaviour is explained mostly at the individual level; and the activity-based approach, in which travel is seen as a pattern of day to day behaviour that is related to and derived from variations in lifestyle and the degree of active participation on the part of the population (Blauwens *et al*, 2002). The above stated models of transport demand which will be reviewed are crucial for determining and analysing factors behind transport demand in South Africa.

3.3 The Classical Four-Stage Model

The demand for travel takes place in a multi-dimensional setting. The traditional sequential framework used by many metropolitan transportation planning agencies considers four choice dimensions: trip generation (the total number of trips originating from an area); trip distribution (the locations of the trips' destinations); modal choice (the means of travel, such as car, bus, train, bicycle, or walking); and trip assignment (the exact route used). More recently, researchers have paid greater attention to other dimensions of choice, such as residential and job location, household passenger car ownership, the time of day at which trips are taken, parking locations and the durations of activities for which travel is undertaken. Travel is a derived demand, usually undertaken not for its own sake but rather to facilitate a spatially varied set of activities such as work, recreation, shopping, and home life. This observation links the study of travel demand to studies of labour supply, firms' choices of technologies, and urban development. It also calls attention to an increasingly common form of travel: the linking together of several trip purposes into one integrated itinerary or tour, a process known as trip chaining (Blauwens *et al*, 2002).

As stated above, the classical four stage model is based on different components of travel or transport behaviours. These areas are as follows; the decision on whether or not to travel or have freight transported to a certain destination; the choice of destination; the choice of transport mode and finally, the choice of route. As Blauwens states, although a transport user will take these decisions simultaneously, in transport demand models they are usually considered in sequence. In other words, the output of each phase constitutes the input for the nest phase. In this type of demand model, transport economics makes use of the trip matrix.

In the trip matrix, x_{ij} corresponds to the number of passengers (or tonnes of goods) or the number of trips from zone i to zone$j$. R_i represents the total amount of traffic departing from zone i, while K_i represents the total amount of traffic arriving in zone j.

$$R_i = \sum_{j=1}^{I} x_{ij} \quad (1.1)$$

$$K_j = \sum_{i=1}^{I} x_{ij} \quad (1.2)$$

The grand total X represents the number of passengers (or the tonnage) transported in the area studied. This corresponds to the sum of all row totals and to the sum of all column totals.

$$X = \sum_i R_i = \sum_j K_j \quad (1.3)$$

One can distinguish between four sequential levels of demand determinations: trip generations, i.e. determination of the total transport quantity X as well as the row and column totals K_j and R_i or the incoming and outgoing traffic per region; trip distribution, i.e. the distribution of the row and column totals K_j and R_i over the separate flows X_{ij} between zones; modal split, i.e. determination of the share of each of the modes (road, rail inland navigation, pipelines, ...) in the traffic flows X_{ij}; assignment to infrastructure, i.e. choice of route for transportation but each of the modes, so that one can determine the traffic burden on the infrastructure network (Blauwens *et al*, 2002). If so required, one could also incorporate a traffic convention model after the modal choice in order to translate the traffic flows into the corresponding number of trips. From the perspective of applied transport economics, these four (of five) levels of demand determination correspond to four (or five) successive operational phases. We shall now deal with each of these phases in some greater detail (Oppenheim, 1995).

3.3.1 Trip Generation Model

The first stage in the classical four stage travel demand modelling is that of trip generation, predicting the total number of trip that will be generated in each zone of the study area. The classical methods for this stage of the modelling, category analysis and zonal or household regression, do not allow for the possibility that the numbers of trips may be influenced by the transport networks. These methods also suffer from specific problems as regards their treatment of data and responsiveness to other transport policy and exogenous trends (Daly, 2001). The purpose of the generation phase is to predict the number of trips with origin and destination in each of the zones. Starting from the current (known) row totals, i.e. the totals of incoming and outgoing traffic in each zone, one examines how these totals will evolve in the future.

Various factors determine the number of passengers travelling to and from a certain zone: the number of inhabitants and the related factors of household size and composition, car ownership, employment, income, the distance to various centres of activity etc. The multitude of explanatory variables compels us to divide traffic into a number of categories. Orthuzar and Willumsen (2006), state that generally, one divides traffic according to its purpose, so that one arrives at different types of trip. These include the following: home-based work trips, home based shopping trips and trips between the home and other destination (e.g. between home and school), in either direction. Another category encompasses traffic where the home is neither an origin nor a destination. For each of these types of trip, separate estimations are made on the basis of an appropriate methodology. The travel behaviour of a passenger is a function of this destination. And the sum of outgoing traffic must equal the sum of incoming traffic. If predictions on the basis of the number of jobs and the size of the working population do not meet this condition, a correction will need to be made, especially for data where the uncertainty is greatest. In the case of traffic between the home and work, one will usually correct the column totals, as the demographic evolution (the basic of predicting the row totals) is easier to predict than employment trends (column totals). The method whereby a fixed ration is applied between number of trips on one hand and the size of the population and the employment rate on the other can only be used for home-based work traffic. For other type of trips, one will need to use other methods of forecasting, such as regression analysis or category analysis.

By means of *regression analysis* the row totals are, for example, estimated using the following equations:

$$R_i = a + b_i y_{2i} + \dots + b_n y_{ni} \qquad (1.4)$$

Where: $R_i =$ the row total of zone i

$a =$ a constant

$y_{ni} =$ the value of factor n (e.g. population size, number of cars average income, ...) in zone i.

The coefficient $a, b_1, b_2 \dots, b_n$ are estimated on the basis of observation. They present the effect of the population size, the car fleet, income, ... on the total number of trips leaving the zone. The column totals for zone j can be estimated in exactly the same way.

$$K_j = c + d_1 y_{1j} + d_2 y_{2j} + \dots + d_m y_{mj} \quad (1.5)$$

Where: K_j = the column total of zone j

c = a constant

y_{mj} = the value of factor m (e.g. number of shops, size of the zone, jobs in retailing, land value, ...) in zone j.

In a final step, the calculated totals for each row and column are balanced by means of a correction coefficient.

Category analysis, it divides households into a number of categories on the basis of such characteristics as household income, car ownership, the number of employed individuals. Subsequently, the trips are assigned to each category on the basis of observations in the base year. This shows that the method is essentially based on the assumption that households with equal characteristics produce an equal number of trips. A prediction of the number of trips can then be made by multiplying the average number of trips by the number of households in the category, and by summating over the categories considered. An important drawback in terms of the reliability of such forecasts is that there is no test for analysing the constant nature of the number of trips per household.

According to Jovicic (2001), the weakness and limitations of the four stage models can be summarised as follows: they ignore the fact that the demand for travel is derived from the demand for activity participation; and they focus on individual trips (or tours), ignoring the spatial and temporal relationship between all trips and activities completed by an individual; and they see an individual as a decision-maker isolated from the household context (Jovicic, 2001).

3.3.2 Trip Distribution

The Trip Distribution model concerns the estimation of transport volumes moving between all zones i and j, whereby i represent the trip-generating zone and j represents the trip-attracting zone (Hensher and Button, 2009). In order to determine the trip distribution, various methods maybe used. First, there is the growth factor method, where growth factors are applied to the existing distribution patterns as represented in the trip matrix. And secondly, one can make use of the synthetic approach. Both methods are discussed below.

Growth Factor Method:

The Growth Factor Method is applied to the existing distribution pattern represented in the trip matrix (Blauwens *et al*, 2002). There are a number of different growth factor methods that can be used, but in this study we shall focus on the Detroit growth factor method. In this approach, the new traffic flows are determined by the following formula:

$$x_{ij} = x^0{}_{ij}\left(\frac{r_i \,.\, k_j}{r}\right) \qquad (1.6)$$

Thus the following corrections are made to the observed flows $x^o{}_{ij}$:

-all traffic flows of row i are multiplied by a growth factor r_i;

-all traffic flows of column j are multiplied by a growth factor k_j;

-all traffic flows are divided by the general growth factor r.

The factors r_i , k_j and r are determined in such a way that the new traffic flows add up to the given row and column totals. With each step we multiply the previously determined growth factor r_i by the quotient of the row totals to be attained and the row totals already attained:

r_i (in the new calculation) = r_i (in the previous step)

x (the row total to be attained R_i / the row total already attained in row i).

As a starting value, one takes:

$$r_i = \frac{R_i}{R_i{}^0};\; k_j = \frac{K_j}{K_j{}^0};\; \frac{X}{X_0} \qquad (1.7)$$

So that one calculates the following flows after the first step:

$$x_{ij} = x^0{}_{ij}\left(\frac{(R_i/R^0{}_i)(K_j/K_j{}^0)}{X/X^0}\right) \tag{1.8}$$

Subsequently, a new correction is made, followed by a calculation of new traffic flows. The process is concluded when the given row and column totals have been sufficiently approximated. The growth-factor method is simple to understand and makes direct use of observed trip matrices and forecasts of trip-end growth. They preserve the observations as much as is consistent with the information available on growth rates. This advantage is also their limitation as they are probably the only reasonable point for the short term planning horizons (Willumsen and de Dios Ortuzar, 2009). The most important characteristic of the growth factor method is that the forecasting of future traffic flows does not take into account the changes in travel demand brought about by network changes. For this reason, it may be useful to take into account the synthetic approach rather than a growth factor approach, as the former does take due account of transport costs and also works if no reliable figures are available about the previous traffic flows (Blauwens, 2002).

Synthetic Method:

According to Blauwens (2002), the synthetic method is based the Newton's law of gravitational attraction, which states that: the force of attraction between two zones (i and j) is assumed to be proportional to the mass of zone *i* and the mass of zone *j*, and to be inversely proportional to the distance squared.

$$x_{ij} = k\,.\; O_i\,.\,D_j\,.\,C^{-\beta}{}_{ij} \text{ (where } \beta = 2) \tag{1.9}$$

Where: x_{ij} = traffic flow from zone *i* to *j*

O_i = the importance of zone *i* as an origin, i.e. the origin potential (e.g. the population size)

D_j = the importance of zone *j* as a destination, i.e. the destination potential

C_{ij} = the transport cost from *i* to *j*, which is a function of the distance

k = a constant that is determined in such a way that the total number of trips equals the observed total.

β = a parameter to be estimated ($\beta = 2$ by strict analogy with Newton's law of gravity).

The terms O_i and D_j are measures of the generative and attractive characteristics of the origin and destination localities. The variables that these terms represent may be divided into two categories. On the one hand, one uses proxy variables, i.e. a rough measure such as population size. On the other, there are exact variables, which in the case of traffic between home and the workplace may be working population and the number of jobs. The parameter β has repeatedly been estimated at around 2, which rather surprisingly confirms the analogy with Newton's law of gravity. This implies that, if transport costs on a certain relationship are cut by half, traffic on that relationship will quadruple. Assuming that the transport costs does not change and traffic flow only change through changes in the row and column totals, another variant of the pool model employs correction coefficients that are determined in such a way that the calculated traffic flows add up to the given row and column totals.

$$x_{ij} = \frac{R_i . r_j . K_j . k_j}{X . r} . f(C_{ij}) \qquad (1.10)$$

In other specifications of the pool model, the number of trips between zones i and j are not only affected by the cost on the relationship concerned, but also by the cost of travelling from i to another destination (v).

$$x_{ij} = k . \frac{R_i . K_j}{\sum_{v=1} I \quad K_v (C_{iv}) \beta} . f(C_{ij}) \qquad (1.11)$$

This is a typical example of a multiple gravity model.

With the synthetic method, the gravity models bring with it quite a few problems, including with regards to the determination of the transport cost, the functional form and the potentials. For this reason, the method is predominantly used if the growth factor model has been ruled out, e.g. when the previous traffic flows are unknown.

3.3.3 Modal Spilt

So far we have determined the individual traffic flows from zone to zone. In the next phase of transport demand analysis, we shall establish the share of each mode in the traffic flows. The analysis of the modal choice is established on the decision-making process in the transport sector. Traditionally solutions to mobility problems are sought in the modal choice, as interventions at the level of generation and distribution will directly affect the economic environment, where one thinks in terms of production and consumption patterns. Intervening in the modal choice, in contrast, does not affect the economic environment, but merely has an impact on the manner of conveyance (Hensher and Button, 2009).

In the short term, influencing the modal choice can result in an efficient use of existing capacity. And in the longer term, there will be implications for any replacement or expansion investment in the transport system. Reducing auto mobility by physically hampering car-use, for example, may ultimately be detrimental to employment and earnings. Various procedures have been developed for estimating a modal split on the basis of a number of factors that indicate the appropriateness of the modes.

With the previously discussed 'distribution' phase, the theory stated that traffic flows were separate from zone to zone. But now with this in mind, a question arises of travellers' choice between various modes of transportation; the car as a driver; the car as a passenger, different types of public transport (taxi, bus and train). A choice model is concerned with the behaviour of travellers with regards to the selection of transport modes. The modal choice of travellers is determined by three explanatory factors (Blauwens *et al*, 2002).

1. The socioeconomic status of the traveller plays a determining role in the individual's modal choice. The first factor is *car ownership*: people who own cars will tend to use them under all circumstances. A second is income, which partly determines whether or not one is a car owner. Non-car owners on a high income will tend to make more frequent use of taxis, while those on lower income levels will tend to travel by trains and buses. Then there are the white collar-blue collar distinctions, in which, income being equal, the former group will make more use of private transportation and less of public transport than the latter. The next factor is *age*: people under the age of 18 and above the age of 60 make less frequent use of the car. And finally the household composition plays a role, though often this variable may be reduced to one of the other explanatory factors.
2. The nature of the trip plays a determining role in the individual's modal choice. The first factor in this respect is the length of the trip. Long distances have a negative impact on car-use and a positive impact on the modal share of rail travel and air travel. Also important is the motivation for travelling. The car is used less frequency for travelling between the home and work or school than it is for shopping. This is due to the irregular nature of the latter type of trip.
3. The characteristics of alternative modes. The difference in travel time of the competing modes is important: the greater the difference the more likely that a

traveller will opt for the quickest mode. The total travel time consists of three components, i.e. the in-vehicle time, the walking time and the waiting time. In most case the traveller experiences the negative utility associated with identical increases in each of these components.

The final factor is the difference in cost between competing modes. In the case of public transport it consists entirely of the fare, but matters are not quite as straight forward in the case of private car use. As far as the cost of travelling is concerned, the modal choice between the car and public transport is influenced exclusively by so called out-of-pocket expenses. These are costs that one pays immediately (e.g. parking fees) or the costs that one regards as more or less proportional to the distance covered (petrol, maintenance, etc.). As regards the dependent variable, one can opt for the market share that chooses for a specific mode. It is virtually impossible to incorporate all these determining factors into a single model, especially as data are not available for each variable.

3.3.4 Assignment to infrastructure

Small and Verhoef (2007), state that the modal spilt offers insight into the traffic flows per mode from zone to zone. Subsequently, traffic conversion offers insight into the corresponding number of trips. The problem that, then, arises is how to assign these flows to existing infrastructure. After all, this knowledge is required for infrastructure planning, both in the short-run (optimal use of capacity) and the long-run (optimal development of infrastructure). The actual assignment process involves two passes. In the first instance, one determines which alternative routes the network has to offer. Subsequently, the movements are assigned to a selection of routes.

There are four ways of assigning traffic to available infrastructure: one distinguishes between the all-or-nothing method and the diversion curve method, each of which can be combined with feedback, i.e. back calculation to the influence of traffic density on the modal choice. The all-or-nothing method involves choosing one single route for the entire traffic flow, e.g. the shortest or the cheapest route. This may be combined with feedback: after assignment of all traffic flows, one determines the density of traffic, on the basis of which one recalculates the speed. Then one reassigns. This can be done repeatedly until a stable equilibrium is attained. In the diversion curve method, the share of various routes is influenced in a gradual, continuous manner by differences in terms of time, distance, costs. This method is usually applied if there are two alternative routes (Blauwens *et al*, 2002).

3.4 Microeconomic Approach

The second type of transport demand system is the microeconomic approach to transport choice behaviour (Disaggregated model), where the units of observation and analysis are taken from individuals or households instead of zones. This approach, takes into consideration an individual who makes the transport decision. Consequently, it allows one to respond more efficiently to transport patterns.

$$1\text{n}[P_i/1 - P_i] = \beta_0 + \beta_1.X_{1i} + \beta_2 X_{2i} + \varepsilon_i \qquad (1.12)$$

Where P_i represents the probability that person number i will make a certain choice on the basis of a number of explanatory variables. X_i represents the attribute of the mode β are the unknown parameter vector and $\varepsilon_i$is the non-observed attributes of alternative. The above equation can be estimated by means of a maximum likelihood iterative process. The random utility model is the basic model that captures this behaviour, which is specified for a given individual as:

$$U_i = V\ (\beta;\ X_i; S) + \varepsilon\ (X_i, S) \qquad i = 1, \dots, j \qquad (1.13)$$

where: $U_i =$ the utility that corresponds to mode i, divided into two components: an observed component (a known vector function V), the unobserved tastes of the decision-maker and other unobserved influences (ε).

$X_i =$ the attributes of the mode

$S =$ socio-economic characteristics of the decision-maker

$\beta =$ an unknown parameter vector.

The individual will opt for mode i if $U_i > U_j$for all $i \neq j$.

As utility is random across individual, this event may be expressed as a probability P_i:

$$P_i = P\ [U_i > U_j, \text{for all } i \neq j] \qquad (1.14)$$

When referring to some basic demand theory, we will see that demand is an abstract concept reflecting what individuals would like to consume under different scenarios. It is generally considered that the quantity demanded of a commodity; D_a, is influenced by price, P_a, the price of other goods $(P_1, P_2, \dots, P_n)$, tastes, T, and the level of income Y. The neoclassical demand curve entails focusing on the implications of price changes on demand, holding the other factors constant, that is,

$$D_a = f(P_a P_1, P_2 \ldots, P_n, T, Y) \quad (1.15)$$

A fall in price has two implications for demand – the price of the activity under consideration falls relatively to other prices (substitution effect) and more can be bought for a given income (income effect) – both of which stimulate the quantity of the good of service demand (Button, 2010) This means that normally there is a negative relationship between price and quantity demanded, provided that other elements in the equation (1.15) remain constant. Hence, there is a downward demand curve. The elasticity of demand reflects the demand responsiveness or the relative sensitivity of a change in the quality demanded to a change in prices.

This curve shifts, however, if there are changes in other elements of the equation (1.15). An increase in income by allowing more to be bought at any price level moves it out, whereas a fall in the price of a substitute, by making the good relatively more expensive, pulls the demand at any price down. In some cases, as with fashion goods or where public attitudes alter, the demand curve may shift because of changes in 'tastes', essentially a catch-all concept used to mop up effects not captured in income of price effects.

For calculation purposes, as with many areas of demand analysis, a double logitharimic (or log-linear specification) of the form seen in equation (1.16) is often used to estimate the effects of the various factors on demand. This allows a simple interpretation of parameters as elasticities, but does assume that, for example, the price elasticity of demand is the same at all price levels:

$$1\text{n}Q_M = \alpha + B_1 1\text{n}P_M + \beta_2 1\text{n}Y + \beta_3 1\text{n}P_N \quad (1.16)$$

where: $Q_M$is the quantity of mode M demanded, P_M is the price of mode M, Y is income, and P_N is the price of alternative, N. All variables are expressed as logs (1n) and the parameters would normally be estimated using multiple regression analysis. The price elasticity (defined as $\{\Delta Q/Q\}$ $\{\Delta P/P\}$ is the parameters β_1 in a double logarithmic equation, the income elasticity of demand, reflecting the sensitivity of the quantity demanded to income changes, is β_2 and β_3 is the cross-elasticity of demand. This simple demand function framework holds for transport.

3.5 The Activity-Based Approach

Thirdly, there is the activity-based approach. This according to Fisher (2000), states that many transport economists feel that it is necessary to place transport behaviours in a broader more holistic framework. This can be achieved by concentrating on an individual's reason for undertaking activities at different locations during a certain time period. An individual's movement can after all be related to the following activities: working, attending school, leisure purposes etc. This can show the demand nature of transport demand (Blauwens *et al*, 2002). An activity can be defined as a physical engagement of an individual in something that satisfies his or her/ and family's needs. Activities are motivated by economic, physiological and sociological needs of individuals. This approach can be more complex, but it certainly can be more useful. The main purpose of the activity based approach is to give a better qualitative understanding of the travel-decision making. However, there are certain disadvantages to this kind of approach, and these include: the data required for this approach are very strict, in the sense that it only considers travel and activities patterns and no other. The second disadvantage is that there is a lack of theoretical literature support (Blauwens *et al*, 2002).

The theory behind the activity based travel demand models is based on works of Hagerstrand 1970 and Chapin 1974 in Jovicic (2001). Hagerstrand's time-geography theory from Jovicic (2001) focuses on personal and social constraints when explaining our need for activity participants. It also explains that an individual's choice of activities is limited by a number of personal and social constrains. Hagerstrand divided these constraints between 'capability constraint' (e.g. a need for sleeping and eating), and 'coupling constraints' (e.g. having a family for dinner requires that the family members be present at the same time) and 'authority constraints' (e.g. opening hours of economic active services, shops). Basically the theory assumes, therefore, that travelling to certain destinations at certain times of the day and by certain travel modes results from the demand for activity participation. Chapin's theory, on the other hand, is more concerned with opportunities and choices than the constraints. The theory postulates that the activity demand is motivated by basic human desires, such as the desires for survival, social encounters and ego gratification. This was later been modified by some more factors including commitments, capabilities and health (Jovicic, 2001).

According to Cowie (2010), the basic demand for transportation arises sometimes from two sources: the revealed demand and the latent demand. The revealed demand is expressed in the journeys that are actually made or the goods that are transported using the existing infrastructure. Should this demand increase, it results in pressure to upgrade existing infrastructure to meet the current demand for transportation. The latent demand in technical terms refers to the segment of the demand curve to the right of the equilibrium point. Where there is demand but, the kind of demand that cannot be satisfied due to inadequacies in the existing infrastructure. Revealed demand will be shown where the existing transport infrastructure is under pressure, hence clearly displaying a high demand for the movement of people between two given locations. This most often arises on heavily used commuter routes where roads become severely congested and the public transport services overcrowded. Economic development, therefore, may be suppressed due to the sufficient capacity in the transport system. This would be a clear case of the old business adage 'that time is money' and hence time stuck in traffic is time not spent earning an economic return (Cowie, 2010). Improving the public transport links therefore removes such constraints and economic development can flourish. Latent demand in this case relates to where individuals may travel to a particular area but do not do so due to limitations in the transport services. If these limitations are removed, individuals may then make the journey but will only do so if it increases their net benefit, which then indirectly leads to economic progress. A rather simple example would be where an individual may not commute between Pretoria and Johannesburg due to journey time involved, and also would not re-locate due to social ties and the higher cost of living, particularly housing, in and around the Johannesburg area. If however, a high-speed railway (Gautrain) line was to be constructed between the two locations, then with considerably reduced journey times more individuals are likely to make the daily commute from Pretoria to Johannesburg.

As regards the derived demand effects, increased wealth generally creates a demand for more leisure activities, or even more sophisticated leisure activities. Thus as income rises, individual's may take two foreign holidays rather than one, and /or have more weekends away from home, thus higher incomes lead directly to increased passenger traffic. A second derived demand factor exists where higher incomes tend to produce a modal switch away from public transport towards private transport, hence increasing the number of multiple-car households. As travel is now 'easier' and more affordable, this will directly increase the level of transport. It is therefore clear that something has to be done about these problem areas in public passenger transport.

Gomez-Ibanez (1996) finds that the ridership in Boston, USA between 1970 and 1990 was affected largely by external factors beyond the transit agency's control and less by internal factors such as fare changes. Of the external factors he analyzed, employment was more significant than per capita income: each percentage decrease in central city jobs was associated with a drop in ridership of between 1.24 and 1.75 percent, while each percentage increase in real per capita income was associated with a patronage decline of 0.7 percent. Hendrickson (1986) also examines the relationship between central business district (CBD) employment levels and public transit use in a study of 25 large metropolitan areas. For 1970 and 1980, he finds that CBD employment explains a very high percentage (R^2 = 0.96 and 0.90, respectively) of the number of transit commuters (i.e. transit work trips). When he added metropolitan population to his model, the R^2 increased to 0.98. Hendrickson finds that, in his sample, CBD employment is a more important than region population in explaining transit commuting levels.

Abdel-Aty and Jovanis (1995) explore a different aspect of services quality influencing public transport demand. Using public transport survey data from Santa Clara and Sacramento, California, USA, they find that most respondents were satisfied or very satisfied with available public transport information. Binary logit and ordered probit models estimate that ITS-delivered public transport information might encourage shift people to use public transport: 58.7 percentage of respondents were likely to use public transport at least once per week given the availability of ITS-delivered public transport information, and about half of the non-public transport users who might consider public transport would be more likely to use it if certain information items were available.

3.6 Empirical Literature Review

In the study, "the demand for public transport" by Paulley *et al.* (2006), the effects of fares, quality of services, income and car ownership are highlighted and do alter and have a great influence on the demand for public transport in and around the United Kingdom. The context of the study was principally that of the urban surface transport in Great Britain. However, Balcombe *et al.* (2004) argues that the above mentioned factors cannot be treated either in isolation from each other or in isolation from many other direct and indirect influences on public transport demand.

A few studies find that pricing schemes, such as the deep discounting, induce significantly public transport use, because such schemes account for different sensitivity to price among various market segments. Some public transport agencies have experienced considerable success in providing discounted public transport fares to students through partnerships with universities, particularly in increasing public transport use without increasing services (Brown, Hess and Shoup, 2001).

Elasticity values are found/ shown to increase with fare levels which may have a positive or a negative effect on the public transport demand function. Hensher and Bullock, 1979 found that for fares in Sydney, that fare elasticity was 0.21 when fares are increased but 0.19 when they were decreased. This showed that the response to a fare increase may not be equal and opposite of the response to a fare decrease. However, Wardman (2004), found no evidences of elasticity asymmetry, although his study did not include very many cases where the prices fell.

There is an enormous variation Paulley *et al.* (2006) between different types of area in the pattern and level of public transport services, and the demand for them. This recognises that people who live in population densities that are low will tend to rely more on private cars and less on public transport than people who live in highly populated density areas such as the cities or urban areas. The same type of argument might lead to the expectation that residents of large cities are likely to be more dependent on public transport than those in smaller cities, with corresponding differences in fare elasticity. However, the evidence is less clear cut. According to Jolly *et al* (2004) people in cities of densely populated areas are employed and earn considerably high incomes and thus are more exposed to using and relying on private cars than on public transport, as they can afford it. This can lead to higher demand for land use for the construction of transport infrastructure in terms of road transport. This in return will lead to high rates of externalities such as accidents, congestion and pollution and even sound pollution.

The above is supported by Nolan (1996), in his study of transit demand, in which he emphasize the significant role income plays in determining the mode of transport to be used. Through the study conducted by Jolly *et al* (2004), they came to the conclusion that French cities have the lowest cost of private car use, and a considerably larger parking supply than in the average city with an intensive profile. However, Bresson, Dargay and Pirotte (2003), pointed out that, on average, the possibility of parking at the workplace is statistically equivalent to a time-saving of 24 minutes on a trip which shows how parking supply can have as large an impact on the modal choice as the availability of a private car.

Income levels and passenger car ownership are other socio-economic variables frequently included in regression analyses on determinants of demand public transport. Liu (1993) and McLeod (1991) use per capita income measures, while Gomez-Ibanez (1996) uses a per capita income variable for one of his demand for public transport models for Boston, USA, and a time-trend variable (reflecting a consistent trend in suburbanisation and income growth) in another. The latter study concludes that the positive effect of employment growth on public transport use was offset by the impact of rising incomes and suburbanisation. This led to a net decrease in the demand for public transport; substantial fare reductions and service increases were required to counterbalance this effect.

Liu (1993) and Kani and Liu (1995, 1996) included a measure of passenger car ownership in regression models for various metropolitan areas. However, because car ownership and public transport use are interrelated, a change in one of the variable affects the others, although the magnitude of effect may not be symmetrical in terms of direction. Kitamura (1989) examines the causal relationships between car ownership and public transport use using surveys and trip diaries given to nearly 4000 people in the Netherlands. This study found that a change in car ownership leads to a change in car use, which in turn, influences the demand for public transport. The study found that the reverse relationship, where a change in transit use leads to changes in car use, is weak. Thus it concluded that increase in car use may not be suppressed by public transport improvement.

McLeod *et al.* (1991) include the number of registered passenger vehicle as a variable in two time series regression models. However, the study found that this variable and others thought to be important to the demand for public transport (number of tourists and petrol prices) are in fact not significant factors. In addition to automobile ownership, the petrol price is included in many public transport models. Most, however, find little or only a small influence on the demand for public transport; due to the fact that motor fuels comprise a relatively small share of passenger car operating costs. For example, McLeod *et al.* (1991), in their study of Honolulu, Hawaii, hypothesized that petrol prices were an important determinant of the demand for public transport, but did not find fuel prices to be a significant factor. One exception is Sale (1976), who studied the effects of the energy-crisis-driven fuel price increases during the early 1970s; the study found that these significant increases in fuel prices had an immediate and positive effect on an increasing demand for public transport. Finally, strategies to increase parking costs or the probability drivers will have to pay for parking are found to be more effective in increasing public transport demand mode share than increasing the level of public transport services in terms of frequency and accessibility.

In Dublin, Ireland Nolan (1996) analyzed the demand for public transport by making use of micro data extracted from the 1994/1995 Household Budget Survey (HBS). In this study, the binary and the ordered probit model were used for the construction of the household car ownership decision. The study provided the elasticity of demand for car ownership and use and public transport expenditure with respect to income and various household socio-economic characteristics. In this study, ordinary least squares estimation techniques were used to model the demand for car and public transport use. The positive but inelastic effect of household income observed suggested that, over time, the effect of income on car ownership may be declining. In addition, household characteristics explain large amounts of variation in household car ownership and indicate that while car ownership is becoming increasingly prevalent, there still exist certain categories of individuals termed "captive public transport users" for whom travel by car is not an alternative. The car use model indicates the importance of lifestyle factors in determining the use of a car.

Wardman (2004) found that the key determinants of demand for the public rail transportation in Britain were GDP, variation of fuel costs, CPI and the levels of population. These variables made significant contributions to the demand function for public railway transportation.

Abdel-Aty and Jovanis (1995) explore a different aspect of service quality influencing public transport demand. Using public transport survey data from Santa Clara and Sacramento, Califonia, they found that most respondents were satisfied or very satisfied with available public transport information. Binary logit and ordered probit models estimate that ITS-delivered public transport information might encourage shifts to public transport use (public transport demand): 58.7 percent of respondents were likely to use transit at least once per week given the availability of ITS-delivered public transport information, and about half of the non-public transport users who might consider public transport would be more likely to use it if certain information items were available.

According to Dargay and Hanly (2002), an increase in fares combined with an increase in service, would leave demand unchanged, because service elasticities are in the same order of magnitude as the fare elasticities. The sign of the income elasticity was negative in the long run, suggesting bus travel to be an inferior good. Motoring costs are shown to have a significant positive influence on bus use by the general public, particularly in the urban areas of England. Of the demographic variables included in the model, population density and the percentage of pensioners only the latter was found to have a significant influence on bus patronage.

Gomez-Ibanez (1996) finds that the demand for public transport in Boston, USA, between 1970 and 1990 was affected largely by external factors beyond the public transport agency's control and less by internal factors such as fare changes. Of the external factors considered, employment was more significant than per capita income: each percentage decrease in central city jobs was associated with a drop in public transport use of between 1.24 and 1.75 percent, while each percentage increase in real per capita income was associated with a patronage decline of 0.7 percent. Hendrickson (1986) also examined the relationship between central business district (CBD) employment levels and public transport use in a study of 25 large U.S metropolitan areas. For 1970 and 1980, the study found that CBD employment explained a very high percentage (R^2 = 0.96 and 0.90, respectively) of the number of public transport commuters (i.e. work trips). When the metropolitan population variable was added to the model, this increased R^2 to 0.98. The study found that, CBD employment was more important than regional population in explaining public transport commuting levels.

Tegner and Holmberg in their study "Public transport Demand analysis- a non-linear time series model for Stockholm Region", used aggregate time series monthly data over time period (1973-1996). The following factors were found to have a conclusive impact on the public transport demand: the activity factors (such as population, employment and shopping activities), petrol price and public transport service indicator (vehicle-kilometres). Car ownership (and a car usage) variables, have a strong negative impact on public transport demand, but with a tendency to a diminishing return over time, (however fully robust).

Al-Sahili and Sadeq (2003) conducted a survey in Nablus City, which connects the northern districts with the central and southern districts of West Bank, in Palestine. Public transport demand was derived from socioeconomic data and internal intercity service data using the multiple linear regression analysis. The factors that most influence intercity demand for public transport for the study routes were origin and destination city population, percent of employees and students, and bus fare. Public transport users reported that the number one reason for riding a bus was the cost and the highest two problems with riding a bus were its high number of stops and waiting times. Furthermore, the overwhelming majority of trip purposes was educational and work.

In July 2007, a research report on Trends in Passenger Transport in South Africa was published by the Development Bank of South Africa. The purpose of this document was to provide information on travel behaviour and the transport experience of South African transport users between the years 1996 till 2003. The data for the country as a whole disaggregated to the nine provinces as well as the six metropolitan municipalities.

Despite concerns about the comparability of the different data sets used in the analysis, on account of different survey sizes and data collection methods, the few indicators available for the description of trends have proved to be consistent and fairly reliable. The research concluded that population densities in the South African cities are extremely low by world standards, impacting negatively on the viability of public transport, particularly on trains and bus services. Travel distance is significantly higher than in more densely populated cities elsewhere in the world. The public transport market share for trips to work dropped from 58% to 56% between 1996 and 2003. The most significant feature of public transport is the increase in the market share of minibus-taxis for work trips from 57% to 63% of public transport trips, mostly at the expense of bus services. Moreover, in the metropolitan areas the minibus-taxi market shares for work trips increased by 47% between 1996 and 2003 (Mokonyama *et al,* 2007).

3.7 Assessment of the Literature

According to the literature reviewed, the demand for public transport is basically influenced by behavioural factors of individual commuters. Accordingly, the different models of transport demand were designed to provide behavioural grounding. This is based on the assumption that individuals travel to maximise their utilities and the transport firms to minimise cost.

From the empirical literature reviewed there are a variety of micro and macro-economic factors that can influence a country's overall demand for Public Transport. These factors could be of relevance to South Africa as well. It is an empirical matter to estimate which of these factors are significant in the South African situation which this study focuses on.

CHAPTER FOUR

Research Methodology

4.1 Introduction

In the previous chapters we discussed the overview of the public transport in South Africa and the theories involved in determining the demand for public transport. The purpose of this chapter is to specify the determinants of the public transport in South Africa and identify the data to be used. In the first part of the section, the model to be used in the study is presented. This is followed by data sources and method of analysis.

4.2 Model specification and definition and of variables

In order to evaluate the determinants of demand for public transport in South Africa, a functional specification is needed. When taking a closer look at the literature review, some of the empirical investigations in the review show that demand for public transport may be determined by use of surveys or data collected from the surveys or by use of econometric analysis of the time series data.

The model that will be used for this purpose will be based on the micro and macro-economic framework for explaining the factors that determine the demand for public transport in South Africa. From micro and macroeconomic perspective it will take into account the variables such as GDP, employment figures, etc., which are important for determining transport demand in South Africa. This is in-line with the study of Joly *et al*, 2004. Accordingly, the model is specified as follows:

$$D_a = \beta_0 + \beta_1 GDP_t + \beta_2 PP_{pt_t} + \beta_3 P_{f_t} + \beta_4 S_{p_t} + \beta_5 lEMP_{g_t} + \varepsilon_t \qquad (4.1)$$

In order to avoid any misinterpretation of empirical results, this section provides the description of all variables appearing in the estimated equations. All the variables are converted to logarithms for the obvious reasons of obtaining elasticity coefficients on these variables and minimising the impact of outliners. The model is thus of the form:

$$lD_a = \beta_0 + \beta_1 lGDP_t + \beta_2 lPP_{pt_t} + \beta_3 lP_{f_t} + \beta_4 lS_{p_t} + \beta_5 lEMP_{g_t} + \varepsilon_t \qquad (4.2)$$

Where:

$\boldsymbol{lD_a}$ = is the logarithm of the number of commuters of land public transport. This variable is

proxied by receipts for services: transportation – passenger fares, seasonally adjusted at annual rate in this study (R millions).

$lGDP_t$ = is the logarithm of the gross domestic product per capita.

lPP_{pt_t} = is the logarithm of the proxy for the price of public transport – passenger fares, seasonally

adjusted

lP_{f_t} = is the logarithm of the price of fuel.

lS_{p_t} = is the logarithm of the number of passenger cars sold.

$lEMP_{g_t}$ = is the number of employed people within South Africa

ε_t = is the error term

In the above equation (4.1), S_p is expected to have a negative relationship. As the number of sold passenger cars increases the demand for public transport is expected to decrease. This would be due to either dissatisfaction with public transport commuters or an increase in the disposable income of commuters. PP_{pt} is expected to have a negative relationship with regard to the demand for public transport. As prices decrease more commuters will make use of public transport. GDP_t is expected to have a negative influence on the demand for public transport. As stipulated above, an increase in income would lead to a decrease in the demand for public transport. The number of employed people (economically active people) is expected to have a coefficient that has a positive sign.

4.3 Data Source

The time series data will be collected from various sources such as Statistics South Africa, and the Department of Minerals and Energy. It will also be obtained from Response Group Trendline as well as the Department of Trade and Industry and some data will be taken from the Department of Transport, and finally the CSIR. The study will cover quarterly time series data from the year 1990 to 2009 as this covers most of the period during which South Africa moved into a new democratic dispensation which resulted in the implementation of new policies including those concerning the road infrastructure.

4.4 A review of estimation techniques for the study

There are several techniques available for parameter estimation. These range from classical regression methods to co-integration based techniques. The former is based on the assumption that all the variables to be included in a regression are stationary. Most economic series are not stationary in their levels such that estimation based on this technique will be meaningless. Determining whether a series is stationary or otherwise is very important as it can strongly influence its behaviours and properties. Thus, this section is going to review the techniques employed to test for stationarity and co-integration.

4.4.1 Testing for Stationarity /Unit root

According to Gujarati (1995), regression models that make use of time series data, may sometimes give results that are spurious, in the sense that superficially the results may look good but on further investigation they look suspicious. So to understand spurious (nonsense) results we have to look at the concept of stationary time series. According to Brooks (2002:367), a stationary series can be defined as one with a constant mean, and the variance is constant over time and the value of the covariance between two time periods depending only on the distance or lag between the two time periods and not on the actual time at which the covariance is computed. Generally some regression models may show trends that are upward when plotted over the sample period. Such a picture may generally indicate that such a time series may be non-stationary. A non-stationary time series will have a time varying mean or a time varying or both. The use of non-stationary data can lead to the danger of running nonsense or spurious regression. If two stationary variables are generated as independent random series, when one of those variables is regressed on the other, the t-ratio on the slope coefficient would be expected not to be significantly different from zero, and the value of R^2 would be expected to be very low.

If a series is non-stationary it must be differenced *d* times before it becomes stationary, then it is said to be integrated of order *d*. This would be written as I (*d*). Applying the difference operator more than d times to an *I* (*d*) process will still result in a stationary series (but with an MA error structure). An *I* (*0*) series is a stationary series, while an *I* (*1*) series contains one unit root. An *I* (*2*) series contains two unit roots and so would require differencing twice to induce stationarity. *I* (*1*) and *I* (*2*) series can wander a long way from their mean value and cross this mean value rarely, while *I* (*0*) series should cross the mean frequency.

The stationarity or otherwise of a series can strongly influence its behaviour and properties. An important econometric task is determining the most appropriate form of the trend in the data. If the data are trending, then some form of trend removal is required. Two common trend removal or de-trading procedures are first differencing and time-trend regression. First differencing is appropriate for *I* (*1*) time series and time-trend regression is appropriate for trend stationary *I* (*0*) time series. Unit root tests can be used to determine if trending data should be first differenced or regressed on deterministic functions of time to render the data stationary.

Classical regression models deal with relationships between stationary variables however; most of the economic indicators usually follow a non-stationary trend. Brooks (2002) shows that if two independent sets of non stationary variables Y and X were generated with sample size 500, one regressed on the other and the R^2 noted. The expected R^2 values for each regression should be close to zero; hence the explanatory variables in each case are independent of one another. If non-stationary variables are employed in a regression, then the standard assumptions for asymptomatic analysis will not be valid. Thus, the usual t-ratios will not follow a t-distribution and the F-statistic will not follow an F-distribution (Verbeek, 2000).

Enders (1995:215) noted four cases of spurious regression: Case I: when both variables are stationary, the classical regression is appropriate. Case II: regression equations using variables which are integrated of different sequences are meaningless. Case III: if the variables in non-stationary sequence are integrated of the same order and the sequence contains a stochastic trend, the regression is spurious. The results from such spurious regression are meaningless in that all errors are permanent. In this case, it is often recommended that the regression equation be estimated in first differences. Case IV: if variables in non-stationary sequence are integrated of the same order and the residual sequence is stationary and the variables are co-integrated. Because of spurious and or nonsense regression, unit root or stationary test should be done in all the variables before estimating the parameters and testing for co-integration. In this study we are going to discuss one unit root test (Augmented Dickey-Fuller).

4.4.2 Dickey Fuller and the Augmented Dickey-Fuller Test

Dickey and Fuller (1979) consider three different regression equations that can be used to test the presence of a unit root. The test involves estimating the equation using OLS in order to obtain the estimated value of α, and the associated standard error and compare the resulting t-statistic with appropriated value reported in the Dickey- Fuller (DF) tables. Basically the three regressions differ due to the presence of the deterministic element β_1 and$\beta_2 t$, which take them under three different null hypotheses.

$$\Delta Y_t = \alpha Y_{t-1} + \mu_t \qquad (4.3)$$

$$\Delta Y_t = \beta_1 + \alpha Y_{t-1} + \mu_t \qquad (4.4)$$

$$\Delta Y_t = \beta_1 + \beta_2 t + \alpha Y_{t-1} + \mu_t \tag{4.5}$$

where t is the time or trend variable. In each case, the null hypothesis is that α =0; that is, there is a unit root and implies that the time series is non-stationary. The alternative hypothesis is that α is less than zero; that is the time series is stationary. We rule out the possibility that α > 0, because in that case $p > 1<$ in which case the underlying time series will be explosive. If the null hypothesis in equation (4.3) Y_t is a pure random walk, and in equation (4.4) Y_t is a random walk with drift term or an intercept and in equation (4.5) Y_t is a random walk with drift around a stochastic trend or at a linear trend. In equation (4.3), (4.4) and (4.5) it's assumed the error term μ_t is uncorrelated. The weakness of the (DF) test is that it does not take account of possible autocorrelation in the error term. But in the case where the error term is correlated, Dickey and Fuller have developed a test, known as the Augmented Dickey-Fuller (ADF) test. According to Gujarati (2003), this test is conducted by "augmenting" the preceding three equations by adding the lagged values of the dependent variableΔY_t in order to eliminate autocorrelation. The ADF test consists of estimating the following regression:

$$\Delta Y_t = \beta_1 + \beta_2 t + \alpha Y_{t-1} + \sum_{i=1}^{m} d_i \Delta Y_{t-i} + \mu_t \tag{4.6}$$

where μ_t is a pure white noise error term and where$\Delta Y_{t-1} = (Y_{t-1} - Y_{t-2})$, $\Delta Y_{t-2} = (Y_{t-2} - Y_{t-3})$, etc. The number of lagged difference terms to include is often determined empirically, the idea being to include enough terms so that the error term in (4.6) is serially uncorrelated. In ADF we still test whether α = 0 and the ADF test follows the same asymptotic distribution as the DF statistic, so the same critical values can be used. The assumptions that the error terms are independent and have a constant variance raises problems related to the fact that (1.) the true data generating process may contain both autoregressive and moving average (MA) components. In this case, we do not know how to conduct the test if the order of the MA terms is unknown, (2.) we cannot properly estimate α and its standard error unless all the autoregressive terms are included in the estimating equation, (3.) the DF test considers only a single unit root and (4.) it is difficult to ascertain where the intercept and /or time trend belongs (Enders, 1995). In addition, the DF test trends to accept the null hypothesis of unit root more often than is wanted. That is, according to Brooks (2002), it exhibits low power.

4.4.3 Phillips-Perron (PP) test

One of the many unit roots tests used in the time series analysis to test the alternative hypothesis that a time series is I (1) is the Phillips-Perron test, and it builds on the DF of the null hypothesis that $\delta = 0$ in $\Delta Y_t = \delta Y_{t-1} + \mu_t$. The PP test is performed when the limitation of the DF test which includes that the alternative hypothesis of the time series is stationary with a large autoregressive root, wants to be eradicated. The PP test differs from ADF mainly in how they deal with serial correlation and heteroscedasticity in the errors. The PP test has an advantage over the ADF test as it gives robust estimates when the series has serial correlation and time dependent heteroscadasticity and there is a structural break. In particular, where the ADF test uses a parametric autoregressive to approximate the ARMA structure of the errors in the test regression, the PP tests ignores any serial correlation in the test regression. In test regression, the PP tests ignore any serial correlation in the test regression. The test regression for the PP test is,

Where, $$\Delta Y_t = \alpha_1 + \gamma Y_{t-1} + \alpha_2 \left(t - \frac{T}{2}\right) + \sum_{t=1}^{m} \phi_i \Delta Y_{t-1} + u_{2t} \qquad (4.7)$$

Where, ΔY_t is the first difference operator, T is the sample size and μ_{2t} is the covariance stationary random error term. The lag length m is decided according to Newley-West's suggestion (Newly and West, 1987). The null hypothesis of non-stationary is tested using the t-statistics with critical values calculated by Mackinnon (1996). The null hypothesis that the series is I(0) is rejected when the test statistic is more negative than the critical value and is significant in favour of the alternative hypothesis that the series is stationary.

4.4.4 Johansen Technique Based on VARS

The Johansen (1995) test for co-integration will be applied in this study because the maximum likelihood framework involved is known to offer better properties than the traditional Engel and Granger approach which is residual based. The following steps are used when implementing the Johansen procedure:

The first step in the Johansen approach is to test for the order of integration of the variables under examination. The aim is to have non-stationary variables in order to detect among them a stationary co-integrating relationship(s) and avoid the problem of spurious regressions. It is clear that the most desirable case is when all the variables are integrated of the same order and then to proceed with co-integration test. However, it is important to stress that it is not always the case, and that even in cases where the mix of *I (0)*, *I(1)* and *I(2)* variables are present in the model, co-integrating relationships might exist. The inclusion of such variables, though, will massively affect our results and more consideration should be applied in such cases (Asterious and Hall, 2007).

The second step, as Asterious and Hall (2008:322) stressed, involves determining the appropriate order (k) of the VAR where they argue that the Johansen test can be affected by the lag length employed in the VECM, thus it is crucial to attempt to select the lag length optimally. Finding the optimal (appropriate) lag length is very important because we want to have Gaussian error term, (i.e. standard normal error terms that do not suffer from non-stationarity, autocorrelation and heteroscedasticity). Before we estimate, we take a careful inspection of the data and the functional relationship in order to decide whether to include dummy variables that take into account short run effects on such as political events and financial crises that had important effects on macroeconomic conditions.

In the third step, we decided whether an intercept/ or a trend should be included either in the short run or in the long run, or both models. In choosing the dynamic model we employ the Puntula principle which involves the estimation of models and the presentation that the results from the most respective hypothesis (i.e. r = number of co-integrating relations = 0 and modell) and through the least restrictive hypothesis (i.e. r = number of variables entering the VAR-1 = n-1 land model 4). The model selection procedure then comprises moving from the most restrictive model, at each stage comparing the trace test statistic to its critical value, stopping only when we conclude for the first time that the null hypothesis of no Co-integration is not rejected (Asterious and Hall, 2008).

The fourth step involves determining the rank of Π or the number of co-integrating vectors. There are two methods and corresponding statistics for determining the number of co-integrating relations and both involved estimation of the matrix Π:

Assuming a set of variables $[LD_a; LGDP_t\,; LPP_p\,; LP_f\,; LS_p\,; LPOP]$ that are in I (1) are thought to be cointergrated. AVAR with k lags containing these variables could be set up as:

$$y_t = \beta y_{t-1} + \beta_2 y_{t-2} + \ldots + \beta_k y_{t-k} + \mu_t \qquad (4.8)$$

In order to use the Johansen test, the VAR needs to be into a vector error correction model (VECM) y_t of the form

$$\Delta y_t = \Gamma_1 \Delta y_{t-1} + \ \ldots + \Gamma_{k-1} \Delta y_{t-k+1} + \Psi D_t + \mu + \varepsilon_t, t = 1, \ldots T \qquad (4.9)$$

Where $D_t$deterministic variables such as dummies and μ are is vector of constants. The hypothesis of reduced rank, r of the long-term impact matrix Π = αβ' is then used to formulate the hypothesis of co-integration. Where α represents the speed of adjustment matrix, indicating the speed with which the system responds to last period's deviations from the equilibrium relationship and β is a matrix of long run coefficients. Estimates of β are found by solving the eigenvalues form the estimated β matrix. The size of the eigenvaluse provides a measure of how large the correlation between the co-integrating relationship and the stationary part of the model is. The next step is to establish how many co-integrating vectors exist for each of the relationships. Two test statistics are employed, the λ_{max} statistic and the λ_{trace} statistics. The λ_{max} statitic is of the form:

$$\lambda_{max} = -TIn(1 - \lambda_{s+1}) \qquad (4.10)$$

Where T is the sample size, and the λ's are the eigenvalues (ordered in descending order), r is the number of co-integrating vectors (which lies between zero and$p$) p is full rank and s is the hypothesized number of cointergrating vectors. The λ_{max} statistic tests the null hypothesis of $r = s$ cointergrating vectors against the alternative that $r = s + 1$. The λ_{trace} statistic is as follows:

$$\lambda_{trace} = -T \sum_{i=s+1}^{P} In\,(1 - \lambda i) \qquad (4.11)$$

It tests the null hypothesis that there are r-s co-integrating vectors against the alternative that r≥s+1. Johansen and Juselius provide critical values depends on the value of r-s, the number of non-stationary components and whether constants are included in each of the equations. In each case, the null hypothesis is rejected if the test statistic is greater than the critical value.

4.4.5 Co-integration and vector error correction modelling

According to Gujarati (2003), co-integration is when two or more time series variables have a long term or equilibrium relationship between them. Of cause in the short run there may be disequilibrium. Therefore, one can treat the error term to tie the short-run behaviour of the other time series variable to its long run value. A set of variables is defined as co-integrated if a linear combination of them is stationary.

In other words, a co-integrating relationship may also be seen as a long term or equilibrium phenomenon, since it is possible that co-integrating variables may deviate from their relationship in the short run, but their association would return in the long run. There are several ways of testing for co-integration. Among these the two main tests are the Engel-Granger approach and the Johansen technique.

The Engle-Granger Approach is residual based while the Johansen and Julius technique is based on maximum likelihood estimation on a VAR system. However, the majority of these techniques have numerous problems when applied to multivariate models. The Engel and Granger (1987) (EG) approach can be used to combine both the short run and long run properties, and at the same time maintain stationarity in all variables. One of the best features of the EG approach is that it is very easy to understand and implement. However, it is has some shortcomings: it is silent about the arrangement of variables (i.e., which variables can be used as a regressor and why?), it fails to treat the possibility of there being more than two variables and finally, it is subjected to the tendency of carrying forward errors, as it relies on a two step estimator where the residual series generated in the first step can be used to estimate a regression in the second step. In addition, one of the models has more than two variables, and hence the possibility of having more than one co-integrating vector. This happens when variables in the model from several equilibrium relationships govern the joint evaluation of all the variables. Actually, a problem arises when, for example; only one co-integration relationship exists, where there are actually more than one. This problem, however, cannot be resolved by the (EG) single-equation approach.

The Johansen technique (1991, 1995) has several advantages over other co-integration based techniques. The Johansen technique allows for more than one co-integrating vectors with two tests to help establish the number of co-integrating vectors. Similarly, once the number of co-integrating relationships has been established, a series of likelihood-ratio tests can be performed to test different hypotheses about them. The Johansen technique, which is based on full system estimation, has greater power and can help to eliminate simultaneous-equation bias and raise efficiency relative to single equation methods.

4.5 Error Correction Model

If it is established that the relevant variables are co-integrated it is appropriate to estimate an error correction model. In an error correction model, the short–term dynamics of the variables in the system are influenced by the deviation from equilibrium:

$$\Delta yt = \beta_1 \Delta xt + \beta_2 (y_{t-1} - \gamma_{xt-1}) + \mu t \qquad (4.12)$$

The error correction term is given by $y_{t-1} - \gamma_{xt-1}$. This implies that the coefficient on x_{t-1} of one in this term suggests a proportional long run relationship between y and x. Error correction models are interpreted, as y is purported to change between *t-1* and as a result of changes in the values of the explanatory x between *t-1* and *t*, and also, in part, to correct for any disequilibrium that existed during the previous period. The error correction term would appear without any lag for this would imply that y changes between $t-1$ and t in response to a disequilibrium at time t. γ defines the long run relationship between x and y while β_1 describes the short run relationship between changes in x and changes in y. β_2 describes the speed of adjustment back to equilibrium, and its strict definition is that it measures the proportion of last period's equilibrium error that is corrected for.

The Error Correction Model has a number of advantages, but in this study we will state only a few of them. This model is considered convenient when measuring the correction from disequilibrium of the previous period which has a very good economic implication. The other advantage is that the disequilibrium error term is stationary because the error correction mode has important implications. For example, the fact that the two variables are co-integrated implies that there is some adjustment process which prevents the errors in the long-run relationship from becoming larger and larger.

4.6 Diagnostics Checks

This stage is the most crucial in the analysis of the determinants of public transport because it validates the parameter estimation outcomes archived by the estimated model. Diagnostic checks test the stochastic properties of the model such as residual autocorrelation, heteroscedasticity and normality, among others. The multivariate extensions of the residuals tests just mentioned will be applied in this study; therefore, they are briefly discussed here.

4.6.1 Residual normality Test

One of the most commonly applied tests for normality is the Bera-Jarque (BJ) test. This is an asymptotic or large sample test and is based on OLS residuals. This test computes the coefficients of skewedness, S (a measure of asymmetry of a probability distribution function) and kurtosis, K (a measure of how tall or flat a probability distribution function is in relation to the normal distribution) of a random variable. The BJ test uses the property of a normally distributed random variable that the entire distribution is characterised by the first two moments – the mean and the variance. The BJ test statistic asymptotically follows a X^2 under the null hypothesis that the distribution of the series is symmetric. The null hypothesis of normality would be rejected if the residuals from the model are either significantly skewed or leptokurtic/platykurtic or both. If a variable is normally distributed, S is zero and (K – 3) is also zero, and therefore the value of the BJ statistic will assume increasingly larger values. What constitute a large or small value of the BJ statistics can be easily learned from the chi-square table. If the computed chi-square value exceeds the critical chi-square value for 2 d.f.

at the chosen level of significance, we reject the null hypothesis of normal distribution; but if it does not exceed the critical chi-square value, we do not reject the null hypothesis.

4.6.2 Heteroscedasticity

According to Brooks (2002), there are number of formal statistical tests for heteroscedasticity. One such popular test is (White's, 1980) general test for heteroscedasticity. The test is useful because it has a number of assumptions; for example it assumes that the regression model estimated is standard linear. After running the regression, residuals are obtained and then the test regression is run by regressing each product of the residuals on the cross products of the regressors and testing the joint significance of the regression. The null hypothesis for the White test is homoscedasticity, and if we fail to reject the null hypothesis, then we have homoscedacity. If we reject the null hypothesis, then we have heteroscedasticity.

4.6.3 Autocorrelation LM test

Lagrange Multiplier centres on the value of the R^2 for the auxiliary regression. If one or more coefficients in an equation are statistically significant, then the value of R^2 for that equation will be relatively significant, while if none of the variables is significant, R^2 will be relatively low. The LM test operates by obtaining R^2 from the auxiliary regression and multiplying it by the number of observations, T. It can be shown as:

$$TR^2 \approx x^2(m) \tag{4.12}$$

Where m is the number of regressors in the auxiliary regression (excluding the constant term), equivalent to the number of restrictions that would have to be placed under the F-test approach.

4.7. Conclusion

In this chapter, based on the theory, the potential determinants for public transport in South Africa were specified in the model to be estimated. The potential determinants of public transport in South Africa included among others, the number of commuters of land public transport, the gross domestic product per capita income, the consumer price index per year; the price of fuel per year and the number of passenger cars sold. The procedure for testing stationarity and unit roots such as the Augmented Dickey-Fuller and the Phillips Perron tests was considered. The Johansen (1991, 1995) co-integration technique is to be employed because of its several advantages over other techniques such as the Engel-Granger. A number of diagnostic checks will be done including among others, residual normality test, heteroscedasticity, autocorrelation Lagrange Multiplier to see whether the residual passes all these diagnostic checks.

CHAPTER FIVE

Presentation and Analysis of Empirical Findings

5.1 Introduction

The previous chapter outlined the analytical framework and showed model estimation techniques that are to be used in this study. This chapter will present the application of the previously mentioned framework and the analytical techniques proposed on quarterly data covering 1990 to 2009. The results from this chapter, wil provide answers to questions which were raised in the first chapter of this study: what are the long and short term determinants of the demand for public transport in South Africa, and which of those deteminants show the bigest impact on the demand for public transport in South Africa? In attempting to answer these questions, the Johansen approach is employed to estimate and test the public transport demand model specified in the previous chapter. The next section presents and discusses the emperical findings obtained from application of the Johansen technique.

5.2 Empirical Findings

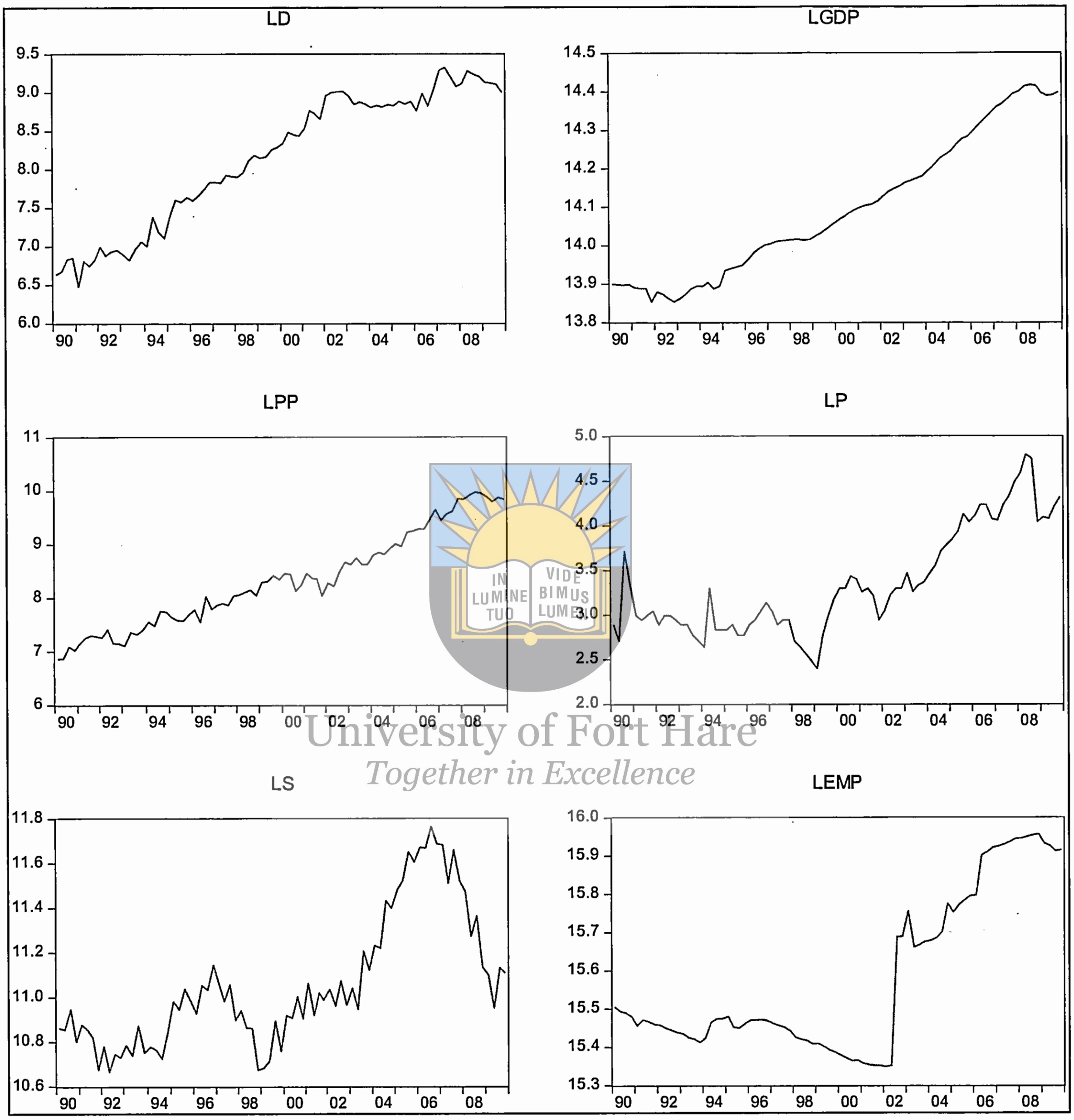
This section is divided into four sub-sections. The first presents the results of stationarity/unit root tests, the second presents and discusses the co-integration and long run tests, while the fourth presents the results of the short run dynamics and diagnostic checks.

5.2.1 Stationarity/unit root test results

The first step in the procedure is to test whether the time series are stationary. In this study two informal tests for stationarity and two formal tests are employed. The most popular informal test for stationarity is the visual graphic analysis, and this will be cross checked by means of each variable's Correlogram (auto-correlation function). Both the graphs and the Correlograms serve as a benchmark for the formal measure of unit root.

Figure 5.1(A.) Graphical Analysis for stationarity

Graphs test: levels



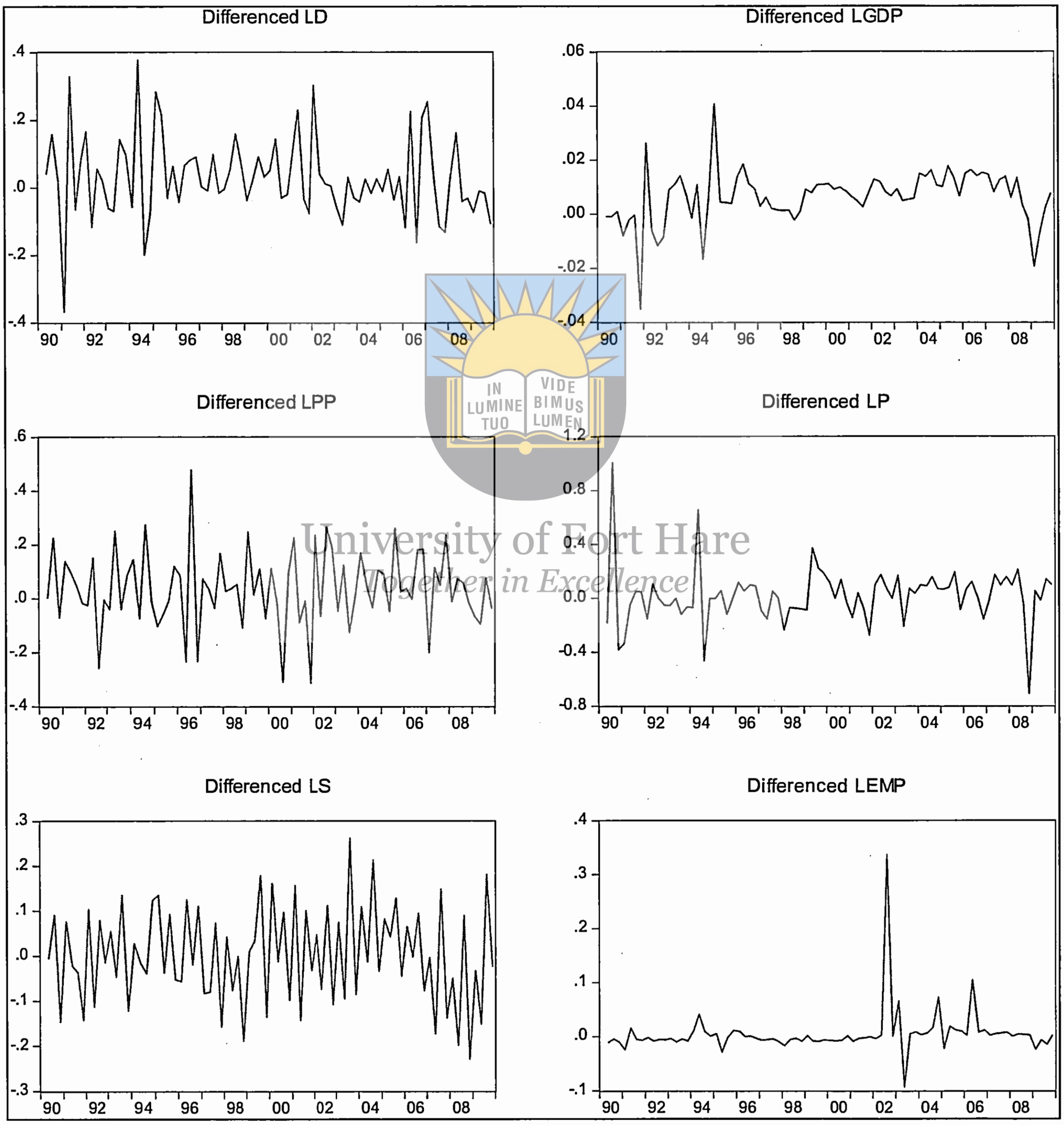
Source: *Author's Computation using Eviews 7 Econometric Packages*

As figure 5.1 (A) above shows, it appears that the series are non-stationary at levels. Certain characteristics of the series with variables LD, LGDP, LPP and LP show signs of a trend while the others (LS and LEMP) show signs of fluctuations. Referring to annexure 6, we see the correlograms of all the series variables in which they all exhibit an ACF (autocorrelation function) converging very slowly and thereby confirming the visual the graphical observation that the series are all non-stationary in levels.

However, to overcome the non-stationarity problem, the variables were differenced, and as figure 5.1(B) shows, all the variables become stationary with the first difference. This means they are integrated of order one, that is, I (1).

Figure 5.1 (B.) Graphical Analysis for stationarity

Graphs test: first differenced



Source: *Author's Computation using Eviews 7 Econometric Packages*

As was referred to in the previous chapter, the formal unit root tests which are widely employed in other studies and also used in this study are the Augmented Dickey-Fuller test (ADF) and the Phillip Perron test (PP). The two tests enable us to formally test for unit roots and thereby identify the order of integration, i.e., the number of times each variable needs to be differenced to make it stationary. The results obtained from these two unit root and stationary tests are indicated in Table 5.1 below.

Table 5.1 Unit root/stationarity tests

Series	Model	Critical Values at 1% and 5 %	ADF test	PP	Decision I
LD	Trend & Intercept	1%: -4.08 5%: -3.47	-1.755732	-1.477764	I(1)
	Intercept	1%: -3.52 5%: -2.899	-1.475402	-1.644731	
	None	1%: -2.59 5%: -1.94	1.983926	2.681988	
ΔLD	Trend & Intercept	1%: -4.082 5%: -3.47	-8.840519***	-11.96453***	I(0)
	Intercept	1%: -3.52 5%: -2.899	-10.95160***	-11.42428***	
	None	1%: -2.59 5%: -1.945	-10.25274***	-10.30438***	
LGDP	Trend & Intercept	1%: -4.08 5%: -3.47	-3.072498	-3.024133	I(1)
	Intercept	1%: -3.52 5%: -2.899	1.051454	1.093506	
	None	1%: -2.59 5%: -1.945	3.884017	4.153985	
ΔLGDP	Trend & Intercept	1%: -.4.08 5%: -3.47	-7.365174***	-7.427637***	I(0)
	Intercept	1%: -3.52 5%: -2.899	-7.080476***	-7.219407***	
	None	1%: -2.59 5%: -1.945	-5.458778***	-5.854049***	
LPP	Trend & Intercept	1%: -4.08 5%: -3.47	-2.469796	-3.517716	I(1)
	Intercept	1%: -3.52	-0.395102	-0.357045	

		5%: -2.899			
	None	**1%:** -2.59 **5%:** -1.95	3.375440	4.384152	
ΔLPP	**Trend & Intercept**	**1%:** -4.080 **5%:** -3.47	-13.08220***	-14.31944***	**I(0)**
	Intercept	**1%:** -3.52 **5%:** -2.899	-13.16950***	-14.40299***	
	None	**1%:** -2.59 **5%:** -1.94	-11.89742***	-11.70347***	
LP	**Trend & Intercept**	**1%:** -4.08 **5%:** -3.47	-2.796016	-2.655939	**I(1)**
	Intercept	**1%:** -3.51 **5%:** -2.9	-1.253126	-0970313	
	None	**1%:** -2.59 **5%:** -1.94	0.536921	1.115769	
ΔLP	**Trend & Intercept**	**1%:** -4.08 **5%:** -3.47	-10.29299***	-10.97302***	**I(0)**
	Intercept	**1%:** -3.52 **5%:** -2.9	-10.34565***	-10.95531***	
	None	**1%:** -2.59 **5%:** -1.94	-10.30122***	-10.58974***	
LS	**Trend & Intercept**	**1%:** -4.085 **5%:** -3.47	-3.247804	-2.060621	**I(1)**
	Intercept	**1%:** -3.52 **5%:** -2.90	-1.996737	-1.679711	
	None	**1%:** -2.59 **5%:** -1.61	0.234596	0.247979	
ΔLS	**Trend & Intercept**	**1%:** -4.085 **5%:** -3.47	-4.867379***	-13.31678***	**I(0)**
	Intercept	**1%:** -3.52 **5%:** -2.89	-4.921894***	-13.36469***	
	None	**1%:** -2.59 **5%:** -1.04	-4.945368***	-13.41590***	

LEMP	**Trend & Intercept**	**1%:** -.4.08 **5%:** -3.47	-1.869124	-1.880397	**I(1)**
	Intercept	**1%:** -3.51 **5%:** -2.9	-0.256527	-0.275776	
	None	**1%:** -2.6 **5%:** -1.94	1.050406	1.063099	
Δ*LEMP*	**Trend & Intercept**	**1%:** -4.08 **5%:** -3.47	-9.087066***	-9.091525***	**I(0)**
	Intercept	**1%:** -3.52 **5%:** -2.899	-8.992623***	-8.991082***	
	None	**1%:** -2.59 **5%:** -1.9	-8.912713***	-8.920603***	

* Statistically significant at 10% level [stationary]
** Statistically significant at 5% level [stationary]
*** Statistically significant at 1% level [stationary]
where there are **no** stars (***, **, *) it means it is non-stationary
Δ is the first difference symbol and *L* means in levels
Source: *Author's Computation using Eviews 7 Econometric Packages*

It should be noted that both ADF and PP tests test the null hypothesis of a unit root, which means, it is non-stationarity. The null hypothesis of a unit root is rejected in favour of the stationary alternative in each case if the test statistic is more negative than the critical value. Therefore, a rejection of the null hypothesis means that the series do not have a unit root. It should also be noted that, the tests were carried out with no constant and trend, with constant but no trend, with both trend and constant.

The results for the ADF and PP tests in tables 5.1 above show that all variables at levels for all trend and intercepts, intercept and none (no trend and intercept), are non-stationary. But only after first differencing all the variables are stationary and are statistically significant at 1%. We can therefore conclude that all the variables become of first order integration, I (0), which means that we can proceed to perform Co-integration tests.

5.2.2 Co-integration test results

After having established that the variables are intergrated of the same order, the next step would be to determine whether there exists a long-run equilibrium relationship amongst the same variables. A co-integration decision describes the existence of an equlibrium or stationarity relationship among two or more, times series each of which is individually non-stationary. The reason for conducting co-integration tests on the time series data is that it allows one to intergrate the long-run and short run relationship between variables within a unified framework (Brooks, 2002). In this study, we make use of the Johansen (Johansen, 1988 Johansen and Juselius, 1990) maximum likelihood approach to test for co-integration, as it is shown to be superior to Engle and Granger's (1987) residual-based approach. Among other things, Johansen's approach is capable of detecting multiple Co-integration relationships but this can make a researcher's task difficult, as it can sometimes produce many cointergrating relationships, which are difficult if not impossible to interpret. The approach requires that we specify the lag order and the deterministic trend assumption for example without a constand in the VAR eqaution (Hendry, 2000). The lag order can be achieved by performing VAR Lag Order selection Criteria, which can be seen in Table 5.2 below.

Table 5.2 VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	179.7874	NA	3.45e-10	-4.761298	-4.573041	-4.686274
1	603.6008	766.3476	8.40e-15*	-15.38632	-14.06853*	-14.86116*
2	636.3635	53.85648	9.36e-15	-15.29763	-12.85029	-14.32232
3	677.5374	60.91475	8.55e-15	-15.43938	-11.86250	-14.01393
4	699.6409	29.06762	1.38e-14	-15.05865	-10.35223	-13.18306
5	747.7700	55.38140*	1.18e-14	-15.39096	-9.554993	-13.06522
6	783.7306	35.46804	1.55e-14	-15.38988	-8.424373	-12.61401
7	826.3943	35.06605	1.98e-14	-15.57245*	-7.477398	-12.34643

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Source: *Author's Computation using Eviews 7 Econometric Packages*

The results in Table 5.2 above indicate a maximum of 7 lags that were automatically generated with the application of the lag order selection after criterion the Final Prediction Error (FPE), Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC) and Hannan-Quinn Information Criterion (HQ). Asterious and Hall (2008) stated that the lower the SIC (Schwarz Information Criterion), the better the model. On the basis of this and the information in Table 5.2 we consider the performance of the model under the suggested lag orders, with a lag length 1 as optimum.

Table 5.3 below shows the results of the co-integration test performed on the series of variables using the Trace and Maximum Eigenvalue tests. According to the Trace Statistics test the null hypothesis of at most zero co-integrating relation is rejected in favour of at most one co-integrating relationship, then in the next step the null hypothesis of at most one co-integrating relationship is tested against the alternative of at most 2 co-integrating relationships, and so on. Suppose *p* is the number of variables (LGDP, LPP and LEMP etc.) and *r* is the rank (number of co-integrating equations), then the trace tests the hypothesis that $r \leq p$ against the alternative. The null hypothesis fails to be rejected when the test statistic is smaller than the trace test's critical values. The maximum eigenvalue test tests the null of *r* co-integrating equation against the alternative of $r + 1$ co-integrating equations. The null hypothesis fails to be rejected when the test statistic is smaller than the maximum eigenvalue test's critical values (Brooks, 2002).

Table 5.3 Johansen Co-integration tests in lag interval of 1

Unrestricted Co-integration Rank Test (Trace Statistics Test)			
Hypothesized No. of CE (s)	**Trace Statistic**	**0.05 Critical Value**	**Prob. ****
None	113.4100*	95.75366	0.0018
At most 1	66.27216	69.81889	0.0928
At most 2	40.49784	47.85613	0.2052
At most 3	22.65174	29.79707	0.2636
At most 4	11.01875	15.49471	0.2104
At most 5	3.833270	3.841466	0.0502

Unrestricted Co-integration Rank Test (Trace Statistics Test)

Trace test indicates 1 co-integrating equation at the 0.05% level

Unrestricted Co-integration Rank Test (Maximum Eigenvalue)			
Hypothesized No. of CE (s)	**Maximum Eigenvale**	**0.05 Critical Value**	**Prob. ****
None	47.13780*	40.07757	0.0068
At most 1	25.77431	33.87687	0.3347
At most 2	17.84610	27.58434	0.5080
At most 3	11.63300	21.13162	0.5841
At most 4	7.185479	14.26460	0.4674
At most 5	3.833270	3.841466	0.0502
Unrestricted Co-integration Rank Test (Maximum Eigen value)			
Max-eigenvalue test indicates 1 co-integrating equation at the 0.05% level			

*denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

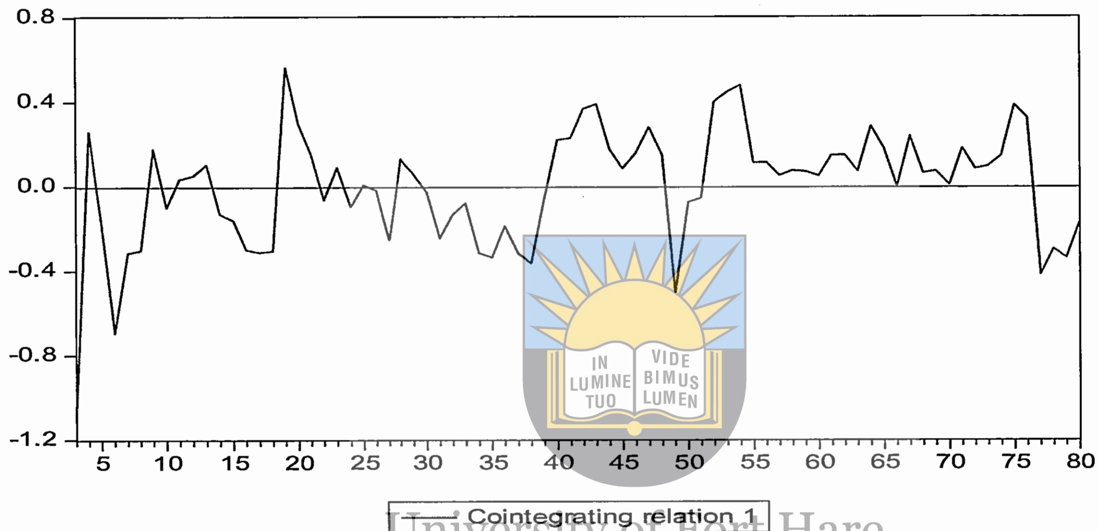
Source: *Author's Computation using Eviews 7 Econometric Packages*

Both Trace Test and Max-Eigenvalues test indicated 1 co-integrating equation at 0.05 % level of significance. The series of estimation are for the variables LD, LGDP, LPP, LP, LS and LEMP. Starting with the Trace statistic results of table 5.3, the null hypothesis of no co-integrating vectors is rejected, since the test statistic of about 113.41 is greater than the 5 per cent critical value of approximately 95.75. In the same way, the null hypothesis that there are at most 1 co-integrating vectors cannot rejected , since the test statistics of approximately 66.27 is now less than the 5 per cent critical value of about 69.82. The Trace test, therefore, indicates 1 co-integrating relationship (vectors) at the 5 per cent level of significance.

The Maximum eigenvalue form of the Johansen test also rejects the null hypothesis of no co-integration, but fails to reject that of at most co-integrating vectors, since the test statistics of about 25.77 is now less than the 5 per cent critical value of about 33.88. The Maximum eigenvalue test, therefore, suggests that there is only 1 co-integrating relationship in the determinants of public transport model. Luintel and Khan (1999:392) showed that the trace statistics is more robust than the maximum eigenvalue test. In contrast to this statement, Anoruo (2003) suggests that the maximum eigenvalue test provides more conclusive evidence regarding the exact number of critical values in the system and hence is more reliable than the trace test. Given this, it becomes evident that it is better to rely on both tests for making informed judgement with regards to co-integration. From this we can confirm that there is only one co-integrating relationship among variables such as the number of employees in South Africa, the number of cars sold, the price of fuel, the price of public transport, GDP and the number of commuters using land public transport. This implies the existence of a long-run relationship among the variables in the study. Thus a vector error correction model (VECM) can be specified from the results of the regression analysis.

Our conclusion is supported by the plot in Figure 5.2 showing the first vector in the co-integration once, which appears to be stationary.

Figure 5.2 Co-integrating Graph



Source: *Author's Computation using Eviews 7 Econometric Packages*

The vectors in the co-integrating equation are relatively stationary. This shows that the data has been correctly co-integrated. The graph flows around the mean or on the mean zero showing that it is stationary.

5.2.3 Long-run and Short-run Co-integration Relationship

Referring to Annexure 5, the vector error correction model was estimated and yielded the long and short run estimates for the relationship.

The long run regression results are provided below:

$$LD = 126.1879 - 11.14215LGDP + 0.698418LPP + 0.964892LP + 0.159353LS + 0.762525LEMP$$

(1.20745)	(0.21382)	(0.14797)	(0.23324)	(0.36788)
[-9.22784]	[3.26638]	[6.52082]	[0.68322]	[2.07276]

Notes:

( ) standard errors [ ] t – statistics

Source: *Author's Computation using Eviews 7 Econometric Packages*

The empirical results indicate that there is a positive relationship between all variables except the GDP variable, as it shows a negative relationship with the demand for public transport in South Africa. The positive sign of LS (number of passenger cars sold) can be explained by the inclusion of GDP variable in the equation of the determinants of demand for public transport in South Africa. According to Paulley *et al.* (2006), income (GDP) on public transport demand has an offsetting negative impact. So as car ownership growth slows and reaches saturation, these negative effects will diminish.

In addition to this, Paulley *et al.* (2006) stated that, in the short-term, increases in income will result in an increase in the demand for public transport, but in the long-run, they will decrease demand for public transport, but increase car ownership. LEMP has a positive sign, showing that as employment figures rise, so will the demand for public transport, as this is what was anticipated in this study. The price of public transport has a positive sign; this shows that as prices of public transport increases so will the demand for public transport. If taxi fares increase, most people will not stop using the taxis. And others will switch modes of public transport, but will not stop using public transport. This shows that commuters are willing to pay more for public transport, even when prices of public transport increase. The price of fuel has a positive sign, showing that, as the prices of fuel increases, so will the demand for public transport.

The short-run co-integrating results were extracted from the Vector Error Correction estimates depicted on Annexure 5 and displayed on Table 5.4 below.

Table 5.4 Vector Error Correction Model

Error Correction:	D(LD)	D(LGDP)	D(LPP)	D(LP)	D(LS)	D(LEMP)
CointEq1	-0.152704	0.009359	-0.172896	-0.387262	0.042089	-0.010283
	(0.05785)	(0.00485)	(0.05890)	(0.09605)	(0.04712)	(0.02240)
	[-2.63976]	[1.92785]	[-2.93546]	[-4.03182]	[0.89331]	[-0.45916]

Source: *Author's Computation using Eviews 7 Econometric Packages*

Notes:

( ) standard errors [ ] t – statistic

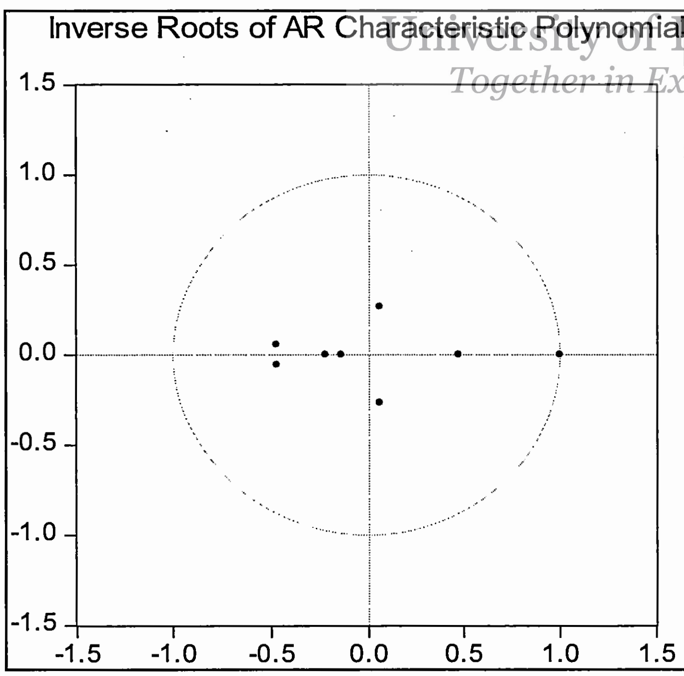
In table 5.4 the speed of adjustment is indicated by the coefficients of the error correction terms. D(LD), D(LPP), D(LP) and D(LEMP) have coefficients that are negative indicating that these variables converge to their long run equilibrium. However, D (LGDP) and D (LS) have a positive coefficient indicating that any disequilibrium in both these variables will continue to grow. However, it should be noted that a positive coefficient in an error correction model can also signify incomplete specifications. This conclusion is supported by Arestic and Demetriades (1997:788). A comparison of the error correction terms (cointEq1) for the first vector shows that LD has the most significance, with a t-value of -2.63976 and the correct sign. This suggests that the demand for public transport equation constitutes the true co-integrating relationship in the first co-integrating vector.

5.4 Diagnostic Tests

The VAR model was subject to rigorous diagnostic tests. Diagnostic checks are crucial in this analysis because if there is a problem in the residuals from the estimation of the model, it will be an indication that the model is not efficient such that parameter estimates from such a model may be biased.

The VAR was tested for AR roots test and serial correlation and the results are indicated in figure 5.3.

Figure 5.3 AR Roots Graph



Source: *Author's Computation using Eviews 7 Econometric Packages*

The AR Roots Graph reports the inverse roots of the characteristics AR polynomial. The estimated VAR is stable (stationary) if all roots have a modulus of less than one and lie inside the unit circle. Figure 5.3 shows that all roots lay inside the unit circle which is an indication that our VAR is stable.

Other well known diagnostic tests were performed and the results are stipulated on the table below (Table 5.5). These tests assist in checking for serial correlation, normality and heteroscedasticity. These diagnostic checks are based on the null hypothesis that: there is no serial correlation for the LM test; there is normality for the Jarque-Bera test and there is no heteroscedasticity for the White heteroscedasticity test.

Table 5.5 Diagnostic Tests Results

Test	Test Statistic	P-Values	Conclusion
Jarque-Bera Test	5.8545	0.0535	Not normally distributed
LM Test	56.045	0.1177	No serial correlation
White Test (no cross terms)	317.11 (chi-sq)	0.1694	No Heteroscedasticity

Source: *Author's Computation using Eviews 7 Econometric Packages*

From the table 5.5 above, the model was tested for normality, and the results show that we reject the hypothesis of normal distribution as Jarque-Bera test of 5.8545 and a p-value of 0.0535 is a clear indication of normality at 1 percent and 5 percent significance level. However at 10 percent we reject the hypothesis of normality caused by outliners (Annexure 3). The model was tested for serial correlation LM and the results stipulate a p-value of 0.1177 at lag length 1. This suggests that there is no serial correlation in the variables up to lag order 1, where 1 is the pre-specified integer, in the VAR lag order-selection criteria. Then lastly, the results of the White Heteroscedasticity (no cross term) the p-value is 0.1694 implies that the null hypothesis of homoskedastic residuals cannot be rejected, so there is no indication of heteroscedasticity.

5.5 Conclusion

This chapter analyzed the demand for public transport and its determinants in South Africa. Firstly, an analysis of the time series properties of the data was carried out using the informal and formal stationary tests. The informal test considered a graphical analysis test and the correlogram. And for formal stationarity/unit root test, the ADF (Augmented Dicky Fuller) and the PP (Phillips Perron) unit root tests revealed that the time series were first differenced stationary which means they were all integrated of the same order I(1). The Johansen Co-integration analysis was employed and provided evidence that there is co-integration between the variables in the specified model. The proof of co-integration allowed the estimation of the VECM which provided long term and short term parameter estimates. To check for robustness of the VECM results, the diagnostic tests were performed and the results were presented.

CHAPTER SIX

Summary, Conclusions, Policy Implications and Recommendations

6.1 Summary and Conclusions

The determinants of the demand for public transport have long been a focal point of interest and have generated much discussion in the theoretical literature for long. Public tarnsport in South Africa has been noted to be inadequate and this has pushed people to rely more on private passenger cars for transportation. The increase in the mobility needs associated with economic development progressively raises concerns about pollution and traffic congestion, inducing policy makers to adopt measures to control the use of private transport modes. The focus on negative incentives to private transport has sometimes put on second place complementary policies aimed at improving the public transport services, thus directly trying to capture the deteminants of the demand for public transport in order to know if the demand is being met adequately by the supply of public transport services.

It is against this particular background that it was necessary to investigate and document the various factors that determine the demand for public transport (both road and rail public transport) in South Africa. The variables that were considered to be potential determinants of the demand for public transport in South Africa were specified in our estimating model represented by equation 4.2. The variables included were GDP per capita, payments for public transport usage, which is a proxy for the price of public transport, the price of fuel, the number of passenger cars sold, and lastly the the number of employed people in South Africa.

In order to determine both the long and short run determinants of demand for public transport in South Africa, the Johansen cointergration and error correction methodology was preferred to the other techniques, because it holds several advantages over alternatives techniques. In the application of this methodology, the time series properties of the data were initially investigated by employing both formal and informal tests for stationarity and unit roots. The variables were found to be integrated of the same order, that is, each series was found to be characterized as integrated of order one I(1). Johansen Co-integration tests on alternative model specification provided evidence of Co-integration between the demand for public transport and its determinants, which were included in the model. This allowed the estimation of VECM, which simultaneously yielded the parameter estimates for both long and short run relationships.

Based on the cointergration results obtained, it can be concluded that there is a positive long run relationship between the demand for public transport and the price of public transport (payments made for public transport), the price of fuel, the number of sold passenger cars, and employement levels. By contrast, there is a negative relationship between GDP per capita and the demand for public transport in South Africa. This means that in the long run, as income per capita increases it will have a negative effect on the demand for public transport. In support of this conclusion, Dargay and Hanly (2002), and Bresson *et al.* (2004) have shown a negative relationship between the number of bus trips and income. Our findings were obtained with robust diagnostic tests and they concur with the findings in the literature. However, in the short run, the speed of adjustment is indicated by the coefficients of the error correction model, shown in Table 5.4 or as referred to on Annexure 5. In the short run, the demand for public transport D(LD), the price of public transport D(LPP), the price of fuel D(LP) and employment figures D(LEMP) have coefficients that are negative indicating that these variables converge to their long run equilibrium. However, D(LGDP) and passenger cars sold D(LS) have positive coefficients indicating that any disequilibrium in both variables will continue to grow.

6.2 Policy implications and recommendations

Taken together, the results of this study have a number of policy implications. The presence of the long-run and short-run movements (co-integration) between the determinats of demand for public transport found in this study, implies the effectiveness of one of the variables in influencing either the long run behaviour of the other variables or the short run behaviour of the other variables. This research makes a contribution to the policy debate by examining the major determinants of the demand for public transport in South Africa in both the long run and the short. The study highlights that, in the short run growth in GDP per capita has a positive influence on the demand for public transport in South Africa. However, in the long run this variable impacts the demand for public transport inversely, as more people can afford to rely on their own transportation. With prices of fuel and public transport fares, these variables inversely affect the demand for public transport, in the short run as hypothesised. However, in the long run, the variables seem to positively impact the demand for public transport. This implies that irrespectiveof price rises, the demand for public transport steadly grows, other things remaining constant. This conclusion was reached after evaluating the results for both the long and short run.

According to Walter (2008), there is now a general realization that public transport has a significant role to play in enhancing urban mobility, reducing road congestion, decreasing the impact on the environment through harmful emissions and better serving the economy. Furthermore, there is a need to increase the demand for public transport so that the supply of public transport can be met efficiently. Therefore there is a need for policy measures to maintain stability in the demand for public transport in South Africa in both the long and short terms.

The role of policymakers is therefore to improve the efficiency, reliability and the affordability of the public transport system, in ways that can support economic prosperity, while also promoting technological advances that can mitigate the impacts of high levels of mobility on the environment and society. In oder to reduce private car use and shift the demand towards the use of public transport, it is, of course, true that we can wait for an increase in the user cost of the private passenger car which wil rise partly as a result of a rise in fuel prices. South Africa should facilitate with the steering of the demand for public transport use for both long and short terms to meet the supply side of public transport. Therefore, there is a need to:

- Continue to improve current services levels in order to ensure, that existing public transport users are not 'lost' to private cars transportation.
- Provide a new range of more personalised services to cater for current and future markets demand in the CBD and the non-CBD commuting and educational market commuting.
- Introduce the use of smart card technology for fare collection, and for the switching of public transport mode (for example, with the same smart card, one can shift from using the Gautrain to BRT, or Metro Rail, or commuting bus services). This will offer the opportunity for commercial partnerships and passenger loyalty schemes which will help retain existing markets and attract new ones.
- Promote public transport amongst the society, by increasing investment in infrastructure for both rail and road public transport. This can be done by providing more routes for traveling by public transport, which may lead to a reduction in the prices of public transport as more people will make use it.
- Reduce the time spent on travelling needs (modes to reach destination quickly, reducing the time spent waiting for the mode of public transport and reducing the time spent trying to get to the public transport mode, using feeder taxis and busses). The main problems experienced by most half of the households that use the public

transport system are that public transport was either not available or was too far away (Key results of the National Household Travel Survey, 2003:13).

- Promote and impliment safety measures at public transport stations for all modes. Excessive security patronage, in and around the public transport routes and stations.
- Increase the cost of private vehicle use, either for parking in the CBD area or with urban tolls Raux and Souche (2004). Moreover, this situation would have a double benefit of reducing pollution and providing new revenue for funding public transport.
- The experience of public transport under the free market orientated society will be mixed. Where a market exists such as in a large cities and main inter-urban routes, services will improve as companies compete to corporate profitable services. This will be evidenced in the re-branding of public transport by private operators using commercial marketing techniques. Buses and trains will be recognised as being lucrative (and captive) advertising markets stimulating investment partnership between operators and other commercial organisations. This will result in e-mail, television, radio and other forms of interactive entertainment being standard on-board facilities. These facilities will improve the perception of public transport, making its uses more socially acceptable within major urban areas (Lyon *et al*, 2002). Less profitable services, particulary those in the rual areas will struggle to survive in a culture where government subsidy of unprofitable services meets with strong disapproval.

The determinants of public transport demand must be understood for sound public transprt growth strategies in South Africa, through the implimentation of Integrated Development Plans (IDP/s) and Integrated Transport Plans (ITP/s).

6.3 Limitations of the study and areas for further research

The unavailability and inconsistency of time series data for the actual variables that are included in the theoretical models is a major drawback that has been faced by empirical reasearchers on the demand for public transport in South African studies. In addition, a great many of the variables which the researchers would have wanted to incorporate in their studies on the demand for public transport are omitted from the theoretical models. This compels empirical researchers to augment the theoretical models, by giving economic theory reasoning for why these variables should be used in the empirical models they estimate. However, augmenting or applying proxies to the variables in the theoretical models might not give accurate and consistent estimation results. Striking this balance poses a serious challenge to emperical studies on the determinants of demand for public transport. However, these problems seem not to have significantly affected the findings presented in this study.

This study has effectively identified and assessed the significance of the determinant factors of demand for public transport in South Africa. However, future studies should advance this study by applying the causality test between the variables and identifying which variables causes others. This reasearch did not evaluate the relationship between the demand for public transport and public transport investement strategy, neither did it evaluate the supply of public transport in South Africa. Therefore, further research should be conducted on the determinants of supply on public transport in South Africa and it's investement strategy to assess whether the supply of public transport is meeting the demand for public transport through out the country. And that the public transport systems is adequate for the users.

List of References

Annual Transport Statistics Bulletin. 2008. Republic of South Africa. Available online at www.transport.gov.za/siteimgs/Transport%20Statistics%202008V1.pdf. Date accessed 8 November 2010.

Abdel-Aty, M.A and Jovanis, P.P. 1995. ***"The effects of ITS on Transit Ridership".*** ITS Quarterly, Fall 21-25.

Al-Sahili, K.A and Sadeq A.H. 2003. ***"Ridership demand analysis for Palestinian Intercity Public Transport."*** Journal of Public Transportation: 6(2): 19-34.

Anoruo, E. C., 2003. ***"An Empirical Investigation into the Budget Deficit-Inflation Nexus on South Africa".*** South African Journal of Economics, Economic Society of South Africa: 71, 2: 146-154.

Arestic, P., and Demetriades, P., 1997. ***"Financial development and economic growth: assessing the evidence".*** The Economic Journal. 107, 442: 783-799.

Asterious, D., and Hall, S.G., 2008. ***Applied Econometrics, a modern approach***. Revised Edition. New York: Palgrave Macmillian

Balcombe, R. et al., 2004. ***"The demand for public transport: a practical guide".*** Report TRL 593, TRL. UK: Wolkingham.

Blauwens, G., De Baere, P., and Van de Voorde, E., 2002. ***Transport Economics***. Uitgeverij: DeBoeckinv.

Bowman, J.L., and Ben-Akiva, M.E. 2000. ***"Activity-based disaggregate travel demand model system with activity schedules".*** Transport Research Part A, 35:1-28. Available online at www.elsevier.com/locate/tra. Date accessed 12 August 2010.

Bresson, G., Dargay, J., Madre, J-L., Pirotte, A. 2003. ***"The main determinant of the demand for public transport: a comparative analysis of England and France using shrinkage estimators".*** Transport Research Part A, 37:605-627.

Bresson, G., Dargay, J., Madre, J-L., Pirotte, A. 2004. ***"Economic and structural determinants of demand for public transport: an analysis on a panel of French urban areas using shrinkage estimators".*** Transportation Research Part A, 38:269-285.

Brooks, C., 2002. ***Introductory econometrics for finance***. Cambriage: Cambridge University.

Brown, J., Hess, D.B and Shoup, D. 2001 ***"Unlimited Access".*** Transportation 28: 233-267. Available online at www.uctc.net/papers/525.pdf. Date accessed 10 March 2012.

Button, K., 1993. ***Transport Economics***. 2nd ed. Cheltenham, UK: Edward Elgar Publishing.

Button, K., Ngoe, N., Hine, J .1993. ***"Modelling vehicle ownership and use in low income countries"***. Journal of Transport Economics and Policy: 27, 1:51-67.

Button, K., 2010. ***Transport Economics***. 3rd ed. Cheltenham, UK: Edward Elgar Publishing Limited.

Camagni, R., Gibelli, M-C., Rigamonti, P. 2002. ***"Urban mobility and urban form: the social and environmental costs of different patterns of urban expansion"***. Ecological Economics, 40:199-216.

Cowie, J., 2010. ***The economics of Transport: A theoretical and applied perspective***. New York: Routledge.

Crane, R., 2000. ***"The influence of urban form on travel: an interpretative review"***. Journal of Planning Literature: 15, 1:3-23.

Daly, A.J., 2001. ***"Alternative tree logit models: comments on a paper by Koppelman and Wen"***. Transport Research 35, B: 717-724.

Dargay, J. M., Gately, D. 1999. ***"Income's effect on car and vehicle ownership, worldwide: 1960-2015"***. Transport Research Part A, 33:101-138.

Dargay, J.M., and Hanly, M., 2002. ***"The Demand for Local Bus services in England"***. Journal of Transport Economics and Policy: 36, Part 1:73-91.

Davidson, W., Donnelly, R., Vovsha, P., Freedman, J., Ruegg, S., Hicks, J., Castiglione, J., Picado, P. 2007. ***"Synthesis of first practices and operational research approach in activity-based travel demand modelling"***. Transport Research Part A, 41: 464-488.

Department of Transport. 2008. Available online at www.dot.gov.za. Date accessed 18 July 2010.

Department of Transport. 2009. ***"National Freight Monitoring Framework".*** Available online at www.transportsig.com/imdex.php?option=com

Dickey, D.A., and Fuller, W.A. 1979. "***Distribution of the estimators for Autoregressive time series with a unit root"***. Journal of the American Statistical Association 74:427-431.

Dickey, D. A., and Fuller, W. A. 1984. ***"Testing for unit root in autoregressive moving averages models of unknown order"***. Diometrika, 71: 599-607.

Enders, W. 1995. ***Applied Econometrics time series.*** New York: John Wiley and Sons.

Engle, R. F., and Granger, C.W.J, 1987. ***"Co-integration and Error Correction: Representation, Estimation and Testing"***. Econometrica. 55: 251-276.

Fisher, M.M.,2000. Travel Demand, in POLAK. In: A.J Heertjie, ed. 2009. ***"Analytical Transport Economics"***. Cheltenhan: Edward Elgar 51-78.

Giulliano, G., Dargay, J. 2006. ***"Car ownership, travel and land use: a comparison of the US and Great Britain"***. Transport Research Part A, 40: 106-124.

Gomez-Ibanez, J.A., 1996. ***"Big-city transit, ridership, deficits, and poliyics".*** Journal of the American Planning Association, 62(1), 30-50.

Gujarati, D.N., 1995. ***Basic Econometrics***. 3rd ed. New York: McGraw-Hill

Gujarati, D.N., 2003. ***Basic Econometrics***. 4th ed. New York: McGraw-Hill

Heertjie, A., and Polak J.B. 2001. ***Analytical Transport Economics: An international perspective.*** USA: Edward Elgar Publishing, Inc.

Hendrickson, C. 1986. ***"A Note on the Trends in Transit Commuting in the U.S. Relating to Employment in the CBD'".*** Transport Research Part A: General, 20A, (1): 33-37.

Hendry, P. 2000. ***"The econometric analysis of time series"***. International Statistical Review. 51: 111-163.

Hensher, D.A. and Bullock, R.G., 1979. ***"Price elasticity of commuter mode choice"***. Transport Research, 13A, (3): 193-202.

Hensher, D. A., and Button, K. J., 2009. ***Handbook of Transport Modelling.*** 2nd Edition. Netherland: Elsevier Ltd

Holmgren, J. 2007. ***"Meta-analysis of public transport demand"***. Transportation Research: Part A, 41: 1021-1035.

Johansen, S., 1988. ***"Statistical analysis of cointergration vectors"***. Journal of economic Dynamics and Control, 12: 231-254.

Johansen, S., and Juselius. K. 1990. ***"The full information maximum likelihood procedure for inference on Co-integration-with applications to the demand for money"***. Oxford Bulletin of Economics and Statistics, 52: 169-210.

Johansen, S., 1991. ***"Estimation and hypothesis testing of Co-integration vectors in Gaussian vector autoregressive models"***. Econometrica, 59: 1551-1580.

Johansen, S., 1995. ***Likelihood-based inference in cointegrated vector autoregressive models***. Oxford: Oxford University Press.

Jolly, I., Masson, S., Petiot, R., 2004. ***"The determinants of urban public transport demand: an international comparison and econometric analysis"***. Transportation Research A.

Jovicic, G. 2001. ***"Activity based travel demand modelling: a literature study"***. Note 8: Danmark Transport for skinning. Available online at www.adm.dtu.dk/up/load/institutter/dtu%20transport/pdf. Date accessed 28 January 2011.

Kain, J.F., and Liu Z. 1995. ***"Ridership Models for San Diego and Houston" in Secrets of Success: How Houston and San Diego Transit Providers Achieved Large Increases in Transit Ridership***. Prepared for the Federal Transit Administration, U.S. Department of Transportation, May 25. Available online at: www.mendeley.com/research. Date accessed 13 March 2012.

Kain, J.F., and Liu Z. 1996. ***"Econometric Analysis of Determinants of Transit Ridership: 1960-1990"***. Prepared for the Volpe National Transport System Centre, U.S Department of Transportation, May 25. Available online at: www.mendeley.com/research. Date accessed 14 March 2012.

Kain, J.F., and Liu Z. 1999. ***"Secrets of Success: assessing the large increases in transit ridership achieved by Houston and San Diego transit providers"***. Transportation Research Part A: Policy and Practice, 33 (7/8): 601-624.

Key World Energy Statistics. 2009. ***"International Energy Agency"***. Available online at www.iea.org/stats/index.asp. Date accessed 02 November 2010.

Kitamura, R. 1989. ***"A causal analysis of car ownership and transit use".*** Transportation, 16(2): 155-173.

Litman, T., and Laube, F., 2002. ***"Automobile Dependency and Economic Development."*** Available at online www.vtpi.org/ecodev.pdf. Date accessed 29 July 2010.

Liu, Z. 1993. ***"Determinants of Public Transit Ridership: Analysis of Post-World War II Trends and Evaluation of Alternative Networks".*** Cambridge, MA: Harvard University, September. Available online at www.library.its.berkeley.edu/. Date accessed 9 March 2012

Luintel, K.B. and Khan, M., 1999. ***"A quantitative reassessment of the finance-growth nexus: evidence from a multivariate VAR"***. Journal of Development Economics. 60: 381-405.

Lyons, G., Chatterjee, K., Beecroft, M., Marsden, G. 2002. ***"Determinants of travel demand – exploring the future of society and lifestyles in the UK"***. Travel Policy, 9: 17-27.

MacKinnon, J.G., Haug, A.A., Michelis, L. 1999. ***"Numerical distribution function of likelihood ratio tests for Co-integration"***. Journal of Applied Econometrics, 14: 563-577.

Masemola, M.E., and Prof. Van Wyk, de J., Compiled a Research Report (383). ***"Household Income and Expenditure Patterns and Trends 2006-2009".*** Issued 2009 August 10. Available online at www.unisa.ac.za/contents/facilities/ems/docs. Date accessed 16 February 2011.

Mcfadden, D. 1974. ***"The measurement of urban travel demand"***. Journal of Public Economics. 3: 303-328.

Mcleod, M.S., Flannelly, L. and Behnke, R. 1991. ***"Multivariate Time-Series Model of Transit Ridership Based on Historical, Aggregate Data: The Past, Present, and Future of Honolulu".*** Transportation Research Record No. 1297, 76-84.

Mokonyama, M., Shaw, A., Cameron, B., and Lombard, M., 2007. ***"Reports on trends in passenger transport in South Africa"***. Development Bank of Southern Africa. Research and Information Division, Midrand.

National Household Travel Survey. 2003. Available online at www.dot.gov.za. Date accessed 03 May 2010.

Nolan, J.F. 1996. ***"Determinants of productive efficiency in urban transit"***. Logistics and Transportation Review: 32, 3:310-342.

Oppenheim, N., 1995. ***Urban Travel Demand Modelling.*** New York: John Wiley and Sons, Inc.

Orturzar, J de D., Willumsen, L.G. 2006. ***Modelling transport***. John Wiley and Sons, 3rd edition, 497p.

Paulley, N., Balcombe, R., Mackett, M., Titheridge, H., Preston N, J., Wardman, M., Shires, J., White, P. 2006. ***"The demand for public transport: The effects of fares; quality of service; income and car ownership"***. Transport Policy: 13,4: 295-306.

Population Growth Annual Percentages. Available online at www. data.worldbank.org/indicators/SP.POP.GROW. Date accessed 10 March 2011.

Quinet, E., and Vickerman, R., 2004. ***Principles of Transport Economics***. Chelterham, UK. Edward Elgar Publishing Limited.

Raux, C., Souche, S. 2004. ***"The acceptability of urban road pricing: A theoretical analysis applied to experience in Lyon"***. Journal of Transport Economics and Policy: 38, 2: 191-216.

Response Group Trendline. 2010. Available online at www.rgt.co.za/systems/autoEconomics. Date accessed 30 January 2011.

Sale, J. 1976. ***"Increasing Transit Ridership: The Experience of Seven Cities"***. Prepared for the Urban Mass Transportation Administration, U.S. Department of Transportation, November 1976. Available online at www.worldcat.org/title/increasing-transit-ridership-the-experience-of-seven0cities/oclc/006507562. Date accessed 10 February 2012.

Small, K.A., and Verhoef, E.T., 2007. ***The economics of Urban Transportation***. New York: Routledge.

Souche, S. 2009. ***"Measuring the structural determinants of urban travel demand"***. Transport Policy: 17, 3, 2010: 127-134. Available online at www.halshs.archives-ouvertes.fr/halshs-00578019/fr/. Date accessed 28 March 2011.

Southern African Bus Operator Association. 2009. ***"Annual Reports"***. Available online at www.saboa.co.za/Annual reports/2009. Date accessed 16 February 2010.

South African Economic Data Indicators Database. Available online at www.quantech.co.za/database/easydata-rsa-economic-indicators. Date accessed 24 April 2011.

South African Rail Commuter Corporation. 2007. Available online at www. sarcc.co.za. Date accessed 18 February 2010.

South African Reserve Bank Database. 2010. Available online at www.resbank.co.za. Date accessed 16 April 2011.

Statistics South Africa. 2010. "***Provincial Population Figures 2004-2010***". Available online at www.statssa.gov.za. Date Accessed 21 October 2010.

Tegner, G., Loncar-Lucassi, V., Nilsson, C., Transek Consultants and Holmberg, I. 1997. ***"Public transport demand analysis: A non-linear time series model for Stockholm Region"***. European Transport Conference 1998. Transportation Planning Methods, 1. Available online www.etcproceeding.org/paper/public-transport. Date accessed 10 September 2010.

Thompson, J.M. 1974. ***Modern Transport Economics***. Harmondsworth: Penguin.

Tiwari, G. 2003. ***"Transport and land-use policies in Delhi"***. Bull World Health Organ: 81, 6: 444-450. Available online www.litd.ac.in/tripp/publications/paper/planning. Date accessed 19 August 2010.

Van De Coevering, P., Schwanen, T. 2006. ***"Re-evaluating the impact of urban form on travel patterns in Europe and North America"***. Transport Policy, 13: 229-239.

Venables, A.J. 2007. ***"Evaluating urban transport improvements"***. Journal of Transport economics and Policy: 41, 2: 173-188.

Walters, J. 2008. ***"Overview of public transport policy developments in South Africa"***. Department of Transport and Supply Chain Management. University of Johannesburg. Available online at: www.ses.library.usyd.edu.au/bitstream/2123/6040/1/thredbo10-plenary-Walters.pdf. Date accessed 28 August 2010.

Wardman, M. 2004. ***"Public Transport values of time"***. Transport Policy, 11: 363-377.

Wardman, M., 2006. ***"Demand for rail travel and the effects of external factors"***. Transportation Research E: 42, 3: 129-148. Available online at www.its.leeds.ac.uk/publications. Date accessed 10 August 2010.

White Paper on National Transport Policy. 1996. Available online at www.info.gov.za/whitepapers/1996/transportpolicy.htm. Date accessed 15 February 2010.

World Bank. 2011. ***"Population Growth Annual Percentages"***. Available online at www.data.worldbank.org/indicator/SP.POP.GROW. Date accessed 29 April 2011.

Zahavi, Y. 1973. ***"The TT-relationship: a unified approach to transportation planning".*** Traffic Engineering and Control 1: 205-212.

Zhou, B., Kockelman, K.M. 2008. ***"Predicting the distribution of households and employment: a seemingly unrelated regression model with two spatial processes".*** Article in Press In Journal of Transport Geography (doi:10.1016/j.trangeo. 2008.09.003).

Annexure 1

Johansen Co-integration test Results

Sample (adjusted): 1990Q3 2009Q4

Included observations: 78 after adjustments

Trend assumption: Linear deterministic trend

Series: LD LGDP LPP LP LS LEMP

Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.453560	113.4100	95.75366	0.0018
At most 1	0.281392	66.27216	69.81889	0.0928
At most 2	0.204509	40.49784	47.85613	0.2052
At most 3	0.138552	22.65174	29.79707	0.2636
At most 4	0.088006	11.01875	15.49471	0.2104
At most 5	0.047956	3.833270	3.841466	0.0502

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Co-integration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.453560	47.13780	40.07757	0.0068
At most 1	0.281392	25.77431	33.87687	0.3347
At most 2	0.204509	17.84610	27.58434	0.5080
At most 3	0.138552	11.63300	21.13162	0.5841
At most 4	0.088006	7.185479	14.26460	0.4674
At most 5	0.047956	3.833270	3.841466	0.0502

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

LD	LGDP	LPP	LP	LS	LEMP
4.394714	-48.96656	3.069347	4.240423	0.700312	3.351078
-2.050893	-0.649840	3.809816	-2.510679	6.037195	-7.233914
2.098988	9.263801	-3.759232	-1.535628	-0.375161	8.554007
-0.918846	-12.77346	3.711543	-1.357958	-2.386665	6.809079
-2.459880	16.62755	-0.333460	2.039865	-0.967434	-5.665189
0.628028	-16.26783	0.027283	0.163921	4.191799	5.940029

Unrestricted Adjustment Coefficients (alpha):

D(LD)	-0.034747	0.039882	-0.030462	-0.002752	-0.005930	-0.001191
D(LGDP)	0.002130	0.003198	0.000859	-0.000431	-0.001665	0.000586
D(LPP)	-0.039342	-0.015864	0.015618	-0.020040	0.000592	0.016561
D(LP)	-0.088120	0.024258	0.036832	0.017331	-0.029348	-0.012775
D(LS)	0.009577	-0.011374	-0.004680	-0.004297	-0.025123	-0.001745
D(LEMP)	-0.002340	0.003792	0.004244	-0.013183	-0.000472	-0.004462

1 Cointegrating Equation(s): Log likelihood 635.4885

Normalized cointegrating coefficients (standard error in parentheses)

LD	LGDP	LPP	LP	LS	LEMP
1.000000	-11.14215	0.698418	0.964892	0.159353	0.762525
	(1.20745)	(0.21382)	(0.14797)	(0.23324)	(0.36788)

Adjustment coefficients (standard error in parentheses)

D(LD)	-0.152704
	(0.05785)
D(LGDP)	0.009359
	(0.00485)
D(LPP)	-0.172896

	(0.05890)
D(LP)	-0.387262
	(0.09605)
D(LS)	0.042089
	(0.04712)
D(LEMP)	-0.010283
	(0.02240)

Annexure 2

Auto Correlation Test Results

VEC Residual Serial Correlation LM Tests
Null Hypothesis: no serial correlation at lag order h
Date: 04/06/11 Time: 12:23
Sample: 1 80
Included observations: 78

Lags	LM-Stat	Prob
1	56.04526	0.1177
2	42.20144	0.2206
3	39.90921	0.3005
4	49.34573	0.0683
5	20.53423	0.9820
6	39.01152	0.3359
7	30.13079	0.7433
8	38.52616	0.3560
9	32.15050	0.6523
10	26.37117	0.8800
11	37.41734	0.4039
12	27.71616	0.8372

Probs from chi-square with 36 df.

Annexure 3

Normality test

VEC Residual Normality Tests
Orthogonalization: Cholesky (Lutkepohl)
Null Hypothesis: residuals are multivariate normal
Date: 04/06/11 Time: 12:26
Sample: 1 80
Included observations: 78

Component	Skewness	Chi-sq	df	Prob.
1	0.193272	0.485605	1	0.4859
2	-1.013822	13.36186	1	0.0003
3	-0.555064	4.005251	1	0.0454
4	0.240272	0.750500	1	0.3863
5	-0.696353	6.303796	1	0.0120
6	5.172259	347.7794	1	0.0000
Joint		372.6864	6	0.0000

Component	Kurtosis	Chi-sq	df	Prob.
1	4.285294	5.368941	1	0.0205
2	7.303230	60.18282	1	0.0000
3	4.600623	8.326476	1	0.0039
4	4.678580	9.157301	1	0.0025
5	3.784075	1.998012	1	0.1575
6	39.44798	4317.480	1	0.0000
Joint		4402.514	6	0.0000

Component	Jarque-Bera	df	Prob.
1	5.854546	2	0.0535
2	73.54468	2	0.0000
3	12.33173	2	0.0021
4	9.907801	2	0.0071
5	8.301808	2	0.0158
6	4665.260	2	0.0000
Joint	4775.200	12	0.0000

Annexure 4

VEC Residual Heteroskedasticity Tests: No Cross Terms (only levels and squares)
Date: 04/06/11 Time: 12:30
Sample: 1 80
Included observations: 78

Joint test:

Chi-sq	df	Prob.
317.1116	294	0.1694

Individual components:

Dependent	R-squared	F(14,63)	Prob.	Chi-sq(14)	Prob.
res1*res1	0.147760	0.780204	0.6860	11.52530	0.6444
res2*res2	0.134318	0.698216	0.7676	10.47683	0.7266
res3*res3	0.107211	0.540386	0.8992	8.362479	0.8696
res4*res4	0.444508	3.600933	0.0002	34.67166	0.0016
res5*res5	0.111870	0.566826	0.8805	8.725859	0.8482
res6*res6	0.062899	0.302045	0.9919	4.906136	0.9871
res2*res1	0.209380	1.191736	0.3040	16.33165	0.2935
res3*res1	0.178746	0.979426	0.4841	13.94220	0.4540
res3*res2	0.253266	1.526239	0.1278	19.75472	0.1381
res4*res1	0.109895	0.555584	0.8887	8.571815	0.8575
res4*res2	0.276369	1.718643	0.0740	21.55682	0.0882
res4*res3	0.118484	0.604845	0.8510	9.241788	0.8153
res5*res1	0.111459	0.564481	0.8823	8.693783	0.8502
res5*res2	0.126363	0.650880	0.8116	9.856301	0.7726
res5*res3	0.170355	0.924009	0.5386	13.28772	0.5040
res5*res4	0.297956	1.909859	0.0421	23.24061	0.0565
res6*res1	0.122758	0.629714	0.8302	9.575139	0.7925
res6*res2	0.154589	0.822854	0.6421	12.05793	0.6017
res6*res3	0.065161	0.313662	0.9902	5.082544	0.9846
res6*res4	0.110285	0.557801	0.8871	8.602254	0.8557
res6*res5	0.076908	0.374923	0.9774	5.998857	0.9665

Annexure 5

Vector Error Correction Estimates
Date: 06/06/11 Time: 13:41
Sample (adjusted): 1990Q3 2009Q4
Included observations: 78 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LD(-1)	1.000000
LGDP(-1)	-11.14215 (1.20745) [-9.22784]
LPP(-1)	0.698418 (0.21382) [3.26638]
LP(-1)	0.964892 (0.14797) [6.52082]
LS(-1)	0.159353 (0.23324) [0.68322]
LEMP(-1)	0.762525 (0.36788) [2.07276]
C	126.1879

Error Correction:	D(LD)	D(LGDP)	D(LPP)	D(LP)	D(LS)	D(LEMP)
CointEq1	-0.152704 (0.05785) [-2.63976]	0.009359 (0.00485) [1.92785]	-0.172896 (0.05890) [-2.93546]	-0.387262 (0.09605) [-4.03182]	0.042089 (0.04712) [0.89331]	-0.010283 (0.02240) [-0.45916]
D(LD(-1))	-0.153389 (0.12228) [-1.25445]	-0.013443 (0.01026) [-1.31008]	-0.187462 (0.12450) [-1.50572]	-0.026247 (0.20303) [-0.12928]	-0.181554 (0.09959) [-1.82298]	-0.056689 (0.04734) [-1.19749]
D(LGDP(-1))	0.834826 (1.46618) [0.56939]	0.186046 (0.12304) [1.51207]	3.364351 (1.49283) [2.25367]	4.203216 (2.43448) [1.72654]	1.886387 (1.19417) [1.57966]	0.667760 (0.56764) [1.17638]
D(LPP(-1))	0.152754 (0.09875) [1.54694]	0.002678 (0.00829) [0.32317]	-0.443015 (0.10054) [-4.40630]	0.167959 (0.16396) [1.02439]	0.005942 (0.08043) [0.07388]	-0.013430 (0.03823) [-0.35128]
D(LP(-1))	0.028422 (0.07589)	-0.000631 (0.00637)	0.146799 (0.07727)	0.023928 (0.12602)	0.017254 (0.06181)	0.037262 (0.02938)

	[0.37449]	[-0.09915]	[1.89973]	[0.18988]	[0.27912]	[1.26818]
D(LS(-1))	0.226163	0.008763	-0.159587	0.018122	-0.553185	-0.037292
	(0.13447)	(0.01128)	(0.13691)	(0.22327)	(0.10952)	(0.05206)
	[1.68192]	[0.77659]	[-1.16562]	[0.08116]	[-5.05097]	[-0.71633]
D(LEMP(-1))	-0.238694	-0.009735	1.153610	0.267520	-0.266900	-0.025210
	(0.32028)	(0.02688)	(0.32610)	(0.53180)	(0.26086)	(0.12400)
	[-0.74527]	[-0.36218]	[3.53757]	[0.50305]	[-1.02315]	[-0.20331]
C	0.023512	0.005590	0.031960	-0.013349	-9.97E-05	0.003133
	(0.01640)	(0.00138)	(0.01669)	(0.02722)	(0.01335)	(0.00635)
	[1.43408]	[4.06301]	[1.91453]	[-0.49037]	[-0.00746]	[0.49354]
R-squared	0.201295	0.134231	0.367754	0.235527	0.304383	0.046692
Adj. R-squared	0.121425	0.047654	0.304529	0.159079	0.234821	-0.048638
Sum sq. resids	0.946019	0.006662	0.980732	2.608189	0.627566	0.141798
S.E. equation	0.116252	0.009756	0.118366	0.193028	0.094685	0.045008
F-statistic	2.520274	1.550428	5.816623	3.080903	4.375730	0.489792
Log likelihood	61.39864	254.6748	59.99323	21.84686	77.40477	135.4152
Akaike AIC	-1.369196	-6.324996	-1.333160	-0.355048	-1.779610	-3.267056
Schwarz SC	-1.127482	-6.083282	-1.091446	-0.113334	-1.537896	-3.025342
Mean dependent	0.029820	0.006407	0.038077	0.020634	0.003233	0.005396
S.D. dependent	0.124026	0.009997	0.141934	0.210496	0.108243	0.043951

Determinant resid covariance (dof adj.)	6.46E-15
Determinant resid covariance	3.38E-15
Log likelihood	635.4885
Akaike information criterion	-14.90996
Schwarz criterion	-13.27839

Annexure 6

Correlogram for *LD*

Sample: 1990Q1 2009Q4
Included observations: 80

```
 Autocorrelation    Partial Correlation      AC      PAC     Q-Stat   Prob

  . |*******          . |*******         1  0.964   0.964    77.235   0.000
  . |*******          . | .    |         2  0.932   0.021    150.23   0.000
  . |*******          . | .    |         3  0.905   0.071    219.97   0.000
  . |******|          . | .    |         4  0.875  -0.057    286.00   0.000
  . |******|          .*| .    |         5  0.833  -0.171    346.74   0.000
  . |******|          . | .    |         6  0.798   0.050    403.26   0.000
  . |***** |          .*| .    |         7  0.758  -0.121    454.87   0.000
  . |***** |          . | .    |         8  0.720   0.043    502.13   0.000
  . |***** |          . | .    |         9  0.688   0.068    545.89   0.000
  . |***** |          .*| .    |        10  0.649  -0.136    585.33   0.000
```

Correlogram for *LGDP*

Sample: 1990Q1 2009Q4
Included observations: 80


```
 Autocorrelation    Partial Correlation      AC      PAC     Q-Stat   Prob

  . |*******          . |*******         1  0.973   0.973    78.583   0.000
  . |*******          . | .    |         2  0.945  -0.032    153.63   0.000
  . |*******          . | .    |         3  0.915  -0.041    224.96   0.000
  . |******|          . | .    |         4  0.883  -0.063    292.23   0.000
  . |******|          .*| .    |         5  0.846  -0.100    354.84   0.000
  . |******|          . | .    |         6  0.807  -0.058    412.58   0.000
  . |******|          . | .    |         7  0.767  -0.042    465.39   0.000
  . |***** |          . | .    |         8  0.724  -0.064    513.11   0.000
  . |***** |          . | .    |         9  0.682   0.010    556.07   0.000
  . |***** |          . | .    |        10  0.640  -0.020    594.45   0.000
```

Correlogram for *LPP*

Sample: 1990Q1 2009Q4
Included observations: 80

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. |*******	. |*******	1	0.952	0.952	75.207	0.000
. |*******	. | . |	2	0.910	0.049	144.90	0.000
. |******|	. | . |	3	0.872	0.020	209.75	0.000
. |******|	. | . |	4	0.830	-0.063	269.21	0.000
. |******|	. | . |	5	0.790	-0.007	323.74	0.000
. |***** |	.*| . |	6	0.745	-0.066	372.94	0.000
. |***** |	. | . |	7	0.707	0.043	417.89	0.000
. |***** |	. | . |	8	0.665	-0.062	458.22	0.000
. |**** |	. | . |	9	0.621	-0.049	493.83	0.000
. |**** |	. |*. |	10	0.588	0.088	526.27	0.000

Correlogram for *LP*

Sample: 1990Q1 2009Q4
Included observations: 80

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. |*******	. |*******	1	0.916	0.916	69.660	0.000
. |******|	. |*. |	2	0.852	0.081	130.69	0.000
. |******|	. |*. |	3	0.821	0.189	188.18	0.000
. |******|	. | . |	4	0.787	0.010	241.64	0.000
. |***** |	. | . |	5	0.745	-0.023	290.18	0.000
. |***** |	.*| . |	6	0.690	-0.111	332.43	0.000
. |***** |	. | . |	7	0.649	0.022	370.32	0.000
. |**** |	. | . |	8	0.606	-0.055	403.80	0.000
. |**** |	. | . |	9	0.560	-0.027	432.75	0.000
. |**** |	. | . |	10	0.529	0.067	458.96	0.000

Correlogram for *LS*

Sample: 1990Q1 2009Q4
Included observations: 80

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th></th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Prob</th></tr>
<tr><td>. |*******</td><td>. |*******</td><td>1</td><td>0.931</td><td>0.931</td><td>72.015</td><td>0.000</td></tr>
<tr><td>. |*******</td><td>. |*** |</td><td>2</td><td>0.926</td><td>0.445</td><td>144.17</td><td>0.000</td></tr>
<tr><td>. |******|</td><td>**| . |</td><td>3</td><td>0.858</td><td>-0.334</td><td>206.83</td><td>0.000</td></tr>
<tr><td>. |******|</td><td>. | . |</td><td>4</td><td>0.832</td><td>-0.001</td><td>266.53</td><td>0.000</td></tr>
<tr><td>. |***** |</td><td>***| . |</td><td>5</td><td>0.738</td><td>-0.372</td><td>314.22</td><td>0.000</td></tr>
<tr><td>. |***** |</td><td>. | . |</td><td>6</td><td>0.698</td><td>0.040</td><td>357.46</td><td>0.000</td></tr>
<tr><td>. |**** |</td><td>.*| . |</td><td>7</td><td>0.601</td><td>-0.134</td><td>389.95</td><td>0.000</td></tr>
<tr><td>. |**** |</td><td>. | . |</td><td>8</td><td>0.553</td><td>0.045</td><td>417.86</td><td>0.000</td></tr>
<tr><td>. |*** |</td><td>.*| . |</td><td>9</td><td>0.450</td><td>-0.138</td><td>436.56</td><td>0.000</td></tr>
<tr><td>. |*** |</td><td>. | . |</td><td>10</td><td>0.401</td><td>0.040</td><td>451.60</td><td>0.000</td></tr>
</table>

Correlogram for *LEMP*

Sample: 1990Q1 2009Q4
Included observations: 80

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th></th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Prob</th></tr>
<tr><td>. |*******</td><td>. |*******</td><td>1</td><td>0.961</td><td>0.961</td><td>76.628</td><td>0.000</td></tr>
<tr><td>. |*******</td><td>. | . |</td><td>2</td><td>0.922</td><td>-0.012</td><td>148.11</td><td>0.000</td></tr>
<tr><td>. |******|</td><td>.*| . |</td><td>3</td><td>0.874</td><td>-0.135</td><td>213.24</td><td>0.000</td></tr>
<tr><td>. |******|</td><td>. | . |</td><td>4</td><td>0.834</td><td>0.066</td><td>273.27</td><td>0.000</td></tr>
<tr><td>. |******|</td><td>. | . |</td><td>5</td><td>0.790</td><td>-0.060</td><td>327.81</td><td>0.000</td></tr>
<tr><td>. |***** |</td><td>. | . |</td><td>6</td><td>0.746</td><td>-0.039</td><td>377.12</td><td>0.000</td></tr>
<tr><td>. |***** |</td><td>. | . |</td><td>7</td><td>0.701</td><td>-0.013</td><td>421.33</td><td>0.000</td></tr>
<tr><td>. |***** |</td><td>.*| . |</td><td>8</td><td>0.654</td><td>-0.080</td><td>460.25</td><td>0.000</td></tr>
<tr><td>. |**** |</td><td>. | . |</td><td>9</td><td>0.605</td><td>-0.038</td><td>494.07</td><td>0.000</td></tr>
<tr><td>. |**** |</td><td>.*| . |</td><td>10</td><td>0.550</td><td>-0.106</td><td>522.41</td><td>0.000</td></tr>
</table>