CHAPTER 4: ECONOMIC MODELLING AND CASE STUDIES

4.1 INTRODUCTION

This study focuses on the relationship between transport improvements (road construction) and the associated economic implications thereof. From an analysis point of view it implies two types of modelling tools, namely:

(1) transport system models – tools used to forecast the effects of transport system improvements on factors such as travel time, trip generation, modal assignment and travel costs

(2) economic models – tools used to estimate the effects of transport construction and operations on the economy of the study area

Since the aim of this thesis is to investigate tools for maximising the economic returns associated with road investment, the primary aim of this chapter is economic modelling. Various transport modelling techniques are readily available to assess the direct transport improvements associated with road investment proposals – hence there will be no further discussion of transport system models (see ch 3 for a discussion of transport modelling simulations). As stated previously, the aim of conducting an economic impact analysis is to quantify the total economic effects of the proposed road infrastructure project. Economic models are used, inter alia, to forecast income, employment, business sales and value-added impacts stemming from road infrastructure investment.

Economic modelling poses a technical challenge – hence the need to focus on both conceptual and technical issues. This chapter will thus analyse modelling strategies, modelling techniques, the applicability of these models to road infrastructure projects, and the usefulness of these models based on case study

findings. The intention is not to develop new econometric models or explain detailed econometric theory.

4.2 ECONOMIC MODELLING

The majority of economic models applied for road infrastructure investment decisions are used to forecast the expected economic outcomes of a project. The value of using an economic impact model lies in the fact that all the multiplier effects from any stimulation in the economy can be determined (UE 2000:12). This means that the broader economic elements, such as increased employment and other benefits to the community, can be measured. In addition to its application, Gillis et al (1996:131) list a number of advantages of using economic models:

- Economic models can be useful to policy makers concerned with macroeconomic stability and management. This is of specific relevance to the discussions in chapter 6.

- Models of economic structure can give aggregate pictures of an economy's potential to achieve long-run development goals such as income growth, employment creation and poverty alleviation. This benefit is of primary importance given the long gestation periods often associated with roads (see the discussion on the characteristics of roads in ch 2).

- Cost-benefit models have guided governments to maximise the economic returns of infrastructure investment and to minimise costs. Cost-benefit modelling is often used to optimise decisions on mutually exclusive road alternatives.

- Comprehensive models force economists to marshal all extant data on the economy, test the internal consistency of data, and establish a research

agenda to gather additional information on crucial but poorly understood mechanisms in the economy.

When conducting an economic study it is necessary to clearly understand the limitations of each technique, and not only the benefits associated with it. This will help to comprehend the output received from modelling exercises, and put it in perspective. In addition, modellers sometimes make wrong assumptions about their application of economic models. Weisbrod and Weisbrod (1997:11) refer to these errors as the so-called the "seven deadly sins". They are

(1)　confusing the economic role (gross effect) of a facility or project from its net impact on the economy of an area (This requires differentiation between the direct road investment benefits and the indirect economic impacts.)

(2)　adding together different measures of the same economic change (This is the problem of double-counting.)

(3)　confusing study areas (It is often necessary to distinguish between the direct and indirect study areas.)

(4)　confusing time periods (When considering the long-term economic effects of a road project it is necessary to distinguish between the direct construction period and the longer-term operational period. These time periods must be clearly illustrated.)

(5)　assuming that a facility's capacity and its actual level of activity are the same (Roads are generally constructed with spare capacity in mind. The latent traffic demand should thus also be considered.)

(6)　ignoring market effects on wages and land/building costs, which can also affect the economic competitiveness of an area

(7)　using multipliers in areas where they do not apply

From the above discussion of the benefits and problems associated with economic modelling it is thus of paramount importance to have proper modelling strategies that address the above issues. Linking transport modelling and economic modelling is thus a critical step in both the physical (road investment) and the subsequent economic planning process. The integrated approach to transport and economic modelling is termed transport economic modelling.

A variety of economic models and methodologies can be used to estimate the economic impact of road projects. Cost-benefit models will not be analysed because they are used predominantly for the evaluation of the best alternative for mutually exclusive road projects. Owing to the varied nature of economic modelling it is important to develop a modelling strategy that will help economists to model the economic returns of road investment. The next section will address modelling strategies.

4.3 MODELLING STRATEGY

The aim of modelling strategy is to ensure that current modelling theories and supporting methodologies are used correctly to help transport economists assess the potential economic impacts of road investments, and to also assist with the design of specific transport economic modelling studies. These models are conceptual, mathematical and computer based. The modelling strategy merely proposes a model structure for road infrastructure investment analysis. This must be done with a clear acknowledgement of the complexity of the relationship (between road investment and actual economic returns) that will be simulated in the modelling exercise. Chapter 3 discussed the possible causal relationship between transport infrastructure and economic development. Factors such as network performance, the real estate market and land development, the location of the study area, urban market competition, the magnitude of investment and the

local and regional impacts of road infrastructure improvements influence this relationship. The proposed strategy should ensure that all the factors applicable to economic modelling of road projects are considered.

In this regard, the Department of the Environment, Transport and Regions of the United Kingdom (DETR) (1999:11) formulated a set of characteristics that an economic impact assessment should contain:

- The approach should distinguish induced economic impacts from direct impacts and their multiplier effects. The direct construction impacts of the projects must be isolated from, say, the induced impacts during the operational phase of the project. This will provide decision makers with information on the probable short-term economic impacts associated with the construction phase and also the longer-term impacts during the operational phase of the road.
- There should be a clear view on or justification for the reasons why the scheme leads to the induced effects identified, and whether the analysis intends to consider all or only some effects. Hence the economic methodology and goals of the scheme must be clearly spelled out. This information is necessary to assist decision makers with relevant information to compare similar competing projects. Projects with the highest economic potential should ideally receive top priority.
- There should be a linkage from the nature and scale of the transport scheme to the scale of induced effects. Generally a larger transport scheme would have greater effects. However, the linkage between the size of the scheme and its economic effects will also reflect the efficiency of the investment.
- There should be a clear distinction between impacts and benefits. The impacts have to do with the economic effects, while the benefits relate to the direct consequences of the project, say, improved traffic flow.

- There should be at least some consideration of the scope of double-counting between transport benefits and associated induced economic impacts. Transport benefits may include a reduction in transport cost, while the cost savings may also be included in production cost savings.

- There should also be consideration of

  – the time-scale of impacts and benefits

  – the relationship between impacts and other changes

  – the relationship between other aspects of public policy

The above characteristics are thus clearly aimed at addressing the potential pitfalls of economic modelling as discussed in section 4.2. Thus in order to achieve sufficiently accurate modelling results, cognisance should be taken of the following factors when developing a strategy for transport economic models:

- definition of study area

- market and real estate (spatial) analysis

- impacts of road infrastructure improvements

- regional and business attraction impacts

- economic modelling and impact analysis

These aspects will now be discussed.

4.3.1 Definition of study area

This is a vital consideration because it influences both the local impacts and regional impacts. For instance, depending on how the study area is defined, certain economic effects will either be internal or external to the area, and the distribution of gainers and losers will differ.

In this regard, chapter 3 proposed that the study area for economic analysis must be explicitly defined by considering four factors:

(1)   the area of jurisdiction for the sponsoring agency

(2)   the area of direct project influence

(3)   interest in distributional impacts on a subarea

(4)   interest in external area consequences

It is thus important to clearly illustrate the direct study area (direct area of road investment) and the indirect study area (area of distributional impacts). This will limit any confusion about the study area. Because it impacts on modelling results the study area must therefore be clearly defined.

4.3.2 Market and real estate analysis

An assessment of the real estate market in the area will give a satisfactory indication of market demand for specific land development, which, in turn, will provide information on market trends.   This also impacts on the spatial considerations.   The DETR (1999:13) states that the spatial analysis should consider the following:

•   whether the approach is explicitly spatial, by considering in which project impacts are allocated to smaller areas

•   the level of spatial disaggregation

•   whether displacement effects (redistribution from one area to another) is considered

Different land uses have different trip-generating characteristics. A full analysis of the real estate market will assist in identifying the latent traffic demand for the new

road. Information on the current market activity will also provide information on potential displacement effects associated with the new road. For instance, new road construction in an area with a high development demand will ensure an inflow of new traffic into the area with positive economic consequences.

4.3.3 Impacts of road infrastructure improvements

This comprises two components – firstly, the direct impact on road users, say, a reduction in transport costs and secondly, how the transport changes result in indirect economic changes.

The first component is thus related to the direct transport improvement of the road, while the second has more to do with the potential economic leakages or inflows as a result of the new road. The second component ties in with the discussion in section 4.3.2.

4.3.4 Regional and business attraction impacts

The key question here is how the transport change has been linked to the economic assessment. This element tends to focus on the transport economic behaviour. The area of improvement may have lower transport costs than other regions, thus attracting businesses from outside. Road construction projects change the transport costs and associated logistic costs in the study area. These improvements result in certain cost savings which will entice economic agents or firms to relocate in order to benefit from these savings at the new location.

4.3.5 Economic modelling and impact analysis

This analysis includes the identification of the specific modelling technique used – in other words, how the model is applied to analyse the transport economic relationship. This topic was discussed in detail earlier in the chapter. According to Weisbrod and Grovak (1997:6), effective models should combine the following four functions:

(1) forecasting – projecting changes in population, employment, business sales and profits
(2) policy impacts – estimating how policies change prices and business costs in each industry
(3) input-output analysis – accounting of the interindustry flows, and the associated indirect and induced economic effects
(4) changes in population

From this discussion it is evident that the correct modelling and impact analysis should be applied to ensure an accurate model of the transport economic behaviour associated with road investment models.

4.3.6 Economic impact checklist

From the discussions in sections 4.3.1 to 4.3.5 it is evident that caution should be exercised when conducting economic modelling to determine the impacts of road projects.   In order to reduce the risk of improper modelling it is necessary to compile a checklist for such an application.   This checklist is the execution component of the modelling strategy. According to Kalsiki, Smith and Weisbrod (1999:2), an economic impact analysis usually comprises the following five steps:

(1)   transport network analysis

(2)   estimation of user benefits

(3)   calculation of direct economic benefits

(4)   projection of secondary economic benefits

(5)   conducting a benefit-cost analysis

These steps form the conceptual framework for the analysis of economic studies and were used as a basis to develop a checklist that will be used to evaluate the economic impacts of road investment projects. In order to comply with these key steps the checklist has five main items that the economist must respond to (see annexure A). These components will now be briefly discussed.

(1)   **The description of the study area.** This description is required to ascertain whether the economist has a clear understanding of the exact study area. It is necessary to demarcate the direct study area or the area of direct project influence. The wider study area or indirect study area also needs to be defined. A description of the aim of the project will also assist with the demarcation of the study area.

(2)   **Information on the road and transport network analysis.** Firstly, it is necessary to provide information on the road project. Detailled information on the project will prevent any misunderstandings and possible confusion about project details, such as the cost and length of the road. It is also necessary to determine the primary justification for the project. If the road is required to open an area for development, then it can be assumed that the project may have economic benefits. However, if the road is required solely to relieve traffic congestion, then limited economic development benefits can be expected. Information on the transport network analysis must be provided because it will be used in the benefit calculations.

(3)   **Information on the economic impacts.** The indicators used to explain the economic impacts must be listed. This is important not only for the project but also for comparison purposes. The economic modelling methodology used is required to comprehend the magnitude and detail of the economic study. The linkage between the road investment and expected economic returns must also be explained because it will give an indication of the detail and accuracy of the assessment.

(4)   **Information on indirect impacts.** This information is necessary to understand the level of spatial disaggregation in terms of the zoning of the study area. Fine zoning will be indicative of greater detail of the study area, while coarse zoning will indicate the opposite. Information on the real estate market and that of potential displacement effects is essential for an assessment of potential indirect impacts.

(5)   **The expected benefit calculations.** This component must explain the expression of the benefits. It is necessary to provide information on the direct project benefits and the expected economic impacts. Other benefits should also be listed.

From the above discussion one may infer that this checklist will not only assist with the preparation of economic impact studies, but will help decision makers to understand project specific circumstances.

This checklist will now be used to evaluate different case studies.

4.4   INTERNATIONAL CASE STUDIES

An evaluation of international case studies is essential because it will promote a basic understanding of the approaches followed in the international arena as well as their applicability to South Africa.   It is also necessary to identify the actual economic models that were used because this will provide information on the appropriateness of models for transport economic modelling purposes. In addition, it will provide information on the methodological approaches, and how these approaches differ from South African applications.   As such, it is necessary to compare the international studies with the three South African case studies of roads K8, K16 and PWV9.

4.4.1 Case study selection

The selection of the different case studies needs to be justified. The three South African case studies require no further justification because they are an integral part of this thesis. The author decided to use one Australian case study and two UK studies.

The choice of the **Melbourne City Link,** entitled "The Economic Impact of Melbourne City Link", (consultants: Swan Consulting & John Cox 1995) as the Australian case study was fairly straightforward. This is one of the largest recent road investment projects in Victoria State and in Australia as a whole. The City Link project is designed to improve transport links to and from and within the Melbourne area. It is anticipated that the City Link will yield significant economic benefits (Swan Consulting & Cox 1995: 1).   In addition, macroeconomic modelling techniques were used to determine the economic impacts of the project. This is significant, because this approach is not often used in South Africa.

The choice of the UK studies was based on the fact that these two studies were used as important case studies, in a select sample of five studies, by the Standing Advisory Committee on Trunk Road Assessment of the Department of Environment, Transport and Regions during 1999. The brief stated that this small set of studies should be used as a review on studies dealing with the indirect economic impacts of transport infrastructure projects (DETR 1999:7). Of these five case studies the following projects were deemed most appropriate:

- **Dearne Towns Link Road.** Report entitled "Dearne Town Link Roads Report of Surveys: volume 3, Industrial/Commercial Interviews and Forecasting" (consultants: JMP Consultants Ltd, March 1989) provided information on a local economic framework and quantitative approach based upon likely developments, their take-up rates and employment densities.

- **M74 Northern Extension.** This study, entitled "The Relationship between Economic Development and Transport Links, Stage 2: Economic Effects of the M74 Northern Extension" (consultants: OFTPA & Cambridge Systematics, 1993) examines the economic value of the link road.

4.4.2 An Australian approach

The case study is that of the economic impact of the **Melbourne City Link** which was conducted in 1995 (Allen Consulting & Cox, 1995). The purpose of the study is to report on the economic evaluation of the Melbourne City Link, which will link three of Melbourne's major traffic arterial routes.

- **Study area.** Although the location of the proposed road link is appropriately described, there is no specific description of the study area in terms of primary or secondary influence areas. However, in terms of the

structure of the report and the analysis of impacts it is obvious that this report considered two study areas, namely:

(1) the city of Melbourne – to measure the direct impacts of the project

(2) the larger Victorian and Australian economies – to measure the wider economic benefits related to the project

One should bear in mind that the size of the project impacts on the extent of the study area chosen. From this study, it was apparent that the Link was such that it would impact on the entire city. Regarding smaller road projects, the direct impact of the road may only be at suburb level, while the wider impact is only measurable at city level. Economists must thus clearly comprehend the scope of the project.

- **Road and transport network analysis.** The Melbourne City Link is described as an infrastructure project designed to improve transport links to, from and within the Melbourne area. The construction cost of the Link is estimated at $1,2 billion dollars (1993 Australian prices).

  The road and transport network analysis component of the report was fully covered. This section gave a detailed description of the overall road transport context in the Melbourne Metropolitan area. The topics included Melbourne as a major transport centre, patterns of road layouts, previous economic evaluations, comparisons with other projects and the limitations of these projects. The network models used to evaluate the traffic flow models of the project were the Vic Roads and Veitch Lister models. These models are not used in South Africa. The models give a number of traffic flow results, namely:

–   vehicle kilometres of travel (million/day)

–   vehicle hours of travel/day

–   average travel speed (km/h)

–   freeway travel/total travel (%)

The types of results are similar to the results or outputs provided by South African transport models. The analysis also included travel time benefits, vehicle operating cost benefits, accident benefits, benefits from changing the truck fleet mix, off-road user benefits and negative externalities. Hence a full analysis of all benefits was conducted.

The project-specific results are outlined below. Traffic flow modelling predicts that the construction of the link will lead to significant increase in average travel speeds in the city (29,7 km/h to 36,1 km/h). Travel time savings of $200 million (1993 values) are predicted for the year 2001. Similarly a reduction in vehicle operating costs of $5 million is predicted for 2001. The construction of the Link will also lead to proportionately more articulated trucks on the road, with lower freight carrying costs and freight savings of almost $75 million per year in 2001.

- **Wider economic impacts.** This section started with substantial justification for the kinds of wider benefits that had to be captured. In order to properly measure the wider benefits related to price levels, employment, output in various industries and many other variables, it was decided to use macroeconomic modelling for the City Link project. It was clearly stated that this information cannot be obtained from traditional cost-benefit analysis. MMRF modelling was used in this study. MMRF is a multisectoral applied general equilibrium model of the Australian economy. The theoretical structure and database of MMRF recognise the economies of the Australian states and territories as independent economies linked by

interstate flows in commodities, labour and capital. A distinction was drawn between the construction phase and the operational phase. In this instance, the construction phase relates to the construction of the City Link and the expenditure of the $1,2 billion. The operational phase follows this phase. Inputs in the construction phase were

– intermediate inputs - such as mining, manufacturing, domestic trade, transport and communication, and finance
– labour costs
– capital and other costs, such as fixed capital cost and other costs

Inputs into the operational phase were divided into three categories:

(1) productivity gains – such as direct, indirect and labour-saving productivity gains
(2) road maintenance costs
(3) interest payment and accrued debt related to the construction of the project

Other effects that were measured included the welfare effects that were measured by calculating the change in the present value of private consumption. Certain nonmodelled benefits including property values, urban development and benefits related to private financing were considered.

The time scales were extremely specific about the construction phase of six years followed by the operational phase.

- **Spatial disaggregation.** Spatially the impact on the national economy, the different states and the city of Melbourne specifically was measured. This was achieved by the use of the macroeconomic models.

  The real estate market received limited focus. It is only mentioned that property values will increase slightly because of the positive impacts of the road construction. No specific consideration was given to displacement effects, although it is assumed that the macroeconomic modelling should address this issue.

- **Benefit calculations.** The report had separate chapters on the different benefits related to the project, namely the expected direct and indirect economic benefits as well as the direct benefits related to the transport improvements. Double-counting was addressed by distinguishing between construction and operational impacts, and by not adding all the benefits together. Additional benefits included increases in property values, urban development and private finance. The only real criticism that can be levelled at this section is that an integrated benefit matrix was not developed to clearly show all the benefits related to the project.

4.4.3 United Kingdom approaches

Two case studies in the UK will receive attention, namely:

(1)   Dearne Towns Link Road
(2)   M74 Northern Extension

Information on these studies was obtained from a study conducted by the Department of the Environment, Transport and the Regions (1999).

4.4.3.1 Dearne Towns Link Road

The purpose of the study was twofold:

(1)   to forecast the goods vehicle traffic in the corridor, with and without the link road

(2)   To assess changes in development potential due to the road

- **Study area.** A general description of the study area was given. The study area was limited to the areas directly influenced by the proposed road. This included interviews with local businesses.   This interview process is generally extremely expensive and is thus limited to smaller studies or samples of larger areas. Because of the cost implications, very few South African transport economic studies make use of interviews.

- **Road and transport network analysis.** A broad project description was given. The road was justified on the basis of the need for improved freight movements as well as future development potential. In this instance, the change of transport is defined only by the presence of the new road, with no explicit accessibility index or travel time saving matrix. Hence no direct transport benefits or impacts were measured. The performance of the transport network was not studied. Direct transport impacts were measured in qualitative terms. This was derived from businesses interviewed. This is regarded as a serious limitation in the study.

- **Wider economic impacts.** The economic impact indicators used are development and employment. Employment was calculated as a function of available floor space. No economic model was used to calculate the wider economic impacts.

Both a qualitative and quantitative assessment was conducted. The development potential was based on a qualitative assessment derived from a series of structured interviews with local businesses. The quantitative methodology focused on the new physical industrial development that could be associated with the new road. The subsequent quantitative work is shown below:

–   Key sites were identified and their potential floor space obtained.
–   Certain private sector development was dependent on the road.
–   High and low scenarios for the take-up of the sites were applied.
–   Employment densities were applied to the new floor space to calculate new employment levels.
–   An average employment multiplier of 15% was used.

The following findings are of greater significance:

–   There is no explicit link between the size of the transport change and the potential development estimated.
–   There is no assessment of the net distributional effects within the region, only those outside the corridor.
–   There is no theoretical justification for the estimated take-up of new sites.

In addition, although no explicit definition of time scales was given, they appear to be short term because they focus on available sites. However, mention is made of long run effects.

- **Spatial disaggregation.** The study examines the strict corridor only, with no zonal disaggregation, only a process of site identification along the road corridor. However, the study did consider the real estate market in some detail. No mention is made of expected displacement effects.

- **Benefit calculations.** There are no benefit calculations in this study. The style of analysis is extremely informal in its economics, and makes no attempt to argue that employment impacts supplement direct transport benefits.

4.4.3.2   M74 Northern Extension

The study focused on the relationship between economic development and transport links, with specific attention to the M8/M74 link.

- **Study area.** The study area was described in general, since this economic study was part of a wider programme to investigate the implications of the entire M74. It considered both the local and regional implications. The local impacts were related to the direct transport impacts in the Strathclyde Regional Council area. The regional study area was linked to the induced impacts.

- **Road and transport network analysis.** The project was described as the northern extension of the M74. A detailed transport impact assessment was not included in the project. Transport assessments of previous studies were used and fed into the study. The main inputs related to travel time and cost savings.

- **Wider economic impacts.** In this regard, the study examined the impacts throughout the economy of travel time and cost savings, instead of using cost savings themselves as the full measure of the economic benefit. The main economic indicators that were used were jobs, value added and development demand (floor space).

   The methodology adopted in this approach is complex. It focused on the adoption of a Regional Economic Impact Assessment Framework, which was the quantitative analysis. However, this was preceded by a qualitative description of the likely impacts, as well as a discussion, in qualitative terms, of the impacts of special development opportunities.

   The impacts appear to be calculated for an average year.

- **Spatial disaggregation.** There is no spatial disaggregation of the benefits calculated, and everything is undertaken at study area level. However, there was some discussion of several key regional sites. The real estate analysis deals with a few specific sites, but not in a systematic or quantified manner.

- **Benefit calculations.** It is unclear in this report whether any of the impacts are regarded as being in addition to the direct transport benefits. This lack of clarity means that there is danger of double-counting. On the corridor level, however, it is clearly stated that none of the impacts are net additions, only redistributions of the regional growth.

The South African transport economic studies will now be analysed to determine whether a similar approach was followed.

4.5   SOUTH AFRICAN CASE STUDIES

Three South African case studies (roads K8, K16 and PWV9) will now be analysed. The aim here is to compare the South African approaches with those of the international studies. It is necessary to determine common ground as well as differences in approach.   The findings will be used to provide guidelines on transport economic analysis in South Africa.

4.5.1 Proposed road K8

The purpose of the report, (entitled "Economic Returns of the Proposed Road K8", consultants: Urban-Econ, September 2000) is to determine the greater economic returns of the development of the proposed dual carriageway along road K8.

- **Study area.** The study area was well defined and a detailed explanation of the delineation of the primary study area provided. The study area also included the distributional effects of the secondary study area. The road project was justified by increased capacity problems caused by land development in the area.

- **Road and transport network analysis.** This study contained an adequate project description of road K8. The basic premise of this study is that development in the study area is being curtailed by limited road infrastructure, which results in severe congestion and limited accessibility. The study had no section on the direct transport impacts or benefits of the project, and the network performance received no detailed attention. Transport studies had, however, been conducted prior to this study.

- **Wider economic impacts.** The economic indicators used for this study included the following:

  – gross geographic product (GGP)

  – imports

  – employment

  – company tax

  – personal income

  – VAT and other indirect impacts

  Input-output modelling was used to assess expected economic impacts. This study assessed two phases, that of the construction phase and that of the operational phase. The construction phase relates not only to that of road K8, but also to that of the land uses being developed. The operational phase relates to the operational activities of the land uses. The time scales of the study were linked to the construction phase taking one year for road construction to be finalised and the operational phase (full development scenario). The construction phase is once off and the operational phase provides recurring annual figures once the area has been developed. The shortcoming of this approach is that limited information can be derived from the economic study on the growth of development investment from year to year. This is one of the drawbacks of most economic modelling techniques.

- **Spatial disaggregation.** The spatial impacts on the greater Pretoria area, as well as on the entire country, were considered with the use of economic input-output tables. In addition, the real estate market impacts on the retail, office, industrial, commercial and residential sectors were analysed. It should be mentioned that this study did not conduct a detailed real estate demand study by obtaining vacancy rates and rental rates, – the focus was on

the predicted growth in floor areas for these different retail activities. The land-use implications in terms of noneconomic activities (ie residential) and the economic activities (ie retail) were used to create land-use budgets for the economic scenarios in accordance with land-use categories. There was no evidence of displacement effects having been considered.

- **Integrated benefit calculations.** The economic measure of the benefits was summarised in what was described as an economic benefit matrix. The purpose of this matrix is to summarise the economic and financial results of the study. Double-counting was addressed by not adding all the different economic indicators, but listing their impacts separately. The additional benefits, in the form of a financial impact analysis, of the road project were determined by calculating the expected property rates income due to development unlocked as a result of the capacity created by the road.

4.5.2 Proposed road K16

The purpose of this study, entitled "Economic Returns of the Proposed Road K16", (consultants: Urban-Econ, September 2001) was to determine the direct, indirect and induced impacts of the planned K16 road on the economy of the surrounding area.

- **Study area.** The report described the study area for the economic impact analysis as the area that will be immediately affected by development along the route. A detailed description of the study area was provided. Furthermore, the route was divided into three road sections, based on similar business and residential characteristics in each section.

- **Road and transport network analysis.** The road project was aptly described. Three development scenarios were tested, namely:

    – the status quo situation, without road K16
    – the so-called "build and do nothing" scenario
    – the so-called "build and facilitate development" scenario

    However, no direct transport impacts were measured. The preference of one development scenario over the other was thus based purely on economic impact, and not on transport network performance. This is one of the serious shortcomings of this study.

- **Wider economic impacts.** Regarding the indirect economic impacts, the sectoral composition of the area's economy was considered. Input-output modelling techniques were used to model the economic impacts. The indicators were economic growth (GGP), job creation (total employment), aggregate personal income and business output/sales. An economic input-output model was used to forecast expected economic impacts. For road K16, multipliers were calculated by using the said input-output model. The road construction was described as a capital injection that would have a number of impacts on the economy. For instance, the direct economic impacts during the construction phase included expansion of existing businesses associated with road construction activities. The indirect economic impacts would entail the creation of opportunities for economic activities and new businesses to be established along the route. The time scales used for the study were not clear.

- **Spatial disaggregation.** Spatial disaggregation was based on the subregional economic analysis and the urban market analysis. The urban

market analysis provided a detailed real estate analysis in order to identify urban markets that have the potential to influence the future economic and spatial development along road K16. The real estate analysis focused on the retail trade market, the office markets, industrial and warehousing market and the residential market. Factors that were considered were rental rates, market value for stands, vacancy rates, local context and development potential. However, no mention was made of displacement effects.

- **Integrated benefit calculations.** The economic impacts of both the construction and the operational phases were summarised in the report. Double-counting of the benefits was addressed by listing the different types of impacts separately, for instance, the rand value of business sales and additional GGP were not added. Additional impacts that were indicated were the expected additional levy income for the local authority, and other nonmeasurable quality-of-life considerations.

4.5.3 Mabopane-Centurion Development Corridor (MCDC): road PWV9

The aim of the project, entitled "MCDC Integrated Growth and Development Strategy" (Pretoria Metro 1997) was to develop an integrated growth and development strategy for the MCDC, which included the construction of road PWV9.

- **Study area.** There was a detailed description of the project, which includes the enhancement of economic growth and balanced urban, rural and regional development. The study area was demarcated in a primary and secondary study area.

- **Road and transport network analysis.** Limited transport impact information was given, although it was mentioned that road PWV9 forms the main transportation spine along the MCDC. The importance of this road is that the implementation of the MCDC is not possible without it. Although the other studies conducted transport network performance studies, this one did not, which is a serious limitation.

- **Wider economic impacts.** The economic indicators that were used were those of employment, sectoral composition and production, growth trends, business development and industrial linkages. No specific economic modelling tool was applied to determine the economic impacts of the project. Basic economic analysis was, however, conducted but this was based on the levy base of the local authority. This levy base enabled the study to arrive at a projected level of economic activity per suburb. However, from this study it is evident that the linkage between road investment and economic development was based mainly on evidence in a literature survey. Certain time scales were considered.

- **Spatial disaggregation.** The spatial disaggregation was based on coarse zoning, although certain analyses were on suburb level. The real estate market was primarily based on the need for residential land and potential land availability. The business development in the area and the industrial linkages received attention, but this was not adequately matched with the real estate market. Displacement effects were not considered.

- **Integrated benefit calculations.** The expected economic benefits were calculated on the basis of GGP growth, employment growth and GGP per capita.

Three international case studies and three local case studies were analysed. The main findings of this analysis will now be discussed.

4.6   FINDINGS AND COMPARISONS

The case studies are summarised in the checklist table below:

CHECKLIST : ROAD INFRASTRUCTURE INVESTMENT AND ECONOMIC DEVELOPMENT IMPACTS **PROJECT:** Name of the project .....

Key:	Yes	✔		A	K8	D	Melbourne
	NO	X		B	K16	E	M74
				C	PWV 9	F	Dearne Towns

1   STUDY AREA

	A	B	C	D	E	F
1.1 Is the study area described?	✔	✔	✔	✔	✔	✔
1.2 Is a distinction made between direct project influence and external area or subarea consequences?	✔	✔	✔	✔	✔	✘
1.3 Is the purpose of the study described?	✔	✔	✔	✔	✔	✔

2   ROAD AND TRANSPORT NETWORK ANALYSIS

2.1 How is the road project defined?	A	B	C	D	E	F	
				✔		✔	· a specific scheme described
	✔	✔			✔		· a specific scheme quantified
			✔				· a broad type of project

2.2 What justified the road project?	A	B	C	D	E	F	
	✓			✓			· road capacity and congestion problems (general)
	✓	✓	✓	✓	✓	✓	· future development
							· other considerations

2.3 Are there direct road user cost savings or benefits measures?	A	B	C	D	E	F	
		✓	✓			✓	· no quantified measure
	✓	✗	✗	✓	✓	✗	· road user costs savings
	✓	✗	✗	✓		✗	· other savings

2.4 Transport network performance	A	B	C	D	E	F	
	✓			✓	✓		· analysed
		✓	✓			✓	· not analysed

3   ECONOMIC IMPACTS

3.1 What economic indicators were used?	A	B	C	D	E	F	
	✓	✓		✓		✗	· income
	✓	✓	✓	✓	✓	✓	· employment
	✓	✓	✓	✗	✓	✓	· new development/ investment
				✗		✗	· final good prices and production
	✓	✓		✓	✓	✗	· value added
				✗		✗	· consumer surplus
				✗		✗	· population

3.2 Modelling methodology applied.	A	B	C	D	E	F	
			✓			✓	· consultants' own qualitative assessment
						✓	· interviews with experts
			✓				· ad hoc quantified growth assumptions
					✓		· microeconomic partial equilibrium model
				✓			· macroeconomic general equilibrium model
					✓		· macroeconomic model
							· dynamic land-use/ transport model
	✓	✓					· input-output model

3.3 Linkage between road investment and economic development based upon	A	B	C	D	E	F	
			✓		✓	✓	· evidence in literature survey
	✓	✓				✓	· anecdotal evidence
	✓	✓		✓	✓		· economic framework/ collaboration

3.4 Time scales over which impacts were considered	A	B	C	D	E	F	
	✓	✓	✓		✓	✓	· not specific
				✓			· specific time scales

4 INDIRECT IMPACT: SPATIAL DISAGGREGATION

4.1 Level of spatial dis-aggregation	A	B	C	D	E	F	
							· none
					✓	✓	· ad hoc site identification
	✓	✓	✓	✓			· coarse zoning

	✓					· fine zoning

	A	B	C	D	E	F	
4.2 Has the real estate market in the area been analysed?	✓	✓	✓	✓	✓	✓	· market demand for specific land uses
		✓		✗			· market demand for real estate
							· not considered

4.3 Have displacement effects been considered?	A	B	C	D	E	F	
	✗	✗	✗	✗	✗	✗	

5   BENEFIT CALCULATIONS

	A	B	C	D	E	F
5.1 Is there an economic measure of the benefits?	✓	✓	✓	✓	✓	✗
5.2 Has the issue of double-counting been addressed?	✓	✓	✓	✓	✗	✗
5.3 Are there additional benefits?	✓	✓	✗	✗	✗	✗

4.6.1 Key findings

The key findings of these case studies were as follows:

- A detailed description of the direct and indirect study area is of primary importance. This helps the reader to understand the project findings. Furthermore, it seems logical to link direct transport improvement to the

direct study area, while the wider economic effects are linked to the indirect or secondary study areas. Some of the case studies did not define the study area and this complicated the analysis of the study and project benefits.

- Measurement of the direct transport impacts or improvements is equally important. Studies that do not include this component lack one of the principal aspects of transport economic analysis. These improvements include transport cost savings, travel time savings and increases in travel speed. Different transport modelling techniques are used to measure these improvements. The extent of the study will determine what modelling technique is to be used.

- Different economic modelling techniques are used to model the wider economic impacts of road projects. It is useful to break the assessment into two components, that of the construction phase and that of the operational phase. The key indicators that are used are jobs created, value added and consumption increases.

- The spatial disaggregation component of the studies was the most problematic. Only those studies that used complex macroeconomic modelling adequately addressed zonal disaggregation. Furthermore, it is imperative to analyse the real estate market.

- Lastly, it is essential to show all the benefits of the project in an integrated benefit matrix. These should include the direct transport benefits, the economic impacts as well as the nonmodelled benefits. Some studies did not summarise the benefits into a matrix, which tends to complicate matters for decision makers. It is also necessary to clearly justify that the potential problem of double-counting was adequately addressed.

The key findings of the case studies augment the importance of a sound economic strategy. The checklist developed for this thesis is thus adequate for the purposes of transport economic modelling.

4.6.2 Comparisons

The six case studies will now be compared from a methodological and practical perspective. This will identify problem areas as well as areas for improvement for transport economic modelling. Improving modelling methodologies and techniques will optimise transport economic modelling from a theoretical and practical perspective.

It was generally found that the South African case studies gave a better description of the study area in terms of primary and secondary areas. The proposed road project was adequately described in most case studies.

The network performance component was not included in any of the South African case studies, although some of the international studies did address this issue. The question of indicating the direct transport improvements for each road project should be included in all the transport economic models.

No specific economic indicator was emphasised as being more important, although GGP impacts and employment creation were the most widely used. It is thus necessary for transport economists to decide on specific indicators for transport economic studies for this will assist politicians with decision making.

From the case studies it is evident that no modelling technique was prescribed as the "best tool" to use. Some used quantitative economic forecasting techniques adapted for the specific project, while others applied existing economic models.

However, it was evident that only two specific economic models were used, namely input-output modelling and general equilibrium modelling. From these studies, one can infer that the modelling methodology is dependent on the availability of data, time scales and the purpose of the study.

The case studies had no clear approach to the linkage between road investment and economic development. Each study developed its own methodology on the relationship between road investment and economic development.

No correlation was found on the time scales over which the economic impacts were considered. However, it is necessary to focus on the road construction phase and the operational phase of the road project. The construction phase is usually short term (1 – 3 years), while the operational phase can be up to 30 years.

No specific zoning system was prescribed, but the spatial disaggregation was influenced by the modelling technique used. The real estate market assessment was properly done in all the studies except for one. This assessment is vital to reveal the expected economic and land development potential. No economic study can be regarded as accurate if this component is not adequately addressed. Another factor that was totally ignored is that of displacement effects. No true picture of economic impacts can be obtained if the displacement effects are not understood.

Most of the studies used an economic measure to calculate the indirect benefits. The benefit matrix as applied in one study seemed to be extremely appropriate. Double-counting in general was no problem. Most studies allowed for additional benefits.

From the above comparisons it is evident that transport economic modelling is not standardised by prescribed procedures or the use of specific models. The reflection of the benefits of the road project in terms of direct transport benefits and that of wider economic effects also merits further attention.

The next section will provide a more detailed discussion on the use of economic models.

4.7   MODELLING ASSESSMENT

The discussion on the case studies highlighted the prominent use of the following two economic models:

- **Input-output accounting models.**   These are tools used to estimate the effects of transport construction and operations spending on business activity and employment.
- **General equilibrium simulation models.**   These are tools used to handle input-output impacts (as above), plus the effects of travel cost changes on business productivity, competitiveness and growth.

It is thus meaningful to discuss these models in order to identify their practical application and technical requirements for use in transport economic modelling.

4.7.1 Input-output accounting models

Input-output analysis is a planning and forecasting technique with a variety of applications. It provides a framework within which industrial linkages, as well as the feedbacks between the consumer and producing economy, can be simulated (DOT 1993:8-1). Thirlwall (1999:306) supports this definition and states that an

input-output table provides a descriptive set of accounts, recording purchases by and sales from the different sectors of the economy. Gillis et al (1993:137) add to this deliberation by contending that the essence of the input-output table is to display the flow of output from one industry to another and from industries to final consumers. It thus captures the interaction between consumers, investors and exporters. In addition, it provides an industry-by-industry breakdown of the regional economy and places particular emphasis on the inter-industry relationships (Glasson 1985:92).

Input-output tables are used to analyse structural economic relationships. The term "structural relationships" implies the pattern of economic interrelationships between participants in the economic process, which are measured by the monetary transaction that takes place between them (Naude 1998:3). Economic theory determines the nature of input-output models because the objective is to trace chain reactions that are triggered in the economy by a given event, which is expressed as an exogenous change in final demand. This makes input-output models extremely suitable for transport economic modelling. The "event" in this instance is the proposed road, and the "chain reactions" are the cumulative effects on the transport sector, while the "exogenous change" reflects investment spending, government spending, private consumption and changes in inventories. Thus the linear intersectoral production functions are inserted into a system of general equilibrium equations.

According to Naude (1998:4) the input-output models are based on the following assumptions:

- Each sector of the economy produces a single output, with a single input structure, and there is no automatic substitution between the outputs of the different sectors. This **homogeneity assumption** requires that

- – all products of a single sector should be either perfect substitutes for one another or produced in fixed proportions
  - – each sector should have a single input structure
  - – there should be no substitution between products of different sectors
- The **proportionality assumption** requires that a linear homogeneous relationship must hold between inputs and outputs, with the inputs into each sector a linear function only of the level of output of that sector
- The **additivity assumption** rules out any form of external interdependence between sectors other than that specified by the input-output system, so that the total effect of carrying out production in several sectors is the sum of the separate effects.

Input-output models have certain advantages (DOT 1993:8-1; Weisbrod & Weisbrod 1997:8; UE 2000:12), which include the following:

- Input-output tables trace the linkage of interindustry purchases and sales within a given country, region or metropolitan area.
- These models permit the measurement of impacts into industrial or sectoral detail.
- Input-output tables are the simplest way to establish the cumulative effects of a project on a region.

In addition to their advantages, these tables also have certain limitations (UE 2000:12; DOT 1993:8-1). These are as follows:

- Input-output coefficients are costly to develop.
- A great deal of data are required.
- These tables have a linear function with fixed commodity prices.

- Output values are assumed to be proportional to demand, not allowing for economies of scale.

- Production functions are fixed for all output ranges.

- Tables reflect historical data – hence substitution effects are not accounted for.

- Specific impacts have to be isolated from the total impact, such as transport.

- The results only take cognisance of the gross effect of each project on the economy.

- Indirect and induced backward linkages occur in the same year as the initial impact from which it originated – hence the lag in the economy is not accounted for.

4.7.1.1 *Applicability of input-output accounting models*

Given the above discussion on input-output analysis, its applicability to road infrastructure investment decisions needs to be determined for South African conditions. The Department of Transport (DOT) (1993:8-4) describes the applicability of these tables and their usage of regional accounting data as follows:

Regional accounts provide a detailed annual picture of the flow or interrelationships of major sectors in a region. The problem is that regional accounts have large data requirements. As compared to nations, regions are also open economies with numerous cross-boundary transactions with no trade barriers. Little information on these movements is available. It can be particularly difficult to balance the income and expenditure approaches at regional level as a person may for instance work in one area and live in another.

DOT further adds that a second problem relates to the validity of the assumption of constant coefficients. This assumption that an industry will constantly use the same composition of inputs is undoubtedly questionable for many sectors over anything but a very short period.

From the above it seem that DOT is generally fairly critical about the use of these tables. However, this was a general view, as DOT (1993) acknowledges that no input-output analysis of a road project has been undertaken in South Africa at that stage. DOT concludes that input-output analysis for road projects is feasible and research would provide new insight into the justification for road improvements.

In recent years, the CSIR (1997) has used input-output tables to examine the impact of the transport sector on the South African economy (Naude 1998:27). This was done using a model called MOTE (model of transport and the economy). According to Naude (1998:27), MOTE has been applied for analytical purposes. This includes the use of impact multipliers, demonstrating the influence of the transport industry through its interindustry interlinkages on important variables such as employment, wages, consumption expenditure and its contribution to the current account of the South African balance of payments. Although only analysing the relationship between the entire transport sector and the economy on a national scale, the use of input-output tables in the transport industry is indisputable.

Only two significant studies on road infrastructure investment decisions with the use of input-output tables have recently been conducted in South Africa. They are road K8 (see UE 2000) and road K16 (see UE 2001). Road K8 was a pilot project and of importance here is one of the recommendations of the study, namely: "The input-output model should be refined and standardised in order that it may be utilised for all major projects in the city" (UE 2000:43).

In an effort to validate the methodological approach and modelling technique followed, the study was forwarded to Glen Weisbrod in the USA. Weisbrod is a world-renowned specialist in the use of modelling economic implications of transport and highway projects. He is also the author of various references used in this thesis. His comments received via e-mail were as follows: "Your analysis seemed quite good and complete, though I could not tell if your scenario for new development included an adjustment for the fact that some of the road development is likely to be redistributed from other parts of the Pretoria region".

These comments from a specialist in the field support the applicability of input-output analysis for evaluating the economic returns associated with road infrastructure investment. This is further strengthened by a statement on a similar study for road K16, namely that this approach: "… addresses an interesting innovation in development planning, namely the economic quantification of investment in road infrastructure. The most significant feature of this approach is that it facilitates informed decision-making, i.e. investments can be holistically and objectively evaluated" (UE 2001:1).

In conclusion, evidence has been produced to indicate that input-output models can be used to analyse the economic returns of road infrastructure investment projects. This is supported by the fact that at least two local studies have successfully used input-output models to measure the economic returns associated with road investment proposals (see secs 4.5.1 & 4.5.2). Obviously it is necessary to understand the shortcomings of these tables and plan for this.

4.7.2 General equilibrium simulation models

General equilibrium simulation models are used to represent the complex market-based interactions of mixed economies and the kinds of policy interventions that are feasible (Gillis et al 1996:145). These models are particularly useful in simulating the impact of policies and policy packages on the whole socioeconomic system. They can also provide useful results on the trade-off between higher private and government consumption today, and higher output, income and growth tomorrow that would have resulted from lower consumption and more investment. The specific general equilibrium model used and the purpose of the model will have an impact on its structure. These models identify the production of the commodities in the regional economy. The economic agents may include producers, investors, households, governments and foreign consumers. Producers are responsible for the capital creation in each industry. These models have a core set of equations which determine the supplies and demands of commodities based on the assumptions of optimising the behaviour of agents at microeconomic level in the context of competitive market structures. These models also specify demands and supplies of factors of production. The factors of production can cross regional borders, which means that each region's endowment of productive resources need not be fixed (Swan Consulting & Cox 1995:4).

The main limitation of general equilibrium models is their cost because sophisticated computer programs are required to solve these complex models. In general, it is safe to assume that these costs are much higher than those for input-output analysis.

The advantages of the use of these models emanate from the fact that once they have been built they can be run and tested at low cost by expert modellers. It also has become feasible to test hypotheses about economic development and policy development within a general equilibrium framework allowing many interactions that mark a real economy. In addition, according to Weisbrod and Weisbrod

(1997:9), general equilibrium models include all the functions of input-output models, plus additional functions. These functions forecast the effects of future changes in business costs, prices, wages, taxes, productivity and other aspects of business competitiveness, as well as shifts in population employment and housing values.

4.7.2.1   *Applicability of general equilibrium simulation models*

Not much information on the use of general equilibrium models for the evaluation of road infrastructure investment decisions could be obtained in South Africa. However, in the USA and Australia, the use of these models for road infrastructure investment decisions is definitely advocated. In the USA, the REMI model is generally used, while the MR-ORANI general equilibrium model is used in Australia (Weisbrod & Weisbrod 1997:9 and Swan & Cox 1995:2).

With regard to its applicability, Swan Consulting and Cox (1995:2) state that although these macroeconomic analyses are not designed for road investment planning, they have raised the level of interest in and debate on the magnitude of the macroeconomic impacts of investments in these core infrastructure components. They state, however, that there was a significant breakthrough in this analysis with the use of the microreform MR-ORANI general equilibrium model to determine the long-run effects of road investments on economy-wide output parameters. The broad approach to the modelling was to identify and distribute microeconomic benefits from road investments to various industrial and service sectors of the economy, and then to calculate the flow-on effects of the overall macroeconomic outcomes of the Australian economy (Allen Consulting 1993:59). The MR-ORANI model is designed to allow sufficient time for the road investments to be completed and for the economy to fully adjust to the opportunities created by the new road infrastructure.

It is interesting to note that the construction phase of the investment is not modelled. It is necessary to compare this with the input-output modelling results of the South African application where the construction phase has an substantial impact on the total expected economic benefits. Another shortcoming of this model relates to its inability to model employment gains, hence excluding a vital economic contribution of road investments.

Overall, these models seem to be suitable for the evaluation of road infrastructure investment decisions. What is evident, however, is that they seem to be mostly used by First World countries, which may be ascribed to their level of sophistication and data requirements.

This section provided information on two specific modelling techniques that are suitable for transport economic modelling. Given the limited use of transport economic modelling in this country, it is proposed that input-output models be applied for use because the selected case studies have proved the applicability of this modelling technique in South Africa.

Given these findings and comparisons, it is necessary to propose a correct modelling approach to be followed.

4.8   STUDY AND MODELLING APPROACH

The discussion in section 4.6 highlighted the need for a standardised approach to transport economic modelling. This section will formulate a basic modelling approach that will serve as the first step in standardising transport economic modelling is South Africa.

From the above discussion it is evident that the study area in terms of primary and secondary areas of influence needs to be adequately described because this will influence the modelling approach to be followed in terms of data requirements and accuracy. The modelling approach comprises two primary elements, namely modelling the direct transport impacts or transport network performance and modelling the indirect economic impacts. The preceding sections in this chapter provided background on the requirements for a transport economic study and modelling approach to be followed. Section 4.2 focused on the advantages and problem areas associated with economic modelling, while section 4.3 proposed a modelling strategy. The analysis and comparisons of the case studies in sections 4.4 to 4.6 reiterated the need for a standardised approach to economic modelling. In section 4.7 the modelling assessment evaluated two models and ultimately proposed the use of input-output modelling techniques for use in South Africa. In order to implement the standardisation of transport economic modelling in South Africa a modelling methodology is proposed. Figure 4.1 provides a flowchart of the modelling methodology to be followed.

From figure 4.1 it is evident that the process comprises four basic stages, namely:
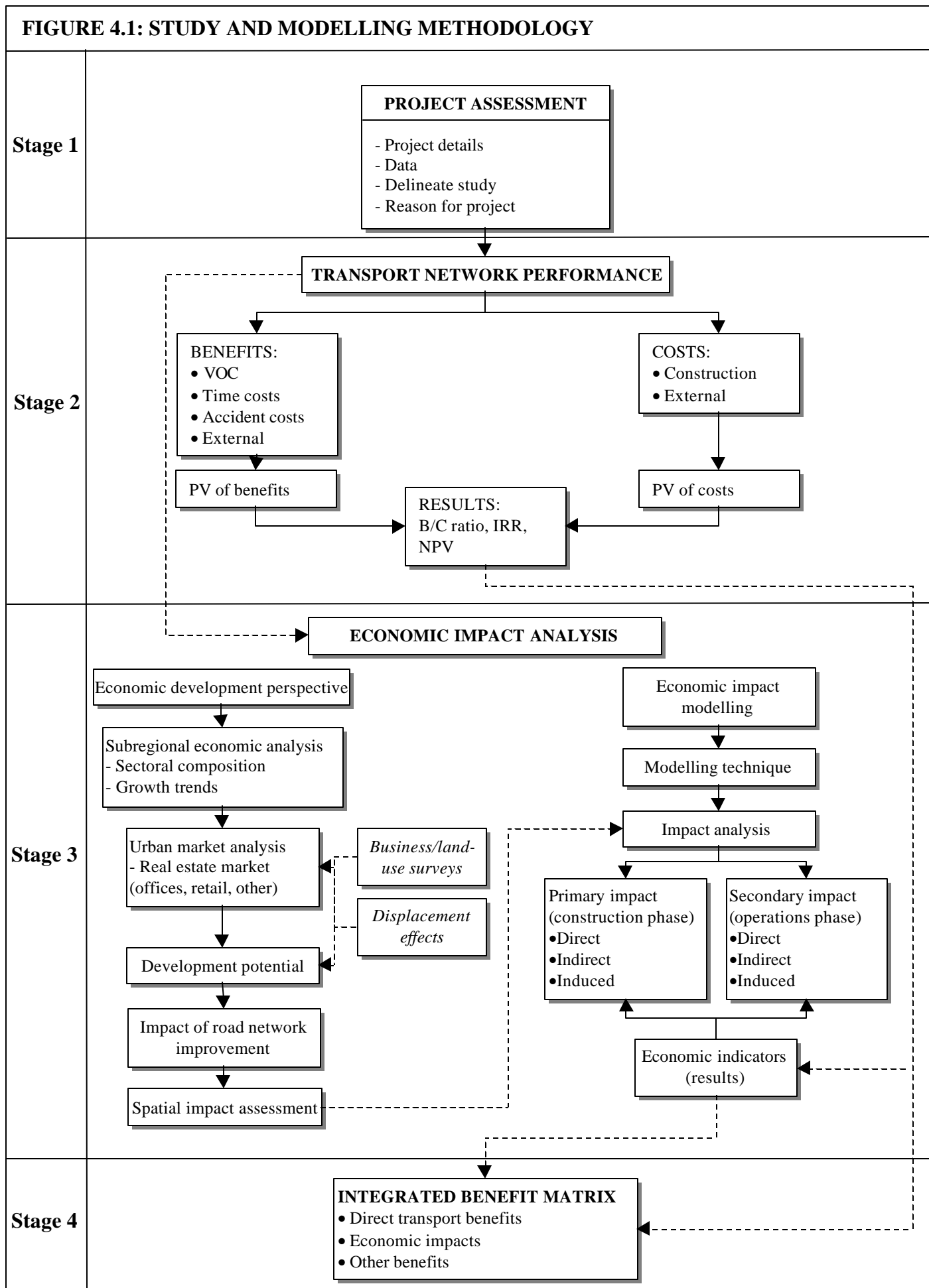
(1)   project assessment
(2)   direct transport impacts
(3)   economic impact analysis
(4)   integrated benefit matrix

These will now be briefly discussed:

(1)   **Project assessment.** The purpose of this stage is to give a detailed description of the project. This includes the reason for the project, the expected project cost, road alignment proposals and other project specific

information. This information will assist with the demarcation of the study area into the direct and secondary impact areas, as well as the data requirements.

FIGURE 4.1: STUDY AND MODELLING METHODOLOGY

Stage 1

PROJECT ASSESSMENT

- Project details
- Data
- Delineate study
- Reason for project

Stage 2

TRANSPORT NETWORK PERFORMANCE

BENEFITS:
- VOC
- Time costs
- Accident costs
- External

COSTS:
- Construction
- External

PV of benefits

PV of costs

RESULTS:
B/C ratio, IRR, NPV

Stage 3

ECONOMIC IMPACT ANALYSIS

Economic development perspective

Subregional economic analysis
- Sectoral composition
- Growth trends

Urban market analysis
- Real estate market (offices, retail, other)

Business/land-use surveys

Displacement effects

Development potential

Impact of road network improvement

Spatial impact assessment

Economic impact modelling

Modelling technique

Impact analysis

Primary impact (construction phase)
- Direct
- Indirect
- Induced

Secondary impact (operations phase)
- Direct
- Indirect
- Induced

Economic indicators (results)

Stage 4

INTEGRATED BENEFIT MATRIX
- Direct transport benefits
- Economic impacts
- Other benefits

(2) **Direct transport impact.** This stage assesses the expected impact of the proposed road investment proposal. The road project must thus also provide benefits to road users. These benefits are usually measured in terms of the vehicle operating costs savings, savings in travel time and accident reduction. This is normally expressed in present value format. These benefits are then compared with the cost associated with the road project. The cost component usually comprises the construction costs and other external costs. The final transport impact is then shown either in the net present value (NPV), the internal rate of return (IRR) or a benefit/cost ratio (B/C). This analysis will provide sufficient information on whether or not to proceed with the project.

(3) **Economic impact analysis.** This stage follows a two-pronged approach. Firstly, it assesses the economic development perspectives, and secondly, the actual economic impact modelling. The first step evaluates the subregional economy and the urban market. This is a crucial component of the process because modelling accuracy will be influenced if it is not done properly. The real estate market assessment provides information on the demand for specific land uses (ie retail), the vacancy rates of existing real estate supply, land availability, market competition and other vital information. This evaluation should then provide sufficient information to make accurate assumptions on expected displacement impacts.

This evaluation provides the development potential, which is subsequently matched to the road network improvements. This provides a sound base for the spatial impact assessment, which is then used to conduct the economic impact analysis. This analysis is conducted by using a modelling technique such as the input-output model. The impact analysis provides the primary

economic impacts that are expected during the construction phase, and the secondary impacts during the operational phase.

(4)   **Integrated benefit matrix**. This matrix shows the benefits associated with the road infrastructure investment. It provides information on the direct transport benefits, the economic impacts and other benefits. This stage must also ensure that no double-counting has occurred.

The above modelling methodology is thus a core step in standardising transport-economic modelling in this country. It clearly illustrates the project assessment, the assessment and inclusion of transport network performance, the approach to economic modelling and the use of the integrated benefit matrix. This methodology thus directly supports the purpose of this thesis, namely to develop methods to maximise the economic returns associated with road infrastructure investment.

4.9   SUMMARY

The main findings of this chapter are as follows:

(1)   The introduction of this chapter highlighted the difference between transport modelling and economic modelling.

(2)   The use of economic models has a number of advantages:

- •   They can be useful to policy makers concerned with macroeconomic stability and management.

- Models of economic structure can give aggregate pictures of an economy's potential to achieve long-run development goals such as income growth, employment creation and poverty alleviation.

- Cost-benefit models have guided governments to maximise the economic returns of infrastructure investment and to minimise costs.

- Comprehensive models compel economists to marshal all extant data on the economy, test the internal consistency of data, and establish a research agenda to gather additional information on crucial but poorly understood mechanisms in the economy.

(3) It is important to clearly understand the limitations of modelling techniques. Modellers sometimes make wrong assumptions about their application of economic models. These include:

- confusing the economic role (gross effect) of a facility or project from its net impact on the economy of an area

- adding together different measures of the same economic change

- confusing study areas

- confusing time periods

- assuming that a facility's capacity and its actual level of activity are the same

- ignoring market effects on wages and land/building costs, which can also affect the economic competitiveness of an area

- applying multipliers in areas where they do not apply

(4) To achieve sufficiently accurate modelling results it necessary to focus on following factors when developing a modelling strategy for transport economic models:

- definition of study area

- market and real estate (spatial) analysis

- impacts of road infrastructure improvements

- regional and business attraction impacts

- economic modelling and impact analysis

- limitations of economic modelling

(5)   In order to implement the modelling strategy it was essential to develop a checklist. This checklist will assist in the preparation of economic impact studies. The economic impact checklist can be used to assess whether any proposed transport economic study is adequate.

(6)   A number of selected case studies were assessed in term of the economic impact checklist. The key findings of these case studies were as follows:

- A detailled description of the direct and indirect study area is of primary importance. Some of the case studies did not define the study area and this complicated the analysis of the study and the project benefits.

- The measurement of the direct transport impacts or improvements is equally important. Studies that do not include this component lack one of the key elements of transport economic analysis.

- Different economic modelling techniques are used to model the wider economic impact of road projects. It is useful to subdivide the assessment into two elements, that of the construction phase and that of the operational phase. The key indicators used are jobs created, value added and consumption increases.

- The spatial disaggregation component of the studies was the most problematic. Only those studies that used complex macroeconomic

modelling adequately addressed zonal disaggregation. It is also meaningful to conduct a proper study of the real estate market.

- It is imperative to show all the benefits of the project in an integrated benefit matrix. These benefits should include the direct transport benefits, the economic impacts as well as the nonmodelled benefits. Some of the studies failed to summarise the benefits into a matrix, which would complicate matters for decision makers. It is also necessary to clearly indicate that the potential problem of double-counting has been adequately addressed.

4.10 CONCLUSION

This chapter provided background on the requirements for an effective transport economic study and modelling approach to be followed. Section 4.1 differentiated between transport modelling, section 4.2 focused on the advantages and problem areas associated with economic modelling, while section 4.3 proposed a modelling strategy. The analysis and comparisons of the case studies in sections 4.4 to 4.6 reiterated the need for a standardised approach to economic modelling. In section 4.7, the modelling assessment assessed two input-output modelling techniques and ultimately proposed the use of two of them for use in South Africa. In order to standardise transport economic modelling in South Africa a modelling methodology was developed. It is proposed that any transport economic study should follow four stages, namely:

(1)   project assessment
(2)   transport impact analysis
(3)   indirect economic impacts
(4)   integrated benefit matrix

The process was depicted in figure 4.1**.**

The modelling strategy developed in this chapter should ensure sufficiently accurate modelling results, and therefore aims to use current modelling theories and supporting methodologies to help transport economists to assess the potential economic impacts of road investments, and to aid the design of specific transport economic modelling studies. Here the complexity of the relationship (that between road investment and actual economic returns) that will be simulated in the modelling exercise needs to be clearly acknowledged. Factors such as network performance, the real estate market and land development, the location of the study area, urban market competition, the magnitude of investment and the local and regional impacts of road infrastructure improvements influence this relationship. The strategy that is developed should therefore ensure that all the aspects of the economic modelling of road projects are considered.

In addition to the modelling strategy, the checklist developed for transport economic modelling should ensure compliance with the minimum requirements for such studies. The checklist developed for this thesis is thus adequate for the purposes of transport economic modelling.

This chapter also highlighted the fact that transport economic modelling is not standardised by prescribed procedures or the use of specific models. The different economic models have various degrees of applicability, which are influenced by factors relating to their cost, data requirements and complexity. Although it was not the purpose of this thesis to recommend a specific model, it was inferred that input-output models are generally used in South Africa.

In conclusion, it can be stated that the aim of this chapter was to focus on transport economic modelling and its application for this thesis, namely to investigate tools

to maximise the economic returns associated with road investment. From the discussion in the conclusion it is obvious that this aim was achieved. The standardisation of the four-stage modelling methodology developed for transport economic modelling in South Africa prescribed the process for transport economic modelling.