Transport productivity and sub-industry measures

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Abbreviations and acronyms

AES	annual enterprise survey
ANZSIC	Australia and New Zealand standard industrial classification
C	confidentialised
CONC	firm concentration ratio
DEA	data envelopment analysis
EC	efficiency change
GDP	gross domestic product
GO	gross output
GST	goods and services tax
HERF	Herfindahl index
IC	intermediate consumption or inputs
ICT	information and communications technology
IDI	integrated data infrastructure
IO	input-output
IR3	individual income return
IR10	financial statement summary form
IRD	inland revenue department
KAP	capital stock
LAB	labour input
LBD	longitudinal business database
LBF	longitudinal business frame
MFP	multifactor productivity
MFPC	multifactor productivity change
MoT	Ministry of Transport, New Zealand
MPI	Malmquist productivity index
OECD	Organisation for Economic Cooperation and Development
PC	Productivity Commission
R&D	research and development
SFA	stochastic frontier approach
SNZ	Statistics New Zealand
TC	technical change
TE	technical efficiency
VA	value added
YOY	year-on-year

Contents

Executive summary

Statistics New Zealand (SNZ) publishes multifactor productivity (MFP) indicators for 'transport, postal and warehousing' as one group, which is an aggregation of 22 sub-industries (ie ANZSIC[1] class codes at four digits). These sub-industries represent a wide range of activities, such as different transport modes, transport services, storage services and postal and courier services. The productivity indicators for the years 1979–2012 are available. From a policy perspective, it may not be appropriate to use a productivity measure that has been obtained by aggregating data observations from such varied sub-industries into one grouping.

Moreover, to ensure that the transport sector is appropriately leveraged to contribute to New Zealand's economic growth, it is important to understand the sources of transport productivity growth, and to identify the drivers and influencers of the sector's productivity. To do this, it is useful to disaggregate transport productivity indicators by mode (air, sea, road and rail) and movement type (people and freight). This serves as a starting point to better understand the contributions that the various transport services make to the economy.

This study was commissioned by the NZ Transport Agency to meet the following objectives:

- to generate longitudinal productivity statistics for the transport sector at the sub-industry level, distinguishing between different transport modes and movement types
- to investigate the contributions of capital, labour and intermediate inputs in driving productivity changes at the sub-industry level
- to ensure that the productivity statistics and associated analysis are relevant to, and meet the requirements of, the transport decision makers and other stakeholders
- to offer a user-friendly interface (software/tool) that can be used by the Transport Agency and the Ministry of Transport (MoT) to update the productivity statistics when more current data becomes available.

To meet these objectives, the following empirical tasks were carried out, from January 2013 to January 2014, as part of this project:

1 calculating the partial labour productivity measure for various transport sector sub-industries as a point of reference

2 calculating MFP at the sub-industry level, using the growth accounting framework and attributing output growth to measured inputs – capital, labour and intermediate inputs, and productivity

3 deriving MFP at the sub-industry level by applying the Tornqvist index and separately identifying growth in the input and output indices

4 calculating MFP at the sub-industry level using the input-output (IO) tables-based approach and identifying the contribution of factor inputs

5 estimating firm-level MFP change, technical change (TC) and efficiency change (EC), using the Malmquist index (computed using the stochastic frontier approach [SFA]), and aggregating the output-weighted firm-level MFP change, TC and EC estimates to derive productivity change indicators at the sub-industry level

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1 Australia and New Zealand standard industrial classification.

6 exploring firm-specific influencers of technical efficiency by using the SFA

7 developing a user manual to allow the productivity indicators to be updated.

For the productivity indicators we developed using the growth accounting approach, the Tornqvist index and the Malmquist index, we used data from the SNZ Longitudinal Business Database (LBD) – this is part of SNZ's Integrated Data Infrastructure (IDI) and contains data collected by SNZ for the national accounts. Note: IDI information based on very small industries and/or those that were dominated by very few firms could not be released, to protect the identities and information of participants in that industry. This means the output, input and productivity data of some of the industries were confidentialised. For the productivity indicators we developed using the IO approach, we used data from the IO tables developed by the MoT in the LBD environment. These IO tables were confidential.

The productivity analyses were undertaken at the ANZSIC group level (three digits) covering the following industries within the transport sector: road freight; road passenger; services to road transport; water freight; water passenger; water transport services; air transport; air support services; other transport services; pipeline transport; scenic transport; postal and courier services; warehousing and storage; and rail transport.

Findings

We found there was a lack of consistency between the indicators of productivity computed using the various approaches: growth accounting, the Tornqvist index, the Malmquist index and the IO approach. It is important to note that while the approaches are fundamentally similar, the indicators that are derived using them should not be expected to align, as the time frame of analysis, data and the factor weights used – as determined by practical considerations – are different. The table following summarises the derived productivity indicators.

Recommendations

At the beginning of this research, it was believed that repeating this exercise once every couple of years or so would be useful. However, we are now of the opinion that it would not be particularly useful to repeat this exercise in the same form, because little policy-relevant insight would be gained by calculating productivity using several methods that are fundamentally the same. If anything, it would be misleading to have different productivity indicators in the public arena. Instead, it would be adequate to compute the productivity of sub-industries by using only the Tornqvist index number formula. (Some of the other methods, such as growth accounting and the IO-based approaches, are simply a form of the Tornqvist index.) We do recommend complementing the Tornqvist-based indicators with analysis based on Malmquist index number approaches. This is because the Malmquist index approach is able to distinguish between TC and EC and also sheds light on the firm-specific determinants of productivity.

Table Summary of productivity indicators

Industry	Labour productivity (2000-2010)	Growth accounting (2000-2010)	Tornqvist index (2000-2010)	Malmquist index (2000-2010) (SFA model)	IO approach (1996-2007)[a]	IO approach (2007-2010)[a]
Transport sector	+11.2%	+7.2%	+13.6%	+6.3%	NA[b]	NA
Road freight[c]	+16.2%	+12.1%	+12.4%	+26.4%	+7.3%	+1.9%
Road passenger[c]	+10.1%	+6.8%	+3.8%	+18.1%	-5.1%	+1.9%
Services to road transport[c]	NA	NA	NA	NA	+0.9%	+1.9%
Water freight[d]	-21.4%	+11.3%	+6.1%	+32.1%	+12.1%	+12.1%
Water passenger[d]	C[e]	NA	+43.6%	-1.5%	+12.1%	+12.1%
Water transport services[d]	+7.6%	-1.3%	-11.5%	-7.2%	+12.1%	+12.1%
Air transport[f]	C	NA	+14.7%	-9.2%	+3.1%	+8.7%
Air support services[f]	+8.22%	+3.2%	-12.1%	-9.5%	+3.1%	+8.7%
Other transport services	+18.7%	+9.3%	+16.3%	+18.3%	NA	+0.4%
Pipeline transport	+20.7%	+14.8%	+2.2%	+53.3%	NA	NA
Scenic transport	+25.2%	+19.9%	+21.4%	+15.3%	NA	-5%
Postal and courier services	+15.1%	+9.2%	+1.7%	+36.7%	+11.6%	+0.9%
Warehousing and storage	+3.7%	+9.9%	+15.5%	+22.8%	NA	-0.5%
Rail transport	C	NA	NA	NA	+18.6%	+7.6%

a) The IO-based statistics are presented separately for each time period as the underlying data for the time periods were based on different industry classification systems (ANZSIC 1996 and ANZSIC 2006) and the data could not be aligned to a common industry classification.

b) NA = not applicable.

c) Road transport for the IO approach.

d) Water transport combines water freight, passenger and transport services for the IO approach.

e) C = confidentialised.

f) Air transport combines air transport and air transport services for the IO approach.

Abstract

This research investigated using four different approaches to measuring the productivity of the sub-industries (ANZSIC three digits) that comprise the New Zealand transport sector. The four approaches investigated were the growth accounting framework, the Tornqvist index, the Malmquist index and the input–output tables-based approach. The unit-record data available from Statistics New Zealand’s Integrated Data Infrastructure were applied to enable the analysis.

The productivity indicators derived from the four approaches that are presented in this report were disaggregated by mode (air, sea, road and rail) and movement type (people and freight). This report offers insights on the sources and components of transport productivity growth and will serve as a starting point to better understand the contributions that various transport services make to the economy.

As part of the research project, the software codes to retrieve and clean the raw data and compute productivity indicators have been placed in SNZ’s datalab. This means that the NZ Transport Agency and other consortium partners will be equipped to replicate the analysis over time.

1 Introduction

1.1 Background

Statistics New Zealand (SNZ) publishes multifactor productivity (MFP) indicators for 'transport, postal and warehousing' as one industry – ANZSIC (Australia and New Zealand standard industrial classification) 2006, Division I, Transport, Postal and Warehousing. The SNZ's published productivity series[2],1979–2012, shows that although the transport and storage (henceforth, transport) sector outperformed most other industries in the 1980s and 1990s, there has been virtually no productivity growth in the sector since the early 2000s (Productivity Commission [PC] 2012). The reasons for this are not clear. This is of concern because, apart from being a sizeable component of the economy, the transport sector also offers critical services to the wider economy by facilitating the movement of people and goods.

To ensure that the transport sector is appropriately leveraged to contribute to New Zealand's economic growth, the sector's productivity needs to be measured in order to increase understanding of the sources of productivity growth and identify the drivers and influencers of the sector's productivity levels. To do this, it is useful to disaggregate transport productivity indicators by mode (air, sea, road and rail) and movement type (people and freight). This research project has contributed to this understanding of the sector by investigating four different approaches to measuring the productivity of sub-industries and generating longitudinal productivity statistics for the transport sector at a disaggregated ANZSIC group level (three digits), using firm-level data from SNZ's Integrated Data Infrastructure (IDI). The four approaches investigated were the growth accounting framework, the Tornqvist index, the Malmquist index and the input–output (IO) tables-based approach. The unit-record data available from Statistics New Zealand's IDI were applied to enable the analysis.

Additionally, the research focused on the role of capital, labour and intermediate inputs when identifying the drivers of productivity growth and found two main sources: technical change (TC) and efficiency change (EC). The results presented in the report will assist in generating policy insights that will be of value to the transport decision makers of New Zealand – the NZ Transport Agency, the Ministry of Transport (MoT) and Local Government New Zealand (LGNZ).

As part of the research project, we have supplied several productivity calculation interfaces (one per approach used) to the Transport Agency, the MoT and the PC. This will allow the Transport Agency and the MoT to update the compiled statistics when data is updated in the IDI. We have also supplied those organisations with data retrieval and manipulation codes, which are located in the folder provided to us in the SNZ's datalab. The codes, which have little value outside of the datalab, should not be extracted without permission from SNZ.

1.2 Objectives

The objectives of this report were to:

- generate longitudinal productivity statistics for the transport sector at the sub-industry level, distinguishing between different transport modes and movement types
- investigate the contributions of capital, labour and intermediate inputs in driving productivity changes at the sub-industry level

2 www.stats.govt.nz/wbos/Index.aspx

- ensure that the productivity statistics and associated analysis are relevant to, and meet the requirements of, the transport decision makers and other stakeholders
- offer a user-friendly interface (software/tool) that can be used by the Transport Agency/MoT to update the productivity statistics when more current data becomes available.

1.3 Scope

The following tasks were considered within the scope of the project, which was undertaken between January 2013 and January 2014:

- computing the partial labour productivity for various transport sector sub-industries
- computing productivity for various transport sector sub-industries, using the growth accounting framework and attributing output growth to measured inputs – capital, labour and intermediate inputs
- computing productivity at the sub-industry level, applying the Tornqvist index and separately identifying growth in the input and output indices
- calculating productivity using the input-output (IO) tables-based approach and identifying the contribution of factor inputs
- computing productivity for various transport sector sub-industries by applying the Malmquist index at the firm level and decomposing productivity changes into technical changes (TCs) and efficiency changes (ECs) (scale and pure efficiency, separately), and aggregating the output-weighted firm-level MFP change, TC and EC estimates to derive productivity change indicators at the sub-industry level
- exploring firm-specific influencers of technical efficiency by using the stochastic frontier approach
- developing a user manual to allow the productivity indicators to be updated.

To meet the objectives of the project, it was necessary to investigate different productivity indicators (calculated using different approaches). Note: although the scope of the project did not include evaluating the 'right' productivity indicator, we have made some comments about the potential use of different indicators.

1.4 Organisation of the report

The remainder of the report is organised in chapters covering:

- approaches to computing and decomposing measures of productivity, and identifying components of productivity growth
- an introduction to the data sources used
- a presentation of summary statistics
- results and discussion
- conclusions and recommendations for further research.

A reader with reasonable knowledge of different formulae/methods to compute productivity – specifically, growth accounting, Tornqvist index number formula, Malmquist index number formula, stochastic frontier approach (SFA), data envelopment analysis (DEA) method and input–output tables-based approach – should be able to miss out chapter 2 of the report and begin at chapter 3. The first section of chapter 2 offers a brief, non-technical summary of the various approaches.

Chapter 3 presents the data used in the computations. A reader familiar with the IDI (the data source) should be able to quickly scan through this chapter.

The summary statistics, chapter 4, provides a context to the results reported in chapter 5.

The appendices contain some additional results, such as indicators of productivity computed based on value-added measures and the parameters of a stochastic production function. These are reported in the interests of comprehensiveness.

Note: Except when explicitly identified as labour productivity, all indicators presented in this report are MFP measures.

2 Review of the computational approaches

2.1 Overview

This chapter focuses on a review of the approaches that are applied to derive productivity indicators. Broadly, productivity is understood to be the performance of businesses in converting inputs into outputs and 'a natural measure of performance is productivity: the ratio of outputs to inputs where larger values of this ratio are associated with better performance' (Coelli et al 2005, p1). For example, a taxi service uses inputs such as materials (petrol), labour (driver) and capital (car) to produce an output (transporting a passenger from point A to B). The performance of this taxi service could be defined in several ways; for example, its productivity in any time period could be measured relative to another time period, or to another cab service in the same time period. In this report we are mostly concerned with the inter-temporal comparisons; that is, the productivity of the observed business (or industry) in the current period with respect to its own productivity in a base period.

Thus, we are referring to total factor productivity, which is a productivity measure involving all factors of production. Since not all factors are measurable, a more acceptable term is 'multifactor' productivity. Other traditional measures of productivity, such as labour productivity, fuel productivity in power stations, and land productivity (ie yield) in farming, are called partial measures of productivity.

The following performance measurement approaches are discussed in this chapter:

- growth accounting framework
- Tornqvist index
- Malmquist index
- IO tables-based approach.

Although there are other approaches of performance/productivity measurement, our research brief was confined to these four, as they are suitable for exploiting the micro-level data from the IDI.

A brief, non-technical summary of these approaches follows, with a more detailed description in the subsequent sections.

Growth accounting framework: The growth accounting framework breaks down economic growth into components that can be attributed to growth of factor inputs such as capital and labour. The growth in output that remains unallocated to factor inputs is called the 'Solow residual' or 'multifactor' productivity. There can be several reasons for productivity increase, including those that impact upon technology and those that impact upon the efficiency with which the input resources are utilised. In effect, using the growth accounting framework helps us work out:

- the contribution of increasing capital input
- the contribution of increasing labour input
- the contribution of greater productivity.

Tornqvist Index number formulae: An index number is defined as a real number that measures changes in a set of related variables. The Tornqvist productivity index is a ratio of an output index to a composite input index. In this report, the Tornqvist index method is used to derive the output index based on the gross output (GO) variable and its associated price deflators, and the aggregate input index (combining various factor inputs) and the associated price deflators. Dividing the output index with the input index gives the productivity index.

Malmquist index number formulae: From the definition of index numbers above, it is clear that the central premise is the idea of comparing values of variables across time (or space). The Malmquist index number approach used in this report is based on output comparisons. Using the concept of distances, the Malmquist index works out a production frontier (a common technological frontier) for the units of observation. The shift of the frontier is interpreted as TC, and movements of data points to and from the frontier is interpreted as EC. The product of the TCs and ECs is the Malmquist productivity index (MPI). The unique aspect of this index is that it distinguishes between the TC and the EC components of productivity.

Input–output (IO) tables-based approach: This approach also computes productivity as a ratio of output over composite input values. It is, in principle, the Tornqvist index. However, the data used in this approach is from annual IO tables constructed by the MoT from SNZ supply-and-use tables.

The output-oriented Malmquist index used in this report is obtained by measuring the change between two data points by calculating the ratio of the distances of each data point relative to a common technology.

2.2 Growth accounting framework

Among the various approaches applied in the economic literature to measure productivity growth, the growth accounting framework introduced in Solow (1956, 1957) is predominant. At the core of growth accounting is the distinction between movements along the production function, associated with capital accumulation (also called capital deepening), and shifts in the production function, resulting from productivity increments.

Solow modelled economic growth at the macroeconomic level, but the model can also be implemented at the microeconomic level, as shown below:

Consider the following equation:

$$g_Q = sh(M)\, g_M + sh(K)\, g_K + sh(L)\, g_L + TC \qquad \text{(Equation 2.1)}$$

Equation 2.1 shows that the growth rate of output can be attributed to three conventional factors: growth rate of intermediate consumption, g_M; growth rate of capital, g_K, and growth rate of labour, g_L, weighted by their respective shares – sh(M), sh(K) and sh(L). The unexplained residual, which Solow termed 'technical change' – TC)[3] is the measure of productivity growth.

This equation is derived from the following:

Consider an aggregate Cobb-Douglas (C-D) production function:

$$Q_t(M_t,Kt,L_t,A_t)=A_t M_t^{\alpha} K_t^{\beta} L_t^{\chi} \qquad \text{(Equation 2.2)}$$

where t is the time period, A is technology, K is the level of capital, L is the labour, α is a production parameter that will equal intermediate input's share of GO, β is capital's share and χ is labour's share.[4,5]

3 Solow (1957, p.312) clarifies '… I am using the phrase "technical change" as a short-hand expression for any kind of shift in the production function. Thus, slowdowns, improvements in the education of the labour force, all sorts of things will appear as "technical change".'

4 Under the conditions that there is perfect competition and the firms are paid their marginal product.

This production function exhibits several important properties, including diminishing returns to capital and labour, constant returns to scale, and constant intermediate input, capital and labour shares. The result holds for more general functions, but assuming C-D simplifies the exposition.

Taking the natural logarithm (ln):

$$ln[Q_t(M_t,K_t,L_t,A_t)] = ln(A_t) + \alpha\ ln(M_t) + \beta\ ln(K_t) + \chi\ ln(L_t) \qquad \text{(Equation 2.3)}$$

Now at time, t-1 (previous period):

$$ln[Q_s(M_{t-1}K_{t-1},L_{t-1},A_{t-1})] = ln(A_{t-1}) + \alpha\ ln(M_{t-1}) + \beta\ ln(K_{t-1}) + \chi\ ln(L_{t-1}) \qquad \text{(Equation 2.4)}$$

Subtracting equation 2.4 from equation 2.3, we get:

$$\Delta ln[Q_t(M_t\ K_t,L_t,A_t)] = \Delta ln(A_t) + \alpha\ \Delta ln(M_t) + \beta\ \Delta ln(K_t) + \chi \Delta ln(L_t) \qquad \text{(Equation 2.5)}$$

where Δ is a first difference. Recognising that $\Delta ln(L_t) = ln(L_t) - ln(L_{t-1}) \approx$ the growth rate of L (and likewise for capital and intermediate inputs), we can see that:

$$\Delta[Q_t(M_t\ K_t,L_t,A_t)]/Q_t = \alpha\Delta M_t/M_{t-1} + \beta\Delta K_t/K_{t-1} + \chi\Delta L_t/L_{t-1} + \Delta A_t/A_{t-1} \qquad \text{(Equation 2.6)}$$

which is exactly equation 2.1.

In essence, the growth accounting framework obtains the productivity growth rate by subtracting the contributions of factors of production from the rate of real output growth. Data sources for estimating productivity using the growth accounting framework are documented in chapter 3 of this report. As neither outputs nor inputs are homogenous, the aggregation of outputs and inputs is a critical issue. The need to aggregate the data has led to the increased application of index number approaches to measure productivity, which are discussed in the next section.

2.3 Index number approaches

An index number is defined as a real number that measures changes in a set of related variables. Index numbers can be used to measure price and quantity changes over time, as well as to measure differences in the levels of economic variables across firms, industries, regions or countries. There are several index number formulae, but the Tornqvist and Fisher index is the most commonly used measurement of productivity and the Malmquist index is increasingly used for decomposing productivity into TC and efficiency components.

5 In this research we used models that had gross output rather than VA as the output variable. This meant that the C-D production function had three inputs: intermediate consumption, capital and labour. Traditionally, the C-D model is illustrated using capital and labour as factor inputs and VA as the output variable.

This section, which draws mostly from Coelli et al (2005), discusses the Tornqvist and the Malmquist indices.[6]

2.3.1 The Tornqvist index

The Tornqvist index has been used in many productivity studies in the last decade. Following from our definition of MFP, we know that it can be measured as a ratio of an output index to a composite input index.

$$MFP_t = \frac{O_t}{I_t} \quad \text{(Equation 2.7)}$$

where O_t is output index, I_t is input index.

The Tornqvist index method is used to derive the (aggregate) output index (in the case of multiple outputs) and the aggregate input index (in case of multiple inputs). In general, the Tornqvist quantity index between period *t* and *t-1* is written as:

$$T_t = \prod_{i}^{n} \left(\frac{q_{i,t}}{q_{i,t-1}} \right)^{\frac{1}{2}\left(w_{i,t} + w_{i,t-1} \right)} \quad \text{(Equation 2.8)}$$

where *q* is the quantity of output (or input), *w* is the share of the output (or input) in total value of outputs (or inputs), *n* is the number of outputs (or inputs), and *i* represents output (or input).

For example, a composite input index of capital (K) and labour (L) is calculated as:

$$I_t = \left(\frac{K_t}{K_{t-1}} \right)^{\frac{1}{2}\left(w_{k,t} + w_{k,t-1} \right)} \cdot \left(\frac{L_t}{L_{t-1}} \right)^{\frac{1}{2}\left(w_{l,t} + w_{l,t-1} \right)} \quad \text{(Equation 2.9)}$$

where w_k and w_l are the shares of capital income and labour income, respectively, in total factor income (firm's value added – VA), that is:

$$w_{k,t} = \frac{Y_{k,t}}{Y_{k,t} + Y_{l,t}} \quad , \qquad w_{l,t} = 1 - w_{k,t} \quad \text{(Equation 2.10)}$$

where Y_k and Y_l represent capital and labour incomes respectively.

The first component on the right hand side of equation 2.9 represents the contribution of capital to output growth and the second component represents labour contribution. Together, the two components make up the composite input index. MFP represents the growth in output that cannot be explained by input growth. This is the same as the growth accounting framework except that a fixed labour share is used in the latter.

6 Some discussion in the literature (eg Coelli et al 2005) compares the Tornqvist index with the Fisher index based on their axiomatic properties. Both of these are superlative index numbers and while the Tornqvist index is exact for a translog function, the Fisher index is exact for a quadratic function. For this study, we estimated both the Tornqvist and Fisher indices. The computed indicators were nearly identical and there was no practical value in discussing the results from both. The results and software programs required to compute the Fisher index have also been made available to MoT, Transport Agency and PC representatives.

In this research project, there was interest in comparing each year's productivity with the previous year's, and then combining annual changes in productivity to measure changes over a given period. The MFP indices constructed using such annual changes are known as 'chain indices'. To facilitate a formal definition, let *I(t, t+1)* define an index of interest for period *t+1,* with *t* as the base period. The index can be applied to a time series with *t* = 0, 1, 2, .., *T*. Then a comparison between period, *t,* and a fixed base period, *0*, can be made using the following chained index of comparisons for consecutive periods:

$$I(0, t) = I(0, 1)\times I(1, 2)\times \ldots \times I(t-1, t)$$ (Equation 2.11)

Data sources for estimating productivity using the Tornqvist index are documented in chapter 3.

2.3.2 The Malmquist index

For several decades following its introduction to the macroeconomic literature by Solow (1956), MFP was synonymous with TCs as economies, in the Solow framework, are implicitly modelled to be fully efficient in the utilisation of factor inputs. This modelling of full efficiency is derived from the behavioural assumptions made in the Solow framework. These assumptions, and consequently the practice of modelling full efficiency, extend even to the conventional index number approaches, including the Tornqvist index.

Recently, it has been widely recognised that the distance functions-based MPI relaxes the behavioural assumptions in the Solow framework and is able to decompose MFP growth into two mutually exclusive and exhaustive components: TC (or shifts of the production frontier) and EC (movements relative to the production frontier).[7] A practical advantage of the MPI is that its computation does not require information on prices, and accurate price data is much harder to obtain. This advantage is particularly relevant in the context of the IDI, which was the primary data source for this research project.

The derivation of the MPI requires exposition of distance functions. The basic idea underlying distance functions is quite simple, involving radial contractions and expansions. For instance, an output distance function describes the factor by which the production of all output quantities could be increased while remaining within the feasible production possibility set for a given input level. Likewise, an input distance function indicates how much input use can be reduced for a given output level and within the production possibilities.[8]

In this exposition, we consider only output-oriented distance functions, which are defined and illustrated below.

Consider the output possibility set:

$$P(x) = \{y: x \text{ can produce } y\}.$$ (Equation 2.12)

The output distance function with technology at time *t-1*, the initial period, can be defined as:

$$d^{t-1}(x, y) = \min\{\theta : \frac{y}{\theta} \in P(x)\}$$ (Equation 2.13)

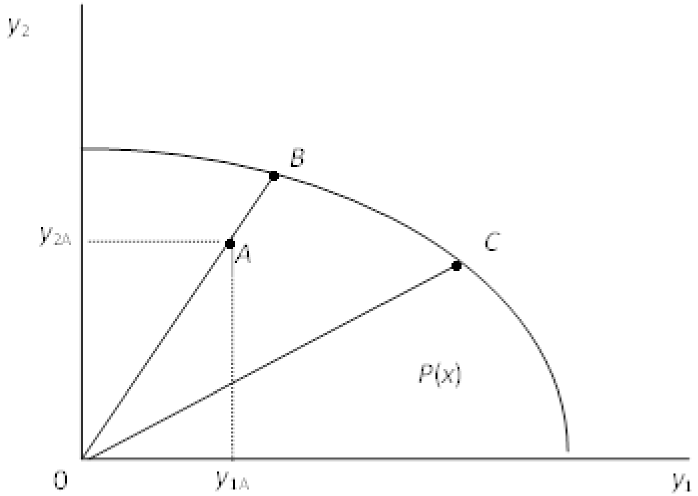
7 Under the assumption of the cost-minimising and profit-maximising behaviour of producers, the MPI is approximately equal to the Fisher index (Färe and Grosskopf 1992). The MPI is identical to the Tornqvist index provided that the distance functions are of translog form with identical second-order coefficients, and that the prices are those supporting cost minimisation and profit maximisation objectives (Caves et al 1982).

8 Output and input orientations result in the same numerical measure if the technology in the reference period exhibits the property of global constant returns to scale.

Note that when θ is minimised, y/θ is maximised. Thus, this distance function measures the maximum possible output that a given amount of inputs can produce.[9]

It is useful to illustrate the concept of an output distance function using an example where two outputs, *y1* and *y2*, are produced using the input vector, *x*. For a given input vector, *x*, we can represent the production technology on the two-dimensional diagram in figure 2.1. Here the production possibility set, *P*(*x*), is the area bounded by the production possibilities contour, *PPC-P*(*x*), and the *y1* and *y2* axes. The value of the distance function for the firm using input level *x* to produce the outputs, defined by the point *A*, is equal to the ratio $\delta=0A/0B$. This distance measure is the reciprocal of the factor by which the production of all output quantities could be increased while remaining within the feasible production possibility set for the given input level. Unlike *A*, points *B* and *C* are on the production possibility surface and, hence, would have distance function values equal to 1 (see figure 2.1).

Figure 2.1 Output distance functions



In a manner similar to equation 2.13, the output distance function with technology at a successive time, *t*, can be defined as:

$$d^t(x,y) = \min\{\theta : \frac{y}{\theta} \in P(x)\} \qquad \text{(Equation 2.14)}$$

The output-oriented Malmquist index is obtained by measuring the change between two data points by calculating the ratio of the distances of each data point relative to a common technology.

9 A few simple properties of the distance functions follow directly from the axioms on the technology set. They are:

- $d^s(x,0) = 0$ for all non-negative *x*
- $d^s(x,y)$ is non-decreasing in *y* and non-increasing in *x*
- $d^s(x,y)$ is linearly homogeneous in *y*
- $d^s(x,y)$ is quasi-convex in *x* and convex in *y*
- if *y* belongs to the production possibility set of *x* (ie, $y \in P(x)$), then $d^s(x,y) \leq 1$
- distance is equal to unity (ie, $d^s(x,y) = 1$) if y belongs to the ‘frontier’ of the production possibility set.

Following Färe et al (1994), the output-oriented MPI between period *t-1* (the initial period) and period *t* (the successive period) is given by:

$$m\ (x^t, y^t, x^{t-1}, y^{t-1}) = \left[\frac{d^{t-1}(x^t, y^t)}{d^{t-1}(x^{t-1}, y^{t-1})} \times \frac{d^t(x^t, y^t)}{d^t(x^{t-1}, y^{t-1})} \right]^{1/2} \qquad \text{(Equation 2.15)}$$

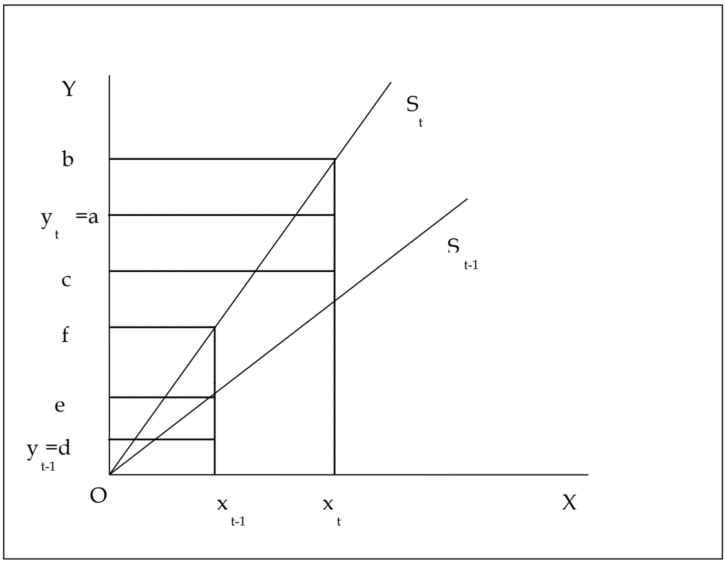
Rearranging the terms in equation 2.15, we get:

$$m\ (x^t, y^t, x^{t-1}, y^{t-1}) = \frac{d^t(x^t, y^t)}{d^{t-1}(x^{t-1}, y^{t-1})} \times \left[\frac{d^{t-1}(x^t, y^t)}{d^t(x^t, y^t)} \times \frac{d^{t-1}(x^{t-1}, y^{t-1})}{d^t(x^{t-1}, y^{t-1})} \right]^{1/2} \qquad \text{(Equation 2.16)}$$

The first factor in equation 2.16 outside the square brackets shows the change in efficiency between the periods *t-1* and *t*. A value greater than one for this factor indicates movements of the observation towards the frontier and thus, positive changes in efficiency. Likewise, a value of less than one indicates movement away from the frontier and increasing inefficiency. The second factor – that is, the geometric mean of the two ratios inside the square brackets – represents TC. It corresponds to the shift of the frontier. In particular, a value greater than one for the second factor reflects outward shifts of the frontier and thus, technological progress, and a value less than one reflects inward shifts and technological regress.

The decomposition of the MPI in equation 2.16 is shown graphically, using a simple one-input and one-output case with a constant returns to scale technology, as shown in figure 2.2.

Figure 2.2 Malmquist index decomposition



In figure 2.2, S_{t-1} and S_t denote the technologies in period *t-1* and *t* respectively. The input–output vectors (x_{t-1}, y_{t-1}) and (x_t, y_t) are feasible in their own periods, but (x_t, y_t) does not belong to S_{t-1}. The points *d* and *a* in figure 2.2 represent the actual output of a business in periods *t-1* and *t* respectively. In both cases, the business is shown to be operating below the production possibility frontier.

Translating this observation in terms of equation 2.16, we get:

$$EC\ (EC) = \frac{Oa}{Ob}\frac{Oe}{Od} \qquad \text{(Equation 2.17)}$$

Similarly, the term inside the square bracket in equation 2.17 is given as:

$$T) = \left[\frac{Oa}{Oc}\frac{Ob}{Oa}\frac{Od}{Oe}\frac{Of}{Od}\right]^{1/2} = \left[\frac{Ob}{Oc}\frac{Of}{Oe}\right]^{1/2} \qquad \text{(Equation 2.18)}$$

Finally,

$$\textit{productivity change} = \frac{1}{TFP}\frac{dTFP}{dt} = EC * TC \qquad \text{(Equation 2.19)}$$

Notwithstanding several of its desirable properties, the MPI only measures MFP changes accurately when the constant returns to scale (CRS) assumption is imposed. Whether this assumption is valid is debatable, especially in case of sub-industries within the transport sector.[10]

In this research project, two principal methods were used to compute and decompose productivity growth (MPI) into TC and EC components. They are the (SFA), which uses econometric methods, and the DEA method, which involves mathematical programming. The two methodologies are discussed below. For ease of exposition, the DEA is discussed first.

2.3.2.1 Data envelopment analysis (DEA)

The DEA, introduced in Charnes et al (1978, 1981), is a mathematical method that can be employed to compute the productivity growth of businesses without requiring information on output and input prices, which are often unavailable or unreliable. The principal advantage of using the DEA, relative to econometric alternatives, is that the technique does not require the specification of a production function. Instead, the DEA is a linear programming method that uses observations on factor inputs and outputs to measure the efficiency and productivity of economic entities. The piecewise linear production frontier resulting from the DEA exercise is the best-practice technology that represents the maximum output that a business can produce given its input mix (ie full efficiency). A comparison between the actual output produced by a business and the fully efficient point on the linear production frontier corresponding to the same input mix yields the measure of efficiency. The closer a business is to its input mix equivalent on the frontier, the more efficient it is. Likewise, the shift of the enveloping frontier over two time periods gives the measure of TC. Changes in technical efficiency and shifts of the frontier combine to yield the productivity growth measure (see equation 2.16).

To construct the frontier, the DEA makes certain general assumptions about the production technology. The assumptions are fairly weak and hold for all technologies represented by a quasi-concave and weakly monotonic production function.

The DEA does not account for measurement errors and statistical noise. Thus, all deviations from the best-practice technology are assumed to reflect inefficiency. This seriously distorts the measurement of efficiency (and consequently the MPI). The DEA also violates Pareto optimality[11] by assigning equal efficiency for several businesses, even though one of them may obviously be superior in terms of some inputs/outputs and equal in terms of others. This situation may arise when firms in the business frame have considerably different input mix characteristics. It is also possible in DEA that a small business with an unusual input mix may get an efficiency score of one. These deficiencies are related to the DEA method rather than the MPI and do not occur when the (SFA) is used to compute the MPI.

10 The nature of this work is exploratory and computing the Malmquist index was mandated. We do not suggest that there are constant returns to scale in transport industries.

11 Pareto optimality describes a state of affairs in which resources are distributed such that it is not possible to improve a single individual without also causing at least one other individual to become worse off than before the change.

2.3.2.2 The stochastic frontier approach (SFA)

In contrast to the DEA, determining the best-practice production technology in the case of the SFA requires explicit specification of the production function, as demonstrated below:

Let the best-practice frontier be defined by the following production function:

$$y_{it}^{*} = f(x_{it}, t) \qquad \text{(Equation 2.20)}$$

where y_{it}^{*} is the potential output on the frontier at time *t* for business *i*, given the best-practice technology as defined by the production function, and x_{it} is the vector of factor inputs.

Taking logs and differentiating (equation 2.20) with respect to *t*, we get:

$$\hat{y}_{it}^{*} = \frac{d \ln f(x_{it}, t)}{dt} = \frac{\partial \ln f(x_{it}, t)}{\partial t} + \sum_{j} \frac{\partial \ln f(x_{it}, t)}{\partial x_{jt}} \frac{dx_{jt}}{dt} = TC + \sum_{j} \varepsilon_{jt} \frac{dx_{jt}}{dt} \qquad \text{(Equation 2.21)}$$

where the TC is the output elasticity of frontier output with respect to time and $\sum_{j} \varepsilon_{jt} \frac{dx_{jt}}{dt}$ measures the input growth weighted by output elasticities with respect to input *j*.

Recall that MFP growth is defined as the growth of real output not explained by the growth in measured inputs (see discussion on the growth accounting framework and the Tornqvist index). Accordingly, MFP growth can be written as:

$$\textit{MFP Growth} = \hat{y}_{it}^{*} - \sum_{j} \varepsilon_{jt} \frac{dx_{jt}}{dt} \qquad \text{(Equation 2.22)}$$

Combining equations 2.21 and 2.22, we get:

$$\textit{MFP growth} = \hat{y}_{it}^{*} - \sum_{j} \varepsilon_{jt} \frac{dx_{jt}}{dt} = \frac{\partial \ln f(x_{it}, t)}{\partial t} = TC \qquad \text{(Equation 2.23)}$$

This reverts to the familiar Solow framework where MFP is assumed synonymous to TC (see equations 2.1 and 2.6). In the stochastic frontier models, a stochastic element is introduced in the production function. Then any observed output y_{it} using x_{it} for inputs can be expressed as:

$$y_{it} = y_{it}^{*} \exp(-u_{it} + v_{it}) = f(x_{it}, t) \exp(-u_{it} + v_{it}) \qquad \text{(Equation 2.24)}$$

where $(-u_{it} + v_{it})$ is a composed error term combining technical inefficiency u_{it}, and a symmetric component v_{it} capturing random variation across countries and random shocks that are external to the country.

The derivative of the logarithm of equation 2.24 with respect to *t* is given by:

$$\hat{y}_{it} = \frac{d \ln f(x_{it}, t)}{dt} - \frac{du_{it}}{dt} + \frac{dv_{it}}{dt} = TC + \sum_{j} \varepsilon_{jt} \frac{dx_{jt}}{dt} - \frac{du_{it}}{dt} \qquad \text{(Equation 2.25)}$$

Through equation 2.25, MFP growth is shown to combine both TC and EC components. The (in)efficiency effects are distributed as truncated normal random variables, which are also permitted to vary systematically with time. Inefficiency effects are directly influenced by a number of explanatory variables.

Accordingly, the distributional assumptions of the error terms are as follows:

$$v_{it} \sim N[0, \sigma_v^2] \quad \text{(Equation 2.26)}$$

$$\mu_{it} = |U_{it}| \text{ where } U_{it} \sim N[m_{it}, \sigma_\mu^2] \quad \text{(Equation 2.27)}$$

$$m_{it} = z_{it}\delta \quad \text{(Equation 2.28)}$$

where z_{it} is a $(1\times M)$ vector of observable exogenous explanatory variables and δ is an $(M\times 1)$ vector of unknown parameters to be estimated.[12]

The SFA can be applied to compute the Malmquist index. Consider a translog stochastic production frontier defined as follows:

$$\ln y_{it} = \beta_0 + \sum_{n=1}^{N} \beta_n \ln x_{nit} + \frac{1}{2}\sum_{n=1}^{N}\sum_{j=1}^{N} \beta_{nj} \ln x_{nit} \ln x_{nit} + \sum_{n=1}^{N} \beta_{tn} t \ln x_{nit} + \beta_t t + \frac{1}{2}\beta_{tt} t^2 + v_{it} - u_{it},$$

$$i=1,2,\ldots,I,\ t=1,2,\ldots,T, \quad \text{(Equation 2.29)}$$

where:

y_{it} is the output of the i-th business in the t-th year

x_{nit} denotes a n-th input variable

t is a time trend representing TC

the βs are unknown parameters to be estimated

the v_{it}s are random errors, assumed to be i.i.d. and have N(0, σ_v^2)-distribution, independent of the u_{it}s

the u_{it}s are the technical inefficiency effects, with appropriately defined structure.

The above model has the time trend, t, interacting with the input variables. This allows for non-neutral TC. The technical efficiencies of each business in each year can be predicted by obtaining the conditional expectation of exp($-u_{it}$), given the value of $e_{it}=v_{it}-u_{it}$. Since u_{it} is a non-negative random variable, these technical efficiency predictions are between zero and one, with a value of one indicating full technical efficiency.

In this parametric case, we can use measures of technical EC and TC to calculate the Malmquist total factor productivity index via equations 2.30 through 2.32:

$$TE_{it}=E(\exp(-u_{it})|e_{it}), \quad \text{(Equation 2.30)}$$

where $e_{it}=v_{it} - u_{it}$ can be used to calculate the EC component.

That is, by observing that $d_o^t(\mathbf{x}_{it},y_{it})=TE_{it}$ and $d_o^s(\mathbf{x}_{is},y_{is})=TE_{is}$, we calculate the EC index as:

$$EC = TE_{it}/TE_{is}. \quad \text{(Equation 2.31)}$$

12 Wang and Schmidt (2002) show that when the objective of the estimation is to determine the effect of exogenous factors on firms'/countries' efficiency levels, the joint estimation of the parameters of the frontier model and inefficiency effects model suffers from considerably lower bias than that of a two-step approach, in which efficiency scores are first obtained and then an estimate of δ is obtained in a second step regression on z.

The TC index between period *s* and *t* for the *i*-th firm can be calculated directly from the estimated parameters. We first evaluate the partial derivatives of the production function with respect to time, using the data for the *i*-th firm in periods *t-1* and *t*. Then the TC index between the adjacent periods *t-1* and *t* is calculated as the geometric mean of these two partial derivatives. When a translog function is involved, this is equivalent to the exponential of the arithmetic mean of the log derivatives. That is:

$$TC = \exp\left\{\frac{1}{2}\left[\frac{\partial \ln y_{it-1}}{\partial t-1}+\frac{\partial \ln y_{it}}{\partial t}\right]\right\}. \qquad \text{(Equation 2.32)}$$

The indices of technical EC and TC obtained using equations 2.31 and 2.32 can then be multiplied together to obtain an MPI.

Data sources for estimating productivity using the Malmquist index are documented in chapter 3.

2.4 Input–output (IO) tables-based approach

Three important MFP measures are derived through the IO tables-based approach:

1 *OECD[13] gross-output-based measure (OECD 2001):*

$$MFP_{industry\ j}(go) = \frac{go_j(qty\ index)}{ic_j(qty\ index)^{w_j^{ic/go}(avg)} * va_j(qty\ index)^{w_j^{va/go}(avg)}} \qquad \text{(Equation 2.33)}$$

where *GO* is gross output, *VA* is value added, *IC* is intermediate consumption, w^{ic} and w^{va} denotes the weights for intermediate consumption and VA respectively, and *j* denotes industry.

2 *OECD value-added-based measure (OECD 2001):*

Using a value-added measure to compute productivity, the formulae can be expressed as:

$$MFP_{industry\ j}(va) = \frac{va_j(qty\ index)}{l_j(qty\ index)^{w_j^{l}(avg)} * k_j(qty\ index)^{w_j^{k}(avg)}} \qquad \text{(Equation 2.34)}$$

where *'l'* denotes labour and '*k'* denotes capital.

3 *Miller and Blair's gross-output-based measure (Miller and Blair 2009):*

This approach utilises a definition of productivity measure as shown in equation 2.35, to separately identify the relative contributions of various input factors.

$$MFP_{industry\ j} = -(da_{ij} + dv_j) \qquad \text{(Equation 2.35)}$$

where *da* = the difference between technical coefficients in the IO table between year 1 and year 0 and *dv* = the difference between value-added coefficients in the IO table between year 1 and year 0.

There are three limitations of using IO tables to derive productivity indicators. First, IO tables are not produced or updated frequently. For example, in New Zealand the last two IO tables related to the years 2006–07 and 1995–96. These are not adequate to develop indices for a number of consecutive years and for a long period of time. Second, the transport industries are aggregated with different categories in different IO tables, which makes comparison difficult. Third, the level of industry detail in published IO tables does not provide the desired level of detail for transport services. For these reasons, it was necessary to construct annual IO tables for this research project. The MoT has constructed these tables, which are confidentialised.

13 Organisation for Economic Cooperation and Development.

The steps applied to computing productivity using IO tables are presented next.

2.4.1 Gross-output-based approach, following OECD (2001)

Step 1: Quantity index for GO	$go_j(qty\ index) = \frac{go_j(movt)}{p_j^{go}(movt)}$ $go_j(movt) = \frac{GO_j(1)}{GO_j(0)} \quad p_j^{go}(movt) = \frac{p_j^{go}(1)}{p_j^{go}(0)}$

Step 2: Quantity index for intermediate inputs	$ic_j(qty\ index) = \frac{ic_j(movt)}{p^{ic}_{supplying\ ind}(movt)}$ $p^{ic}_{supplying\ ind}(movt) = \sum_{i=1}^{n-1} w_i^{ic}\ p_i^{ic}(movt)$ $w_i^{ic} = \frac{IC_i}{\sum_{i=1}^{n-1} IC_i} \quad \sum_{i=1}^{n-1} w_i^{ic}$

Step 3: Quantity indices for primary inputs (labour & capital)	$l_j(qty\ index) = \frac{l_j(movt)}{p_j^{l}(movt)} \quad k_j(qty\ index) = \frac{k_j(movt)}{p_j^{k}(movt)}$

Step 4: Quantity index for VA (total primary inputs)	$va_j(qty\ index) = l_j\ (qty\ index)^{w_j^l(avg)} * k_j\ (qty\ index)^{w_j^k(avg)}$ $w_j^l(avg) = \frac{w_j^l(0)+w_j^l(1)}{2} \quad w_j^l = \frac{L_j}{VA_j}$ $w_j^k(avg) = \frac{W_j^k(0)+W_j^k(1)}{2} \quad w_j^k = \frac{K_j}{VA_j}$

Step 5: MFP for individual industries	$MFP_j(go) = \frac{go_j(qty\ index)}{ic_j(qty\ index)^{W_j^{ic/go}(avg)} * va_j(qty\ index)^{W_j^{va/go}(avg)}}$ $w_j^{ic/go}(avg) = \frac{w_j^{ic/go}(0)+w_j^{ic/go}(1)}{2} \quad w_j^{ic/go} = \frac{IC_j}{GO_j}$ $w_j^{va/go}(avg) = \frac{w_j^{va/go}(0)+w_j^{va/go}(1)}{2} \quad w_j^{va/go} = \frac{va_j}{GO_j}$

2.4.2 Value-added-based approach, following OECD (2001)

Step 1: Price index for VA (Tornqvist price index for VA)	$p_j^{va}(movt) = go_j(movt)^{\frac{1}{va_j(share)}} - ic_j(movt)^{ic_j(share)}$ $va_j(share) = \frac{VA_j(tot)}{GO_j(tot)}$ $ic_j(share) = \frac{IC_j(tot)}{VA_j(tot)}$ $VA_j(tot) = VA_j(0) + VA_j(1)$ $GO_j(tot) = GO_j(0) + GO_i(1)$ $IC_j(tot) = IC_j(0) + IC_j(1)$
Step 2: Quantity index for VA	$va_j(qty\ index) = \frac{va_j(movt)}{p_j^{va}(movt)}$
Step 3: Quantity indices for primary inputs (labour & capital)	$l_j(qty\ index) = \frac{l_j(movt)}{p_j^{l}(movt)}$ $k_j(qty\ index) = \frac{k_j(movt)}{p_j^{k}(movt)}$
Step 4: Primary input weights	$w_j^l(avg) = \frac{w_j^l(0)+w_j^l(1)}{2}$ $w_j^l = \frac{L_j}{VA_j}$ $w_j^k(avg) = \frac{W_j^k(0)+W_j^k(1)}{2}$ $w_j^k = \frac{K_j}{VA_j}$
Step 5: MFP for individual industries	$MFP_j(va) = \frac{va_j(qty\ index)}{l_j(qty\ index)^{w_j^l(avg)} * k_j(qty\ index)^{w_j^k(avg)}}$

2.5 Summary of the approaches

This chapter has discussed four approaches to computing productivity:

- growth accounting framework
- Tornqvist index formula
- Malmquist index formula, through DEA or the (SFA)
- IO approach.

Table 2.1 Summary of the properties of the approaches used to compute productivity

Attribute	Growth accounting	Tornqvist	Malmquist DEA	Malmquist SFA	IO
Parametric method	No	No	No	Yes	No
Accounts for noise	No	No	No	Yes	No
Can be used to measure:					
· technical efficiency	No	No	Yes	Yes	No
· TC	Yes	Yes	Yes	Yes	Yes
· MFP change	Yes	Yes	Yes	Yes	Yes

Attribute	Growth accounting	Tornqvist	Malmquist DEA	Malmquist SFA	IO
Basic method requires data on:					
· input quantities	Yes	Yes	Yes	Yes	Yes
· output quantities	Yes	Yes	Yes	Yes	Yes
· input prices	Yes	Yes	No	No	Yes
· output prices	Yes	Yes	No	No	Yes

It can be seen that columns 2 (growth accounting), 3 (Tornqvist) and 6 (IO approach) are similar. This is not surprising, as all three represent the Tornqvist index. Nonetheless, the productivity indicators that were derived from these approaches were different because annually shifting input weights are used in the Tornqvist index, while the growth accounting uses a fixed labour share. The IO results were different from the Tornqvist because the data applied was different. [14]

The most appropriate method to use will depend on user requirements and the availability of data. The growth accounting framework is possibly the best-known approach to calculating productivity. The key advantage of the growth accounting model is that it is possible to identify the role of factor inputs in explaining output growth. The method, however, requires data on factor weights, which are difficult to compute even at the aggregated level. Suitable data to compute factor weights does not exist at higher levels of industry disaggregation. Moreover, in the New Zealand transport sector, a significant number of firms are operated by a working proprietor without paid employees – the labour and capital weights cannot be accurately estimated in these cases.

The Tornqvist index could be used when a standardised measure that is consistent with the approach taken by SNZ is needed. The Tornqvist index (or the index number approach, more generally) confers several advantages: only two observations are needed; it is easy to calculate; and the approach does not assume a smooth pattern of technical progress. But the principal disadvantage of the Tornqvist index is that the approach requires both price and quantity information. Accurate price information, in particular, is difficult to obtain. Another disadvantage with conventional index numbers such as Tornqvist is the implicit assumption of full efficiency.

If there is a desire to decompose productivity into its sources of TC or efficiency, or if the intention is to determine firm-level drivers of productivity, then the Malmquist index approach is better as it allows a relaxation of the assumption of full efficiency. Some of the advantages of the Malmquist index over the Tornqvist index numbers approach are that it does not require price information; does not assume all firms are fully efficient; does not require the assumption of cost minimisation and revenue maximisation; and permits total factor productivity to be decomposed into TC and technical EC. But the principal disadvantage is that the approach needs a number of firms to be observed in each time period so that the frontier technology in each year can be calculated. Without a cross section of firms, this method cannot be applied. Its usefulness in the IDI-type data environment is clear, but it is of very little use if the data in hand is aggregated at the industry level.

The DEA or the SFA approach can be applied when developing the Malmquist index. Some of the advantages of SFA over DEA are that it accounts for noise and can be used to conduct conventional tests of hypotheses. But the SFA also has some disadvantages relative to DEA. These include the need to specify

14 For example, in the IO approach we used operating surplus to model capital input. In the other approaches we derived a value for capital services using capital stock data. Neither approach was perfect. This could be one reason for the discrepancy in the results.

a distributional form for the inefficiency term and a functional form for the production function. In our view, neither of these disadvantages overrides SFA's ability to account for noise.

The IO approach is useful when it is important to consider the interdependency of the industry being evaluated with other industries (eg between transport service providers and transport-service-using industries). One disadvantage of the IO approach is that it is suited only for measuring productivity at the aggregate level; it is not feasible to generate productivity numbers for individual businesses and aggregate upwards using this approach. The second disadvantage is that there is a reliance on IO tables. Authentic IO tables for New Zealand can be developed only by SNZ, and this work is undertaken only infrequently.

This research project was intended as an exploratory exercise. While we investigated all of the methods discussed in this chapter, we have not made specific recommendations on which method is more suitable for measuring the productivity of the transport sector. This is identified as an area for future investigation

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3 Data

This chapter discusses the data sources used in computing the productivity indicators.

3.1 The transport sector industries

A full breakdown of the ANZSIC 2006 Transport, Postal and Warehousing division is shown in table 3.1.

Table 3.1 ANZSIC 2006, Division I, Transport, Postal and Warehousing (Source: SNZ)

Division	Subdivision	Group (3 digit)	Class (4 digit)
Division I – Transport, Postal and Warehousing	46 – Road transport	461 – Road freight transport	
		462 – Road passenger transport	4621 – Interurban and rural bus transport 4622 – Urban bus transport (incl. tramway) 4623 – Taxi and other road transport
	47 – Rail transport	471 – Rail freight transport	
		472 – Rail passenger transport	
	48 – Water transport	481 – Water freight transport	
		482 – Water passenger transport	
	49 – Air and space transport	490 – Air and space transport	
	50 – Other transport	501 – Scenic and sightseeing transport	
		502 – Pipeline and other transport	5021 – Pipeline transport 5029 – Other transport n.e.c.[a]
	51 – Postal and courier pick-up and delivery services		5101 – Postal services 5102 – Courier pick-up and delivery services
	52 – Transport support services	521 – Water transport support services	5211 – Stevedoring services 5212 – Port and water transport terminal operations 5219 – Other water transport support services
		522 – Airport operations and other air transport support services	
		529 – Other transport support services	5291 – Customs Agency services 5292 – Freight-forwarding services 5299 – Other transport support services n.e.c.
	53 – Warehousing and storage services		5301 – Grain storage services 5309 – Other warehousing and storage services

a) n.e.c. = not elsewhere classified.

3.1.1 Road freight industry

The road freight industry is made up of businesses transporting freight by road. It also includes businesses that rent trucks with drivers for road freight transport and road vehicle towing services. Primary activities include: furniture removal; log haulage (road); road freight transport; road vehicle towing; taxi truck (with driver); and truck hire (with driver). The road freight industry does not include the operation of road freight terminals, freight-forwarding services, providing crating or packing for road freight transport, and leasing or hiring trucks without drivers. In this study's sample, the road freight industry accounted for approximately 21%, on average, of the transport sector GDP between 2000 and 2010.

3.1.2 Road passenger industry

The road passenger industry consists of three areas: interurban and rural bus transport; urban bus transport (including tramway); and taxi and other road transport. Interurban and rural bus transport businesses operate buses that transport passengers over regular routes and on regular schedules, mainly outside metropolitan areas or over long distances. Urban bus transport (including tramway) businesses operate urban buses and tramways that transport passengers over regular routes and on regular schedules, mainly in a metropolitan area. Taxi and other road transport businesses operate taxicabs or hire cars with drivers, or other forms of road vehicles not elsewhere classified, for the transportation of passengers. Primary activities include: bus transport and charter bus services; bus services; airport bus services; school bus services; tramway passenger transport services; hire car service (with driver); road passenger transport not elsewhere classified; taxicab management services (ie operations on behalf of the owner); and taxi services.

The road passenger industry does not include: the operation of bus passenger terminals; the operation of sightseeing/tour bus, coaches or tramways in urban areas; the provision of driving services for taxis or hire cars; the operation of taxi trucks with drivers; the leasing of taxicab plates (not vehicles); the leasing, hiring or renting of motor vehicles without drivers; operating a taxi radio base; or operating sightseeing transport equipment. In this study's sample, the road passenger industry accounted for approximately 5.6%, on average, of the transport sector GDP between 2000 and 2010.

3.1.3 Water freight industry

Water freight industry businesses operate vessels that transport freight or cargo by water. Primary activities in the water freight industry include: coastal sea freight transport services between domestic ports; freight ferry services; harbour freight transport services; international sea freight transport services between domestic and international ports; river freight transport services; ship freight management services (ie the operation of ships on behalf of owners); and water (river, sea and lake) freight transport services. The water freight industry does not include businesses engaged in: repairing, refitting or converting ships; operating water freight terminals providing ship or shipping agency services; providing sea freight-forwarding services; leasing, hiring or chartering ships without crew; or operating tugboats or towing vessels. In this study's sample, the water freight industry accounted for a little over 1% of the transport sector GDP between 2000 and 2010.

3.1.4 Water passenger services industry

Businesses in the water passenger services industry operate vessels that transport passengers by water. Primary activities include: boat charter, lease or rental, with crew for passenger transport; ferry operation, including vehicular and passenger services; passenger ship management services (ie operation of ships on behalf of owners); ship charter, lease or rental, with crew, for passenger transport; water passenger transport services; and water taxi services. The water passenger services industry does not include:

businesses that are mainly engaged in repairing, refitting or converting ships; operating water passenger terminals; operating tugboats or towing vessels; leasing, hiring or chartering ships without crew; or operating charter fishing boats and whale-watching cruises. The water passenger services industry's share in the transport sector GDP is confidentialised .

3.1.5 Water transport services industry

The water transport services industry is made up of three classes: stevedoring services; port and water transport terminal operations; and other water transport support services. Businesses providing stevedoring services load or unload vessels. Port and water transport terminal operations businesses maintain and lease port facilities to facilitate the land–sea transition of goods and passengers. The industry also includes businesses that operate ship-mooring facilities or water transport terminals for passenger or freight (including sea cargo container terminals and coal or grain loaders). Businesses in other water transport support services provide water transport support services not elsewhere classified. Primary activities include: ship-loading or -unloading services (provision of labour); stevedoring services; coal and grain loader and container terminal operations; port operation; ship-mooring services; water freight and passenger terminal operations; wharf operations; lighterage, navigation, pilotage and salvage services; ship registration and agency services; towboat and tugboat operations; and water vessel towing services. The water transport services industry does not include the construction or planning of port facilities, or the repair of ships and boats (including factory overhauls or factory conversions). In this study's sample, the water transport services industry accounted for a little over 2% of the transport sector GDP between 2000 and 2010.

3.1.6 Air transport industry

Businesses in the air transport industry operate aircraft for the transportation of freight and passengers. Primary activities include: air freight and passenger transport services; and aircraft charters, leases or rentals, with crew, for freight and/or passengers. The air transport industry does not include: businesses engaged in providing aerial surveying services; repairing aircraft; operating ticket sales or booking offices of non-resident airlines; domestic and international air freight forwarding; and transport of passengers by aircraft solely for sightseeing purposes. The air transport industry's share in the transport sector GDP is confidentialised.

3.1.7 Air support services industry

The air support services industry is made up of businesses that operate international, national or civil airports. Also included are businesses that provide other services to air transport such as airport terminals, runways, air traffic control services, aerospace navigation or baggage-handling services. Primary activities in the air support services industry include: air traffic control and air transport navigation services; aircraft support services not elsewhere classified; airport baggage-handling services; and airport terminal operations. The air support services industry does not include: businesses involved in repairing aircraft; leasing or chartering aircraft without crew from own stocks; operating ticket sales offices of non-resident airlines; providing airline food-catering services; or wholesaling fuel at airports. In this study's sample, the air support services industry accounted for a little over 11.4% of the transport sector GDP between 2000 and 2010.

3.1.8 Pipeline transport industry

The pipeline transport industry is made up of businesses that transport natural gas, oil or other materials via pipelines. Primary activities include pipeline operations for the transport of gas, oil and other materials. The pipeline transport industry does not include: businesses involved in piping sewage through sewer systems; constructing, repairing or maintaining gas mains; or water reticulation by mains. In this study's sample, the pipeline transport industry accounted for less than 1% of the transport sector GDP between 2000 and 2010.

3.1.9 Scenic transport industry

Businesses in the scenic transport industry operate transportation equipment for scenic and sightseeing activities. This form of transport is distinguished from transit passenger services, as the emphasis is not on the efficiency or speed of the transport service but rather on providing recreation and entertainment. Primary activities include: aerial cable car operations; airboat operations; chairlift operations (except ski chairlift operations); charter fishing boat operations; glider operations; harbour sightseeing tour operations; helicopter ride operations (for sightseeing); hot air balloon-ride operations; hovercraft operations; scenic railway operations; sightseeing bus, coach or tramway operations; steam train operations; and whale-watching cruise operations. The scenic transport industry does not include: businesses that provide recreational activities involving direct participation by the customer, such as bungy jumping, cave diving and white water rafting; or businesses operating ski chairlifts. In this study's sample, the scenic transport industry accounted for about 1.4% of the transport sector GDP between 2000 and 2010.

3.1.10 Other transport services

The other transport services industry is made up of three classes: customs agency services; freight-forwarding services; and other transport support services not elsewhere classified. In customs agency services, businesses provide advice on import and export procedures and documentation, and other related services. Businesses in freight-forwarding services contract the transportation of goods for other enterprises, using one or more different enterprises to perform the contracted services by road, rail, air, sea freight transport or any combination of the modes of transport (in these cases the 'forwarding' unit takes prime responsibility for the entire transport operation). Primary activities include: customs agency and clearance services; export and import documentation preparation services; container terminal operations (road and rail); freight brokerage services; road freight and/or passenger terminal operations; road vehicle-driving services (except owner/operator); railway station or terminal operations; taxi radio-base operations; and toll bridge/road or weighbridge operations. The other transport services industry does not include: businesses engaged in providing surveillance and control of the borders of the country; hiring or leasing pallets (from own stocks); or owning/operating taxis or hire cars. In this study's sample, the other transport services industry accounted for about 6% of the transport sector GDP between 2000 and 2010.

3.1.11 Postal and courier services

The postal and courier services industry is made up of postal services and courier pick-up and delivery services. Businesses in the postal services sector pick up and deliver letters, documents and parcels (usually weighing less than 30kgs). Rather than being from the sender's location, the pick-up activity is from predetermined collection points (eg post offices and postal agencies). The industry also includes businesses that operate/provide predetermined collection points (such as post offices or postal agents). Courier pick-up and delivery services businesses do door-to-door pick up (ie from the customer's residence or place of business), transport and delivery of letters, documents, parcels and other items weighing less than 30kgs.

Primary activities include: mail services and mailbox rental services; post office operations and postal agency operations; customised express pick-up and delivery services; grocery delivery services; home delivery services; messenger services; and pick-up and delivery services not elsewhere classified. The postal and courier services industry does not include: businesses that are mainly engaged in providing courier or messenger services; or operating trucks for the transportation of freight by road. In this study's sample, the postal and courier services industry accounted for about 15.5% of the transport sector GDP between 2000 and 2010.

3.1.12 Warehousing and storage industry

The warehousing and storage services industry consists of two service groups: grain storage services; and other warehousing and storage services. These are relatively self-descriptive groups. Businesses in the grain storage services group store cereal grains. Businesses in other warehousing and storage services operate warehousing and storage facilities (except cereal grain storage). Primary activities include: grain elevator and silo operations; grain storage services; bond store operations; bulk petroleum and cool-room storage services; controlled-atmosphere store operations; free-store operations (storage of goods not under bond); furniture storage services; refrigerated storage services; storage not elsewhere classified; warehousing not elsewhere classified; and wool storage service. The warehousing and storage services industry does not include: businesses that are mainly engaged in operating grain-loading facilities at water transport terminals; or self-storage renting or leasing. In this study's sample, the warehousing and storage services industry accounted for about 3.3% of the transport sector GDP between 2000 and 2010.

3.2 Sources of data for growth accounting and index number approaches

3.2.1 Integrated Data Infrastructure (IDI)

The source of data for the productivity indicators we developed using growth accounting, the Tornqvist index and the Malmquist index was the Longitudinal Business Database (LBD). The LBD is part of SNZ's Integrated Data Infrastructure (IDI) and contains data collected by SNZ for the national accounts (the Annual Enterprise Survey [AES], and Goods and Services Tax [GST] returns, Financial Accounts [IR10] and aggregated Pay-As-You-Earn [PAYE] returns, all provided by the Inland Revenue Department [IRD]).

3.2.1.1 Enterprise, the unit of analysis

The main unit of analysis in the LBD is the enterprise, which approximates to the economic concept of the firm. The enterprise represents a legal business entity, such as a limited company, a partnership, a trust, or an incorporated society. Where there is a group of limited companies linked by share ownership, each individual limited company is recorded in the statistics as a separate enterprise. A firm can be defined as an economic entity that transforms inputs (labour and intermediate inputs, and possibly capital) into outputs. For enterprises to be part of the population of firms, they are required to have reported some kind of labour input (either employment or working proprietor(s)), intermediate consumption or purchases, and have some kind of sales revenue.

3.2.1.2 False births and deaths

It is difficult to conduct longitudinal research where enterprises relate to legal entities. This is because an enterprise may change its identifier, creating a false death and birth. Fabling (2011) provides the following example:

> *a sole proprietor may decide to incorporate their business, while continuing to employ the same staff in the same location, producing the same goods and services. This business may be represented in the LBD as two firms – one exiting, one entering – where an economist would say there is one on-going firm* (p1).

Consequently, in this study we utilised the method developed by Fabling (2011), using repaired plant identifiers to repair broken firm links across years, thus avoiding the problem of false deaths and births.

3.2.1.3 Longitudinal business frame (LBF)

The 'spine' of the LBD is the longitudinal business frame (LBF), which contains data from two main sources: SNZ's Business Frame (BF) and payroll tax records drawn from New Zealand's taxation system. Of these, the BF is the predominant source, as it covers all businesses that are registered with IRD and meet the criteria for economic significance. This means that employing businesses on the LBF that are economically significant exist in both data sources. The unreported economy is outside the scope of the LBF. A business is included in the BF (ie considered economically significant) if it meets at least one of the following conditions:

- the business has an annual GST turnover greater than $30,000
- the business has paid employees
- the business is part of an enterprise group
- the business is part of a GST group
- the business has more than $40,000 income reported on tax form IR10
- the business has a positive annual GST turnover and has a geographic unit classified to agriculture or forestry.

Businesses on the BF are structured according to a three-level statistical model comprising the enterprise unit, the kind-of-activity unit, and the geographic unit (business location), in accordance with the International Standard Industrial Classification of all Economic Activities.[15] The LBF focuses mainly on geographic units, but also records information about the enterprises that the geographic units belong to, as well as the group top enterprise, if there is one.

One of the weaknesses of the LBF is that it has limited information on industry for enterprises that are found only in the payroll data. Because of this, small enterprises found in the BF and not in the payroll data may have industry codes that are only updated once every three years from a questionnaire, if at all. This suggests that our analysis will under-report small firms that shift industries.

3.2.1.4 Annual Enterprise Survey (AES)

The AES is SNZ's primary data source for the production of national accounts, providing the benchmark for estimating VA. The survey covers all large firms, with a stratified sample for smaller firms, and has industry-specific questions in order to accurately measure aggregated GDP.

3.2.1.5 Linked Employer-Employee Data (LEED)

LEED is constructed by SNZ from IRD PAYE returns for employees. LEED variables are aggregated to the firm's level for confidentiality reasons. It is generally assumed by researchers that missing employment data implies zero employees, on the grounds that personal income tax non-compliance is negligible in the population of firms that comply with mandatory GST. Variables available include counts of employers (on

15 http://unstats.un.org/unsd/publication/seriesM/seriesm_4rev4e.pdf

an annual firm-level basis) and employees (on a monthly plant-level basis). Notably, LEED measures the number of filled jobs, not the number of people employed. This means that a person with multiple jobs is counted multiple times. However, at this point it is not feasible to distinguish between full-time and part-time employees, which could potentially bias the results.

- *Employees:* Employment is measured using an average of 12 monthly PAYE employee counts in the year, taken as at the 15th of the month. This figure excludes working proprietors and is known as Rolling Mean Employment.
- *Working proprietors*: The working proprietor count is the number of self-employed persons who were paid taxable income during the tax year (at any time). In LEED, a working proprietor is assumed to be a person who (i) operates his or her own economic enterprise or engages independently in a profession or trade, and (ii) receives income from self-employment from which tax is deducted. From tax data, there are five ways that people can earn self-employment income from a firm:
  - as a sole trader working for themselves, using the IR3 individual income tax form (this is used for individuals who earn income that is not taxed at source)
  - by being paid withholding payments either by a firm they own, or as an independent contractor (identified through the IR348 employer monthly schedule)
  - by being paid a PAYE tax-deducted salary by a firm they own (IR348)
  - by being paid a partnership income by a partnership they own (IR20 annual partnership tax form, which reports the distribution of income earned by partnerships to their partners, or the IR7 partnership income tax return)
  - by being paid a shareholder-salary by a company they own (IR4S annual company tax return, which reports the distribution of income from companies to shareholders for work performed, known as shareholder-salaries).

  Note that it is impossible to determine whether the self-employment income involves labour input. For example, shareholder-salaries can be paid to owner-shareholders who are not actively involved in running the business. Thus there is no way of telling what labour input was supplied, although the income figures do provide some relevant information (a very small payment is unlikely to reflect a full-year, full-time labour input).

3.2.1.6 IR10

IR10s are essentially a set of company accounts composed of profit-and-loss statements and a balance sheet. They include information on sales (and other income) and purchases, as well as detailed breakdowns of expenditure including depreciation, research and development (R&D) costs, and salaries and wages. Balance sheet items include fixed assets (vehicle; plant and machinery; furniture and fittings; land and buildings; and other), liabilities (current and term) and shareholders’ funds.

3.2.2 Construction of variables using IDI data

The variables required for computing the productivity indicators are: gross output (GO), value added (VA), intermediate inputs or intermediate consumption (IC), capital stock (KAP) and labour (LAB). In this study we had multiple sources for some of these variables.

- *GO* is measured as the value of sales of goods and services, less the value of purchases of goods for resale, with an adjustment for changes in the value of stocks of finished goods and goods for resale.

- *IC* is measured as the value of other inputs used in the production process, with an adjustment for changes in stocks of raw materials.
- *VA* is defined, conceptually, as GO-IC.

The primary source used to obtain GO, IC and VA was the AES. However, the AES is not a census and is disproportionately populated by larger firms. Where AES information was not available, we derived comparable measures from IR10s. The data was extracted in current prices and converted to volume measures using SNZ's industry-level producers' price index input (for IC) and output indices (for GO and VA) at the corresponding two-digit ANZSIC 2006 sectors.

- The *LAB* variable is operationalised by total employment and comes from LEED and comprises the count of employees in all of the enterprise's plants, annualised from employee counts as at the 15th of each month, plus working proprietor input, as reported in tax returns.
- *KAP* has four components: depreciation; rental and leasing costs; rates; and the user cost of capital. The inclusion of rental and leasing costs and rates ensures consistent treatment of owned and rented or leased capital. Rental leasing and rates costs are reported separately on the IR10 form but not in AES. We expressed IR10 rental, leasing and rates costs as a ratio to a subset of expenses that were measured consistently across the two data sets. We then imputed AES rental and leasing as the predictions from a group logit of that ratio as a function of depreciation costs and asset values (separately for vehicles, plant and machinery, furniture and fittings, and land and buildings). The user cost of capital was calculated as the value of total assets, multiplied by an interest rate equal to the average 90-day bill rate plus a constant risk-adjustment factor of four percentage points. The capital goods price index was used to convert KAP into volume terms.

The construction of variables we used closely follows the works of researchers such as Devine et al (2011) Doan et al (2013) and Fabling and Maré (2011).

3.3 Sources of data for the input–output (IO) table-based approaches

The datasets required to compute productivity indicators using the IO approach are:

- IO tables with the desired levels of disaggregation
- labour and capital incomes
- intermediate inputs
- relevant price indices.

IO tables: To help with this study, the MoT constructed annual IO tables for the years 1996–2010. Two different industry sub-groupings were used in the series: ANZSIC 1996 for the period 1996–2007 and ANZSIC 2006 for the period 2007–2010. However, the productivity indicators computed under two classifications could not be combined in a meaningful manner. This means that one long time series of the IO-based productivity indicator could not be computed. Further details on the IO tables are available from the MoT.

Labour and capital income: Compensations of employees in the MoT IO tables were taken as labour income. The remaining part of the value-added factor, which is essentially the operating surplus, was taken as the capital income. As described in OECD (2001), taxes (net of subsidies) and imports were assigned proportionately between labour income and capital income. Although OECD recommends an adjustment to allow for gross mixed income earned by households, it was not possible to make any adjustment in that regard due to the lack of available data.

Intermediate inputs: Intermediate inputs or intermediate consumption (IC) are goods and services produced within the industry, or by other industries, to be used as inputs in the production process. Intermediate inputs consist of the value of goods and services consumed as inputs by a process of production. For this study, intermediate inputs for each industry were sourced from IO tables.

Price indices: Output and input price indices at a level of disaggregation that aligns with the IO tables were provided by SNZ.

4 Summary statistics

The summary statistics are presented in two parts:

- aggregate transport sector-related statistics
- sub-industry statistics.

The reported summary statistics represent the sample used in the analysis and are not official data on the transport sector or its constituent industries. The sample we used would not pick up all the firms in the sector, for several reasons:

- Our applied methods to compute productivity required positive values on outputs and inputs.
- Firms that did not meet this condition could not be analysed.
- Zero-employment firms could not be included in the sample.

The analysis was sensitive to outliers, so the top and bottom 5% of the firms (in terms of labour productivity were extracted). It is standard to remove outlier value in productivity analysis using IDI data. The data is in constant 2011 dollars.

4.1 Summary statistics: transport sector aggregates

The analysis covered approximately 4000 firms per year, ranging from to 3800 firms in 2008 to 4180 firms in 2010 (see table 4.1). This means about 40–50% of the firms that are affiliated to ANZSIC 2006 'I' Transport, Postal and Warehousing division were included in the sample – a reasonable capture, given the filters applied (especially relating to zero employment). In terms of contribution to GDP, the sample picked up, depending on the year, between 4 and 5.5 billion dollars of the transport sector VA. On average, this translated to 69% of the VA for Division I firms in the LBF. Around 55,000 employees and working proprietors were included in the labour count of the sample.

Table 4.2 presents the averages from this analysis. We found that an average transport sector firm was larger than an average firm in New Zealand (an employee count of 15 is large by New Zealand standards). We found the average number of employees per enterprise in New Zealand was just over four. However, when non-employing (zero-employee enterprises) were removed, the average number of employees per enterprise was substantially higher, at almost 13 (Ministry of Economic Development 2011).

Towards the end of the sample period, average sales were in excess of $3 million and average VA was in excess of $1.3 million. The averages were high, as several small operators were excluded from the sample because of the filters applied. Moreover, the transport sector has some very large operators who can push the mean substantially higher, resulting in a significant difference between the mean and the median. This argument was substantiated by the quartile values in table 4.3. At the 50th percentile (median) in the year 2010, the VA was $130,000 and the GO was $2,356,000, significantly lower than the reported averages in table 4.2. In fact, the 75th percentile (third quartile) values were also lower than the mean. This means that the analysis was heavily influenced by the large players.

As mentioned earlier, we filtered the top 5% of the firms in terms of labour productivity, but even this was not sufficient to remove the large skew in the sample. To some extent, this was because we were careful not to filter players in the air transport and air transport service industries, because a high productivity is normal in these industries.

Table 4.1 Summary statistics – transport sector aggregates (totals)

Year	Firms	GO $	IC $	VA $	LAB	KAP $
2000	4164	11,607,959,552	8,391,085,568	4,330,781,184	54,100	1,257,537,536
2001	4332	12,448,333,824	9,157,584,896	4,119,647,488	55,800	1,390,759,680
2002	4140	12,047,936,512	8,909,123,584	4,250,749,440	54,500	1,385,258,880
2003	4212	12,613,708,800	8,448,167,936	5,220,317,184	57,600	1,690,690,304
2004	4119	12,627,814,400	8,252,299,264	5,563,212,288	57,900	1,643,929,600
2005	4119	12,437,872,640	7,812,548,608	5,516,101,632	59,400	1,690,247,296
2006	4068	12,110,978,048	7,130,756,096	5,249,551,360	59,300	1,877,705,600
2007	4026	12,543,034,368	8,002,185,728	4,960,907,776	55,700	1,983,822,976
2008	3801	13,352,673,280	7,808,434,176	5,533,281,280	57,800	2,143,561,472
2009	4068	12,850,365,440	8,510,529,024	4,623,760,384	59,300	1,942,127,104
2010	4182	12,081,367,040	7,202,224,640	5,052,276,224	56,700	1,633,355,520

Note: All dollar values expressed in 2011 prices.

Table 4.2 Summary statistics – transport sector aggregates (averages)

Year	Average GO $	Average IC $	Average VA $	Average LAB	Average KAP $
2000	2,787,695	2,015,150	1,040,053	12	302,002
2001	2,872,251	2,112,964	950,542	12	320,895
2002	2,910,130	2,151,962	1,026,751	12	334,604
2003	2,993,997	2,005,262	1,239,097	15	401,303
2004	3,064,260	2,002,499	1,349,967	12	398,915
2005	3,019,634	1,896,710	1,339,185	12	410,354
2006	2,977,133	1,752,890	1,290,450	15	461,580
2007	3,082,584	1,966,622	1,219,196	12	487,546
2008	3,194,420	1,868,047	1,323,752	15	512,814
2009	3,192,637	2,114,417	1,148,760	15	482,516
2010	3,178,471	1,894,824	1,329,197	15	429,717

Note: All dollar values expressed in 2011 prices.

Table 4.3 Summary statistics – transport sector aggregates (quartiles)

Variable	Percentile	Quartiles 2000	Quartiles 2005	Quartiles 2010
GO	25	95,153	108,676	110,518
	50	185,234	220,704	235,956
	75	463,627	589,609	637,272
IC	25	36,833	38,916	36,992
	50	87,064	94,042	91,529
	75	265,160	305,939	302,534
VA	25	53,598	63,706	65,060
	50	99,902	124,095	130,972
	75	225,252	288,381	320,744
KAP	25	10,720	11,757	10,764
	50	24,978	28,652	27,354
	75	66,334	84,536	82,415

Note: All dollar values expressed in 2011 prices.

4.2 Summary statistics: transport sub-industries

4.2.1 Road transport group

Of the industries in the transport sector, the road freight industry appears to be the largest. As seen in table 4.4, our sample of firms in the road freight industry employed between 12,400 and 15,300 people, depending on the year, and the general trend of employment was on the rise. Among the sub-industries for which data could be released, the road freight industry accounted for the largest share of output and inputs. For instance, in the year 2009, the VA of the sample firms was in excess of $1.17 billion and sales were to the tune of $ 2.5 billion. In general, as with employment, the GO and VA were also trending upwards. There was a reasonably large number of firms in this industry and our sample covered between 1785 and 2025 firms. There was a general decline in the number of businesses over the period, suggesting some sort of consolidation in the industry.

The average output and input data for the road freight industry is presented in table 4.5. We found that in terms of employment, an average firm in the road freight industry was a little smaller than an average firm in the transport sector. An average firm in the road freight industry employed between six and nine people (depending on the year) and this trend was increasing. The average firm in the road freight industry recorded sales valued at $1.3 million and the VA of the average firm was less than half of sales, at $639,000.

The road passenger industry employed between 5900 and 8300 employees in the sample period. Again, the trend of employment was increasing. The sales and VA of the road passenger industry in 2010 was about $6.5 million and $3.4 million respectively. The number of road passenger industry firms in our sample declined from 687 to 531, again suggesting consolidation in the industry. On average, a firm in the road passenger industry employed between 9 and 15 people. An average firm in the road passenger industry recorded annual sales valued at $1.3 million and the VA was less than half of sales, at $637,000.

4.2.2 Water transport group

Our sample had between 15 and 21 water freight firms with a total employment between 600 and 800 people. The GO and VA of the water freight industry in the year 2010 was $142 million and $52 million. This was a slight decline from the peak values obtained in 2004 and 2005 (GO of $165 million and VA of $57 million). The data for the water passenger industry is confidentialised, but it was an industry with few businesses and our sample covered between 12 and 21 firms.

Our sample firms in the water transport services industry employed between 1100 and 2000 people over the observed period. The industry appeared to be declining – GO and VA values in 2003 were $221 million and $125 million respectively, but in 2010 were $196 million and $88 million. An average firm in the water freight industry had $7.1 million GO, $2.6 million VA and 40 employees in 2010, and was much larger than an average road freight firm. However, unlike the firms in the road freight industry, water freight firms were decreasing in size and numbers. In 2008, the average GO and VA was $10.1 million and $3.7 million respectively, and the average number of employees was 45. Water transport services firms were also found to be decreasing in size and numbers, but more steeply than in the case of water freight firms.

4.2.3 Air transport group

The data for the air transport industry is confidentialised, due to the dominance of select players, but there were between 87 and 102 air transport firms in our sample. We found that the air support services industry had grown rapidly. Firms in our year 2000 sample employed 1300 workers; this number went up to 2200 in the year 2010. There was also rapid growth in GO and VA, from $467 million GO and $391 million VA in 2000 to $854 million in GO and $702 million in VA in 2010. On average, firms in the air support services industry were large – for example, in the year 2010 an average air support services firm employed 65 workers and had a GO of $24 million and VA of $20 million.

4.2.4 Other transport groups

The postal and courier services industry was the largest industry in this group. Our sample contained between 690 and 846 firms in the observed period, but there was a clear declining trend. From a peak GO of $1.67 billion and VA of $850 million in 2004, the GO and VA for 2010 dropped to $1.38 billion and $634 million respectively. The peak employment was 15,500 in 2001, and in 2010 the employment was 11,400 workers.

The other significant sub-industry in this group was other transport services. Populated by between 200 and 250 firms, this industry registered a GO of $1.2 billion $306 million, and 3800 employees, in 2009. There was a mild dip in the year 2010, but it is too early to call this a declining trend. An average firm in this industry employed only about 15 workers, but the GO and VA values were reasonably high, at $3.9 million and $1.4 million respectively.

The pipeline transport and scenic transport industries contributed a smaller share of transport GDP relative to the main transport industries. The pipeline industry firms in the sample employed between 200 and 500 people, while scenic transport firms had between 1000 and 1300 employees. In 2010, the pipeline industry registered a GO of $67 million while the scenic transport industry registered twice that figure. The average firm in these industries was small; three employees in an average pipeline transport firm and between six and nine employees in an average scenic transport firm.

In the observed period, the warehousing and storage industry had between and 75 and 111 firms, which employed between 1500 and 2800 workers. The industry appeared to trending upwards, with the GO and VA touching $462 million and $222 million in 2009. As with other transport services, there was a dip in the statistics in 2010 but it is difficult to comment substantively based on just one year’s decline.

Table 4.4 Summary statistics – transport sub-industries (totals) (c = confidentialised)

Industry	Year	Firms	VA	GO	IC	KAP	LAB
Road transport group							
Road freight	2000	2025	845,134,656	1,786,375,808	1,085,315,840	219,982,832	12,400
	2001	2103	848,737,792	1,934,085,376	1,193,365,120	244,518,656	13,300
	2002	1989	920,769,152	1,985,752,448	1,216,856,960	233,148,256	13,300
	2003	1998	1,065,250,944	2,254,658,560	1,359,093,760	276,643,616	14,700
	2004	1911	1,096,800,128	2,256,875,776	1,355,106,688	274,380,224	14,100
	2005	1947	1,191,952,896	2,430,275,072	1,397,684,608	305,733,664	14,900
	2006	1980	1,155,449,472	2,382,908,928	1,275,639,808	319,965,280	15,000
	2007	1953	1,069,503,168	2,311,975,168	1,311,307,136	306,442,880	14,200
	2008	1962	1,122,979,328	2,444,150,784	1,319,320,576	333,056,512	14,900
	2009	1872	1,172,039,680	2,501,749,248	1,375,601,792	330,856,096	15,300
	2010	1785	1,139,892,352	2,360,200,448	1,250,365,056	284,091,904	14,400
Road passenger	2000	687	219,744,528	400,009,408	207,857,840	71,007,224	5,900
	2001	705	224,086,048	429,774,560	226,159,408	75,672,000	6,400
	2002	678	252,050,304	456,030,528	233,069,200	75,668,720	6,400
	2003	690	270,799,168	486,060,256	245,971,200	85,887,776	6,900
	2004	666	279,062,048	498,368,256	256,175,936	91,763,200	7,000
	2005	645	272,079,200	511,722,112	270,483,136	103,496,008	7,200
	2006	609	263,235,152	512,274,144	258,814,320	108,963,632	7,100
	2007	603	316,385,536	567,236,352	264,748,352	114,235,576	7,100
	2008	633	319,013,184	587,750,208	268,360,608	116,894,264	7,700
	2009	603	296,734,752	621,168,000	335,630,400	105,631,296	8,100
	2010	531	337,468,576	653,459,328	323,773,728	115,042,032	8,300
Water transport group							
Water freight	2000	21	56,389,988	129,911,296	84,775,128	9,427,501	600
	2001	21	51,431,956	126,942,528	83,025,664	7,384,260	600
	2002	18	49,725,980	140,868,400	104,140,016	6,436,398	600
	2003	18	53,628,608	164,806,944	127,039,504	6,855,849	700
	2004	21	57,318,592	164,424,896	125,112,944	5,669,380	800
	2005	21	57,872,000	162,834,288	118,470,056	5,965,987	700
	2006	18	53,927,484	151,363,120	101,260,256	5,546,543	700
	2007	18	50,147,912	133,658,920	88,137,648	5,248,416	700
	2008	15	51,393,436	142,308,320	90,787,568	4,347,797	700
	2009	21	47,678,424	109,099,208	63,540,544	7,152,930	700
	2010	21	51,960,572	141,732,256	91,982,776	4,821,564	700
Water passenger services	2000	12	c	c	c	c	c
	2001	15	c	c	c	c	c
	2002	15	c	c	c	c	c
	2003	15	c	c	c	c	c
	2004	15	c	c	c	c	c
	2005	12	c	c	c	c	c
	2006	18	c	c	c	c	c
	2007	21	c	c	c	c	c
	2008	18	c	c	c	c	c

Industry	Year	Firms	VA	GO	IC	KAP	LAB
	2009	18	c	c	c	c	c
	2010	15	c	c	c	c	c
Water transport services	2000	42	108,014,160	186,695,360	90,724,848	18,860,540	1,500
	2001	57	104,903,912	189,324,384	92,822,344	18,673,428	1,700
	2002	51	109,991,944	185,207,264	85,941,568	18,790,150	1,500
	2003	63	125,198,536	221,066,224	109,544,520	18,866,768	1,900
	2004	60	124,482,216	209,978,880	99,870,344	16,854,830	2,000
	2005	57	116,354,128	190,140,208	83,281,768	14,588,339	1,800
	2006	57	107,184,304	191,588,160	87,716,816	14,998,898	1,600
	2007	48	73,582,192	148,972,880	79,567,568	14,488,244	1,100
	2008	57	73,914,024	143,597,344	69,585,744	14,446,768	1,100
	2009	69	78,296,936	152,470,288	76,733,264	16,297,084	1,200
	2010	60	87,869,120	196,088,048	110,884,416	19,182,118	1,200
Air transport group							
Air transport	2000	87	c	c	c	c	c
	2001	96	c	c	c	c	c
	2002	90	c	c	c	c	c
	2003	96	c	c	c	c	c
	2004	93	c	c	c	c	c
	2005	96	c	c	c	c	c
	2006	96	c	c	c	c	c
	2007	99	c	c	c	c	c
	2008	102	c	c	c	c	c
	2009	87	c	c	c	c	c
	2010	87	c	c	c	c	c
Air support services	2000	24	391,027,264	467,103,136	87,720,744	205,028,016	1,300
	2001	24	390,438,752	492,388,576	112,096,144	224,353,696	1,300
	2002	24	451,090,592	536,820,768	97,955,544	275,981,504	1,400
	2003	30	499,896,896	608,885,632	124,537,512	308,734,752	1,500
	2004	30	568,555,072	681,073,728	131,435,336	303,639,200	1,600
	2005	30	605,823,808	734,161,472	144,853,888	341,069,568	1,800
	2006	36	623,945,856	774,830,592	156,807,280	472,590,688	1,900
	2007	33	650,482,816	795,816,128	153,385,152	624,132,608	2,100
	2008	36	698,177,600	852,750,592	154,356,400	715,047,360	2,200
	2009	36	666,232,960	838,538,112	178,252,272	623,738,432	2,200
	2010	36	702,158,272	853,652,672	155,225,616	453,742,176	2,200
Others							
Other transport services	2000	204	245,156,480	803,764,736	644,113,792	63,949,856	3,300
	2001	213	247,502,496	808,298,112	616,608,128	66,869,564	3,200
	2002	216	263,518,960	1,009,379,840	852,225,536	68,920,616	3,300
	2003	219	295,026,400	1,048,332,288	860,775,616	77,578,120	3,600
	2004	240	307,180,768	1,045,878,016	862,886,528	77,842,056	3,700
	2005	240	319,366,752	1,046,832,704	821,085,120	83,536,616	3,700
	2006	240	297,131,488	1,003,750,080	734,355,200	88,311,592	3,700
	2007	237	314,360,480	1,018,880,448	743,551,488	91,277,280	3,600
	2008	246	309,308,576	955,607,040	645,393,216	94,340,520	3,500

Industry	Year	Firms	VA	GO	IC	KAP	LAB
	2009	249	306,270,272	1,022,847,872	741,308,928	94,671,080	3,800
	2010	231	312,174,144	890,128,896	592,190,208	82,031,880	3,600
Pipeline transport	2000	48	8,503,363	16,656,778	9,401,445	2,611,136	200
	2001	39	8,507,030	16,429,594	8,711,047	2,621,300	200
	2002	39	9,709,679	21,012,084	12,914,204	2,333,888	200
	2003	42	13,243,715	32,883,052	22,441,178	3,347,045	200
	2004	54	13,007,774	28,112,760	17,644,428	3,861,099	200
	2005	75	14,483,856	33,611,684	21,589,432	3,997,218	200
	2006	90	18,337,130	42,747,652	25,368,690	6,260,849	300
	2007	99	21,571,904	47,907,636	27,794,780	7,210,346	300
	2008	114	26,200,154	54,698,756	28,458,682	9,755,830	400
	2009	129	29,782,644	66,291,136	37,768,496	10,588,044	500
	2010	138	30,131,038	66,923,568	37,698,752	9,568,268	500
Scenic transport	2000	135	54,853,416	104,722,536	57,502,524	18,327,112	1,000
	2001	135	60,578,688	114,932,160	59,762,908	17,209,828	1,000
	2002	144	65,497,900	126,088,688	69,231,456	18,026,456	1,100
	2003	162	73,733,984	156,447,168	94,513,416	21,911,394	1,200
	2004	156	74,260,208	138,835,296	75,431,400	20,600,702	1,200
	2005	159	75,460,384	142,198,960	75,327,248	22,677,648	1,200
	2006	153	71,782,112	134,608,640	65,292,604	25,219,246	1,200
	2007	144	75,596,640	138,521,072	66,410,568	25,636,684	1,200
	2008	156	81,327,992	157,567,872	76,133,024	29,216,324	1,300
	2009	129	74,310,168	136,241,968	64,069,228	25,595,054	1,200
	2010	117	74,642,592	133,414,144	60,219,072	19,383,512	1,100
Postal and courier services	2000	813	747,937,216	1,441,959,168	800,254,912	139,655,792	15,400
	2001	846	711,866,944	1,429,724,416	789,301,248	137,188,720	15,500
	2002	798	788,006,208	1,602,920,064	931,126,912	132,871,888	15,200
	2003	801	813,247,488	1,569,138,304	863,729,344	138,521,168	15,100
	2004	789	849,464,640	1,666,483,072	954,375,232	136,953,680	14,900
	2005	753	821,936,000	1,638,900,096	922,099,712	142,495,104	14,900
	2006	705	772,038,080	1,553,025,536	811,642,304	146,235,824	14,500
	2007	729	780,759,424	1,600,434,816	865,087,168	152,192,672	12,900
	2008	753	764,887,680	1,580,958,080	814,927,552	144,818,064	12,700
	2009	705	672,911,936	1,444,970,240	798,704,064	128,608,528	12,300
	2010	690	634,379,904	1,376,561,280	760,462,592	121,934,328	11,400
Warehousing and storage	2000	75	126,883,288	246,407,888	137,820,000	45,420,084	1,500
	2001	90	128,384,704	262,914,912	147,919,184	45,460,584	1,600
	2002	78	134,806,208	281,298,752	167,383,440	51,057,224	1,600
	2003	81	122,653,288	269,728,320	168,057,520	51,918,088	1,500
	2004	90	141,540,304	314,639,392	202,200,448	58,045,392	1,600
	2005	84	141,325,216	315,586,336	196,687,312	58,157,320	1,800
	2006	84	188,662,944	398,569,504	218,145,744	70,703,064	2,100
	2007	81	162,884,640	352,057,696	199,653,568	65,522,888	1,900
	2008	87	172,702,112	403,354,432	230,329,008	75,300,608	2,200
	2009	111	221,688,864	461,808,832	248,407,136	85,015,456	2,800
	2010	99	222,294,528	398,963,424	181,020,448	75,780,560	2,600

Table 4.5 Summary statistics – transport sub-industries (averages) (c = confidentialised)

Industry	Year	Average VA	Average GO	Average IC	Average KAP	Average LAB
Road transport group						
Road freight	2000	417,557	882,597	536,223	108,687	6
	2001	403,584	919,679	567,458	116,271	6
	2002	463,397	999,372	612,409	117,337	9
	2003	533,426	1,129,023	680,568	138,530	6
	2004	574,241	1,181,610	709,480	143,655	6
	2005	611,885	1,247,575	717,497	156,947	9
	2006	584,150	1,204,706	644,914	161,762	9
	2007	547,340	1,183,201	671,089	156,828	6
	2008	572,365	1,245,745	672,437	169,754	9
	2009	626,090	1,336,405	734,830	176,739	9
	2010	639,311	1,323,724	701,270	159,334	9
Road passenger	2000	320,327	583,104	303,000	103,509	9
	2001	317,853	609,609	320,794	107,336	9
	2002	371,208	671,621	343,254	111,441	12
	2003	393,032	705,458	356,997	124,656	9
	2004	419,642	749,426	385,227	137,990	12
	2005	421,175	792,140	418,705	160,211	9
	2006	432,953	842,556	425,681	179,217	12
	2007	524,686	940,690	439,052	189,445	12
	2008	504,768	929,985	424,621	184,959	12
	2009	493,735	1,033,557	558,453	175,759	12
	2010	636,733	1,232,942	610,894	217,060	15
Water transport group						
Water freight	2000	2,685,238	6,186,252	4,036,911	448,929	30
	2001	2,706,945	6,681,186	4,369,772	388,645	30
	2002	2,925,058	8,286,377	6,125,883	378,612	35
	2003	2,979,367	9,155,941	7,057,751	380,880	35
	2004	2,729,457	7,829,757	5,957,759	269,970	35
	2005	3,045,895	8,570,226	6,235,267	313,999	40
	2006	3,370,468	9,460,195	6,328,766	346,659	45
	2007	2,949,877	7,862,290	5,184,568	308,730	35
	2008	3,670,960	10,164,879	6,484,827	310,557	45
	2009	2,383,921	5,454,961	3,177,027	357,646	35
	2010	2,598,029	7,086,613	4,599,139	241,078	40
Water passenger services	2000	c	c	c	c	c
	2001	c	c	c	c	c
	2002	c	c	c	c	c
	2003	c	c	c	c	c
	2004	c	c	c	c	c
	2005	c	c	c	c	c
	2006	c	c	c	c	c
	2007	c	c	c	c	c
	2008	c	c	c	c	c
	2009	c	c	c	c	c

Industry	Year	Average VA	Average GO	Average IC	Average KAP	Average LAB
	2010	c	c	c	c	c
Water transport services	2000	2,700,354	4,667,384	2,268,121	471,514	40
	2001	1,873,284	3,380,793	1,657,542	333,454	30
	2002	2,075,320	3,494,477	1,621,539	354,531	30
	2003	2,052,435	3,624,037	1,795,812	309,291	35
	2004	2,040,692	3,442,277	1,637,219	276,309	35
	2005	2,006,106	3,278,279	1,435,893	251,523	30
	2006	1,948,806	3,483,421	1,594,851	272,707	30
	2007	1,532,962	3,103,602	1,657,658	301,838	25
	2008	1,274,380	2,475,816	1,199,754	249,082	18
	2009	1,151,426	2,242,210	1,128,430	239,663	18
	2010	1,489,307	3,323,526	1,879,397	325,121	20
Air transport group						
Air transport	2000	c	c	c	c	c
	2001	c	c	c	c	c
	2002	c	c	c	c	c
	2003	c	c	c	c	c
	2004	c	c	c	c	c
	2005	c	c	c	c	c
	2006	c	c	c	c	c
	2007	c	c	c	c	c
	2008	c	c	c	c	c
	2009	c	c	c	c	c
	2010	c	c	c	c	c
Air support services	2000	17,001,186	20,308,832	3,813,946	8,914,262	55
	2001	16,975,598	21,408,198	4,873,746	9,754,509	60
	2002	18,043,624	21,472,830	3,918,222	11,039,261	55
	2003	17,237,824	20,996,056	4,294,397	10,646,026	55
	2004	18,951,834	22,702,458	4,381,178	10,121,307	55
	2005	20,194,126	24,472,050	4,828,463	11,368,986	60
	2006	18,351,348	22,789,136	4,611,979	13,899,727	55
	2007	19,131,848	23,406,358	4,511,328	18,356,842	60
	2008	19,393,822	23,687,516	4,287,678	19,862,426	65
	2009	19,035,226	23,958,232	5,092,922	17,821,098	65
	2010	20,061,666	24,390,076	4,435,018	12,964,062	65
Others						
Other transport services	2000	1,201,748	3,940,023	3,157,421	313,480	15
	2001	1,161,984	3,794,827	2,894,874	313,942	15
	2002	1,219,995	4,673,055	3,945,489	319,077	15
	2003	1,341,029	4,765,147	3,912,616	352,628	18
	2004	1,279,920	4,357,825	3,595,361	324,342	15
	2005	1,325,173	4,343,704	3,406,992	346,625	15
	2006	1,243,228	4,199,791	3,072,616	369,505	15
	2007	1,326,416	4,299,074	3,137,348	385,136	15
	2008	1,252,261	3,868,855	2,612,928	381,945	12
	2009	1,239,961	4,141,085	3,001,251	383,284	15

Industry	Year	Average VA	Average GO	Average IC	Average KAP	Average LAB
	2010	1,351,403	3,853,372	2,563,594	355,116	15
Pipeline transport	2000	184,856	362,104	204,379	56,764	3
	2001	223,869	432,358	229,238	68,982	6
	2002	236,821	512,490	314,981	56,924	3
	2003	307,993	764,722	521,888	77,838	6
	2004	240,885	520,607	326,749	71,502	3
	2005	198,409	460,434	295,746	54,756	3
	2006	206,035	480,311	285,041	70,347	3
	2007	213,583	474,333	275,196	71,390	3
	2008	227,827	475,641	247,467	84,833	3
	2009	227,348	506,039	288,309	80,825	3
	2010	218,341	484,953	273,179	69,335	6
Scenic transport	2000	403,334	770,019	422,813	134,758	6
	2001	452,080	857,703	445,992	128,432	9
	2002	458,027	881,739	484,136	126,059	6
	2003	452,356	959,799	579,837	134,426	9
	2004	482,209	901,528	489,814	133,771	6
	2005	477,597	899,993	476,755	143,529	6
	2006	472,251	885,583	429,557	165,916	9
	2007	524,977	961,952	461,185	178,033	9
	2008	524,697	1,016,567	491,181	188,492	9
	2009	576,048	1,056,139	496,661	198,411	9
	2010	637,971	1,140,292	514,693	165,671	9
Postal and courier services	2000	922,241	1,778,002	986,751	172,202	20
	2001	841,450	1,689,982	932,980	162,162	20
	2002	987,476	2,008,672	1,166,826	166,506	20
	2003	1,015,290	1,958,974	1,078,314	172,935	18
	2004	1,076,635	2,112,146	1,209,601	173,579	18
	2005	1,091,549	2,176,494	1,224,568	189,237	20
	2006	1,095,090	2,202,873	1,151,266	207,427	20
	2007	1,072,472	2,198,400	1,188,307	209,056	18
	2008	1,017,138	2,102,338	1,083,680	192,577	15
	2009	955,841	2,052,515	1,134,523	182,683	18
	2010	920,726	1,997,912	1,103,719	176,973	15
Warehousing and storage	2000	1,691,777	3,285,439	1,837,600	605,601	20
	2001	1,442,525	2,954,100	1,662,013	510,793	20
	2002	1,773,766	3,701,299	2,202,414	671,806	20
	2003	1,495,772	3,289,370	2,049,482	633,147	18
	2004	1,608,413	3,575,448	2,297,732	659,607	18
	2005	1,682,443	3,756,980	2,341,516	692,349	20
	2006	2,300,768	4,860,604	2,660,314	862,233	25
	2007	1,986,398	4,293,387	2,434,800	799,060	25
	2008	1,940,473	4,532,072	2,587,966	846,074	25
	2009	1,997,197	4,160,440	2,237,902	765,905	25
	2010	2,245,399	4,029,934	1,828,489	765,460	25

5 Results

This chapter presents productivity indicators computed using the four approaches mentioned earlier: growth accounting framework, Tornqvist index number formula, IO tables-based approach and the Malmquist index number formula. In addition, labour productivity indicators have been presented as a reference point.

As the key purpose of this research was to go beyond the aggregate official transport sector productivity indicators to shed light on the productivity performance of the transport sector sub-industries, productivity analysis was undertaken for 14 transport sub-industries. Firms within these industries were identified using the 2006 Australia New Zealand Industry Standard Classification (ANZSIC 2006), generally at the three-digit level (see table 5.1).

Table 5.1 Transport sub-sector and 2006 ANZSIC code

Code	Transport sub-sector	ANZSIC code
Road transport group	Road freight	I461
	Road passenger	I462
Water transport group	Water freight	I481
	Water passenger services	I482
	Water transport services	I521
Air transport group	Air transport	I490
	Air support services	I522
Rail transport group	Rail freight	I471
	Rail passenger	I472
Others	Other transport services	I529
	Pipeline transport	I5021
	Scenic transport	I501
	Postal and courier services	I510
	Warehousing and storage	I530

This chapter presents and discusses productivity indicators that were derived using GO as the output variable and IC, KAP and LAB as input variables. An entirely acceptable alternative would have been to use VA as the output variable and KAP and LAB as input variables – since VA is defined as GO-IC, the data requirements across the alternatives are not different. We preferred the GO specification, as it did not require us to exclude enterprises with negative VA (the log function is undefined for non-positive numbers). This helped us avoid selection bias (see Mare and Graham 2009).[16] Furthermore, as Schreyer (2001, p41) points out, 'value added is not an immediately plausible measure of output: contrary to GO, there is no physical quantity that corresponds to a volume measure of value added'.

5.1 Labour productivity indicators

Defining labour productivity as a ratio of VA over LAB, we derived a labour productivity indicator. It is known that at least some transport industries are relatively capital intensive, and that changes in capital

16 We present the VA-based indicators in appendix A.

intensity and capital productivity also influence MFP. It is, therefore, acknowledged that labour productivity indicators do not tell the whole productivity story. However, labour productivity can serve as a reference point, as the ratio is intuitive.[17] We categorised the transport industries under the groups of road, water, air and Others (see table 5.2).

Table 5.2 Grouping of transport industries for the labour productivity index

Broad group	Transport industry	Data confidentialised
Road transport	Road freight	NO
	Road passenger	NO
Water transport	Water freight	NO
	Water passenger services	YES
	Water transport services	NO
Air transport	Air transport	YES
	Air support services	NO
Others	Other transport services	NO
	Pipeline transport	NO
	Scenic transport	NO
	Postal and courier services	NO
	Warehousing and storage	NO

The labour productivity series is presented in table 5.3. The derived productivity series can be presented in two ways: year-on-year (YOY) movements and cumulative movements. Since our focus was on long-term trends, the cumulative series was considered more suitable for the analysis – but since the cumulative series was constructed from the YOY series, we have presented the YOY series and also make reference to it.

Table 5.3 Labour productivity indicators

Industry	Year	Labour productivity (LP)	Change in LP (YOY)	LP index
Aggregate transport	2000	80,071		1.0000
	2001	73,895	0.9229	0.9229
	2002	77,986	1.0554	0.9740
	2003	90,695	1.1630	1.1327
	2004	95,968	1.0581	1.1985
	2005	92,813	0.9671	1.1591
	2006	88,460	0.9531	1.1048
	2007	89,034	1.0065	1.1119
	2008	95,744	1.0754	1.1957
	2009	77,946	0.8141	0.9734
	2010	89,050	1.1425	1.1121

17 The research brief did not include computing labour productivity indicators. However, it was necessary to compute labour productivity to understand the output and input series better. The labour productivity indicators served as a good references point and may be of interest to some readers, so they are included. Labour productivity is derived as the ratio of VA over employment.

Industry	Year	Labour productivity (LP)	Change in LP (YOY)	LP index
Road transport group				
Road freight	2000	68,083		1.0000
	2001	63,852	0.9378	0.9378
	2002	69,391	1.0868	1.0192
	2003	72,683	1.0474	1.0676
	2004	77,637	1.0682	1.1403
	2005	80,094	1.0317	1.1764
	2006	76,915	0.9603	1.1297
	2007	75,248	0.9783	1.1052
	2008	75,366	1.0016	1.1070
	2009	76,398	1.0137	1.1221
	2010	79,126	1.0357	1.1622
Road passenger	2000	37,079		1.0000
	2001	35,188	0.9490	0.9490
	2002	39,428	1.1205	1.0633
	2003	39,127	0.9924	1.0552
	2004	39,678	1.0141	1.0701
	2005	37,957	0.9566	1.0237
	2006	37,077	0.9768	0.9999
	2007	44,529	1.2010	1.2009
	2008	41,261	0.9266	1.1128
	2009	36,773	0.8912	0.9918
	2010	40,835	1.1105	1.1013
Water transport group				
Water freight	2000	89,496		1.0000
	2001	83,584	0.9339	0.9339
	2002	82,248	0.9840	0.9190
	2003	76,878	0.9347	0.8590
	2004	76,340	0.9930	0.8530
	2005	81,923	1.0731	0.9154
	2006	76,774	0.9371	0.8579
	2007	77,081	1.0040	0.8613
	2008	77,023	0.9992	0.8606
	2009	67,757	0.8797	0.7571
	2010	70,328	1.0379	0.7858
Water transport services	2000	70,107		1.0000
	2001	61,011	0.8703	0.8703
	2002	71,594	1.1735	1.0212
	2003	64,736	0.9042	0.9234
	2004	62,252	0.9616	0.8880
	2005	65,057	1.0451	0.9280
	2006	65,916	1.0132	0.9402

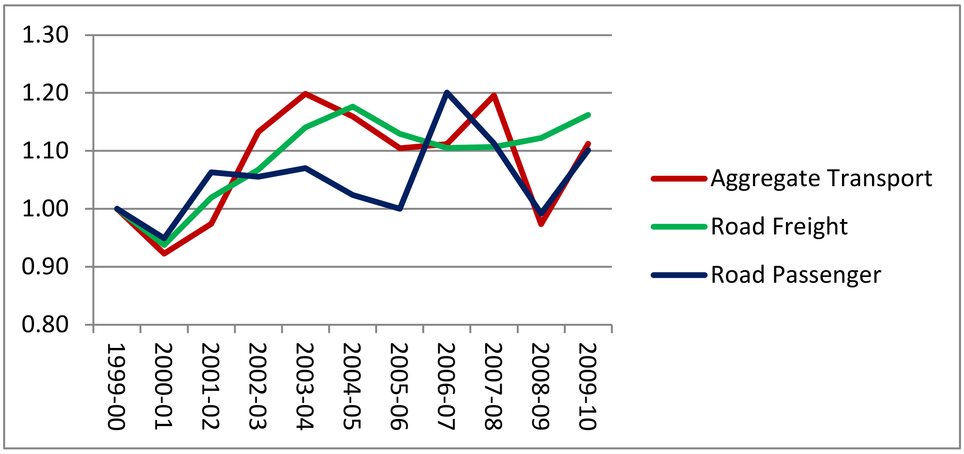
Industry	Year	Labour productivity (LP)	Change in LP (YOY)	LP index
	2007	64,911	0.9848	0.9259
	2008	70,093	1.0798	0.9998
	2009	66,499	0.9487	0.9485
	2010	75,397	1.1338	1.0755
Air transport group				
Air support services	2000	291,364		1.0000
	2001	289,750	0.9945	0.9945
	2002	311,545	1.0752	1.0693
	2003	325,365	1.0444	1.1167
	2004	356,554	1.0959	1.2237
	2005	342,016	0.9592	1.1738
	2006	325,708	0.9523	1.1179
	2007	309,116	0.9491	1.0609
	2008	313,741	1.0150	1.0768
	2009	300,963	0.9593	1.0329
	2010	315,305	1.0477	1.0822
Other transport group				
Other transport services	2000	73,544		1.0000
	2001	76,577	1.0412	1.0412
	2002	79,661	1.0403	1.0832
	2003	82,502	1.0357	1.1218
	2004	83,373	1.0106	1.1336
	2005	85,353	1.0238	1.1606
	2006	80,671	0.9451	1.0969
	2007	87,048	1.0791	1.1836
	2008	88,359	1.0151	1.2014
	2009	81,029	0.9170	1.1018
	2010	87,305	1.0775	1.1871
Pipeline transport	2000	49,558		1.0000
	2001	50,537	1.0198	1.0198
	2002	59,752	1.1823	1.2057
	2003	67,653	1.1322	1.3651
	2004	64,796	0.9578	1.3075
	2005	57,992	0.8950	1.1702
	2006	56,859	0.9805	1.1473
	2007	63,076	1.1093	1.2728
	2008	64,243	1.0185	1.2963
	2009	62,866	0.9786	1.2685
	2010	59,794	0.9511	1.2066
Scenic transport	2000	55,865		1.0000
	2001	60,152	1.0767	1.0767
	2002	59,227	0.9846	1.0602

Industry	Year	Labour productivity (LP)	Change in LP (YOY)	LP index
	2003	61,593	1.0399	1.1025
	2004	62,693	1.0179	1.1222
	2005	60,884	0.9711	1.0898
	2006	59,402	0.9757	1.0633
	2007	62,901	1.0589	1.1259
	2008	62,273	0.9900	1.1147
	2009	61,409	0.9861	1.0992
	2010	69,965	1.1393	1.2524
Postal and courier services	2000	48,529		1.0000
	2001	45,978	0.9474	0.9474
	2002	51,754	1.1256	1.0664
	2003	53,851	1.0405	1.1097
	2004	56,901	1.0566	1.1725
	2005	55,037	0.9672	1.1341
	2006	53,351	0.9694	1.0994
	2007	60,754	1.1388	1.2519
	2008	60,301	0.9925	1.2426
	2009	54,915	0.9107	1.1316
	2010	55,867	1.0173	1.1512
Warehousing and storage	2000	82,862		1.0000
	2001	77,998	0.9413	0.9413
	2002	83,952	1.0763	1.0132
	2003	82,911	0.9876	1.0006
	2004	88,546	1.0680	1.0686
	2005	79,687	0.9000	0.9617
	2006	88,929	1.1160	1.0732
	2007	86,660	0.9745	1.0458
	2008	78,569	0.9066	0.9482
	2009	79,680	1.0141	0.9616
	2010	85,918	1.0783	1.0369

We found the road freight industry was a significant component of the transport sector, accounting for a little over 21%, on average, of the transport sector GDP in the years 2000–2010. Labour productivity growth in the road freight industry increased consistently, as seen in the YOY productivity change indicators, reaching a cumulative productivity increase of 16.2% over the observed 10-year period. This was higher than the cumulative labour productivity growth recorded for the transport sector as a whole (11.2%).

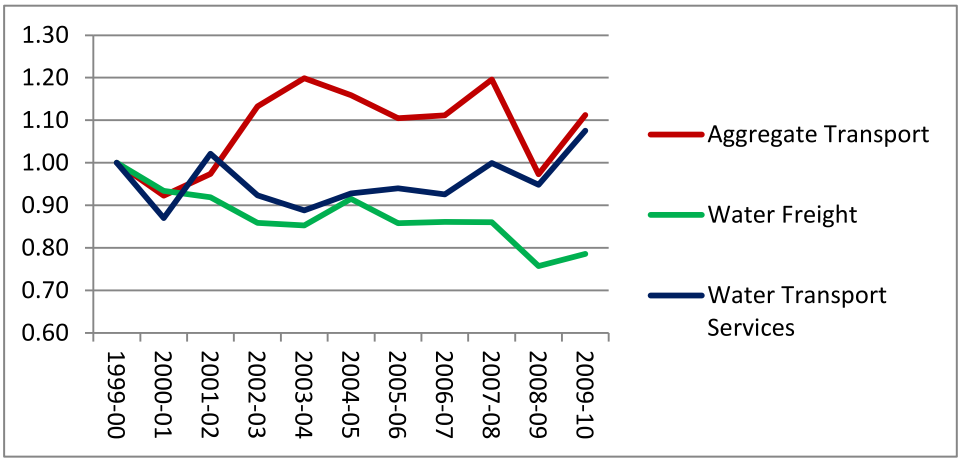
The road passenger industry accounted for a smaller portion (5.6%) of the transport sector VA over the period 2000–10. Labour productivity growth in the road passenger industry was variable, rising in some years and falling in others. However, the cumulative rate of labour productivity growth (10.1%) was close to that of the transport sector as whole.

Figure 5.1 Road transport – labour productivity



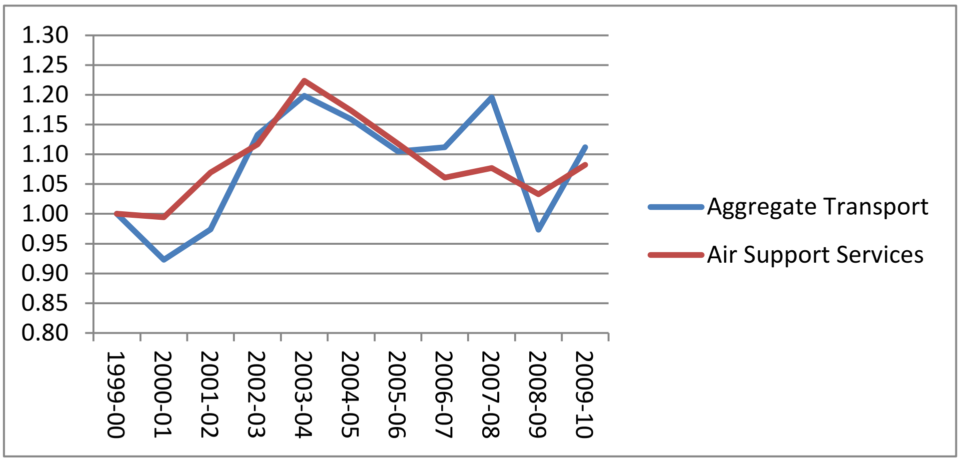
As was the case with the road passenger industry, labour productivity growth in the water freight and water transport services industries was variable. The cumulative labour productivity growth in the water freight industry was significantly negative, at -21.5% over the observed period. In contrast, the cumulative productivity growth in the water transport services industry was positive, although at 7.6%, was lower than the cumulative productivity growth for the transport sector as a whole.

Figure 5.2 Water transport – labour productivity



Labour productivity growth in the air transport industry could not be reported due to confidentiality issues. The YOY labour productivity growth of the air support services industry mostly tracked that of the overall transport sector. Cumulative labour productivity growth of the air support services industry, at 8.2%, was lower than the transport sector as a whole.

Figure 5.3 Air transport – labour productivity

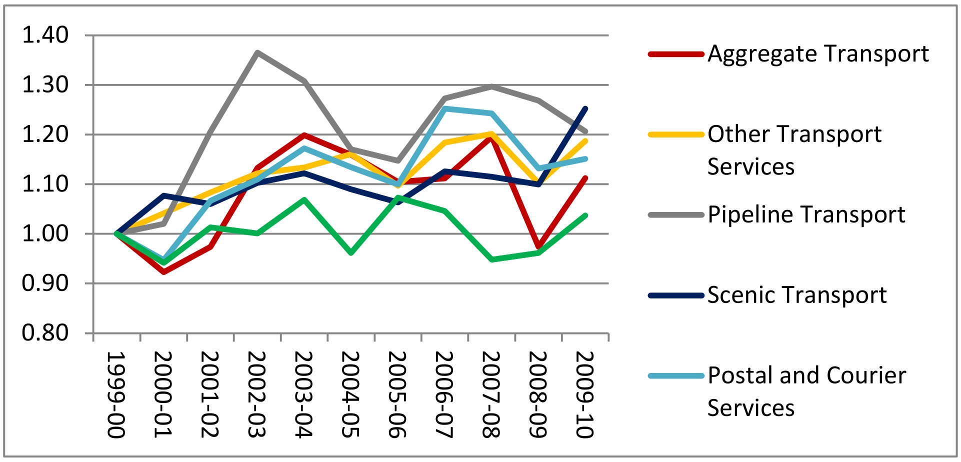


The Others group included other transport services, pipeline transport, scenic transport, postal and courier services, and warehousing and storage services.

The contribution of the pipeline transport and scenic transport industries was small, roughly 0.35% and 1.4% respectively. The average transport GDP shares (2000–2010) of the warehousing and storage services industry and other transport services industries were higher, at 3.3% and 6% respectively. Within the Others group, the postal and courier services industry, accounting for 15.5% of the transport sector GDP, was the largest contributor in terms of VA.

In the Others group (see figure 5.4), the pipeline transport and scenic transport industry recorded the highest rates of labour productivity growth in the observed period. Pipeline transport labour productivity increased cumulatively by 27%, and productivity in the scenic transport industry increased cumulatively by 25%. The other industries to register strong growth in productivity were other transport services (18.7%) and the postal and courier services industry (15.1%). The cumulative labour productivity growth rate in the warehousing and storage services industry was subdued, at 3.7%.

Figure 5.4 Other transport – labour productivity



5.2 Growth accounting-based productivity indicators

The growth accounting framework is a commonly used method to measure productivity. One of the key advantages of using the growth accounting framework is that growth in output can be uniquely attributed to growth in specific factor inputs (intermediate inputs, capital and labour) and productivity. In the analysis, the transport industries were categorised under the groups of road, water, air and Others (see table, 5.4).

Table 5.4 Grouping of transport industries for growth accounting-based productivity indicators

Broad group	Transport industry	Data confidentialised
Road transport	Road freight	NO
	Road passenger	NO
Water transport	Water freight	NO
	Water passenger services	YES
	Water transport services	NO
Air transport	Air transport	YES
	Air support services	NO
Rail transport	Rail transport	YES
Others	Other transport services	NO
	Pipeline transport	NO
	Scenic transport	NO
	Postal and courier services	NO
	Warehousing and storage	NO

The growth accounting-based productivity series are presented in table 5.5.

Table 5.5 Growth accounting productivity indicators, based on GO

		YOY change					Cumulative change				
Industry	**Year**	**Output**	**IC index**	**Capital index**	**Labour index**	**MFP**	**Output**	**IC index**	**Capital index**	**Labour index**	**MFP**
Aggregate transport	2000						1	1	1	1	1
	2001	1.0724	1.0913	1.1059	1.0314	0.9928	1.0724	1.0913	1.1059	1.0314	0.9928
	2002	0.9678	0.9729	0.9960	0.9767	0.9896	1.0379	1.0617	1.1016	1.0074	0.9825
	2003	1.0470	0.9483	1.2205	1.0569	1.0275	1.0866	1.0068	1.3444	1.0647	1.0094
	2004	1.0011	0.9768	0.9723	1.0052	1.0191	1.0879	0.9835	1.3073	1.0702	1.0287
	2005	0.9850	0.9467	1.0282	1.0259	1.0059	1.0715	0.9311	1.3441	1.0980	1.0348
	2006	0.9737	0.9127	1.1109	0.9983	1.0075	1.0433	0.8498	1.4932	1.0961	1.0426
	2007	1.0357	1.1222	1.0565	0.9393	0.9718	1.0806	0.9537	1.5775	1.0296	1.0133
	2008	1.0645	0.9758	1.0805	1.0377	1.0555	1.1503	0.9306	1.7046	1.0684	1.0695
	2009	0.9624	1.0899	0.9060	1.0260	0.9267	1.1070	1.0142	1.5444	1.0961	0.9911
	2010	0.9402	0.8463	0.8410	0.9562	1.0819	1.0408	0.8583	1.2989	1.0481	1.0723
Road transport group											
Road freight	2000						1	1	1	1	1
	2001	1.0827	1.0996	1.1115	1.0726	0.9887	1.0827	1.0996	1.1115	1.0726	0.9887
	2002	1.0267	1.0197	0.9535	1.0000	1.0241	1.1116	1.1212	1.0598	1.0726	1.0125
	2003	1.1354	1.1169	1.1866	1.1053	1.0081	1.2621	1.2523	1.2576	1.1855	1.0207
	2004	1.0010	0.9971	0.9918	0.9592	1.0145	1.2634	1.2486	1.2473	1.1371	1.0355
	2005	1.0768	1.0314	1.1143	1.0567	1.0235	1.3605	1.2878	1.3898	1.2016	1.0598
	2006	0.9805	0.9127	1.0465	1.0067	1.0232	1.3339	1.1754	1.4545	1.2097	1.0844
	2007	0.9702	1.0280	0.9577	0.9467	0.9755	1.2942	1.2082	1.3930	1.1452	1.0577
	2008	1.0572	1.0061	1.0868	1.0493	1.0256	1.3682	1.2156	1.5140	1.2016	1.0848
	2009	1.0236	1.0427	0.9934	1.0268	0.9940	1.4005	1.2675	1.5040	1.2339	1.0783
	2010	0.9434	0.9090	0.8587	0.9412	1.0398	1.3212	1.1521	1.2914	1.1613	1.1212

		YOY change					Cumulative change				
Industry	**Year**	**Output**	**IC index**	**Capital index**	**Labour index**	**MFP**	**Output**	**IC index**	**Capital index**	**Labour index**	**MFP**
Road passenger	2000						1	1	1	1	1
	2001	1.0744	1.0880	1.0657	1.0847	0.9919	1.0744	1.0880	1.0657	1.0847	0.9919
	2002	1.0611	1.0306	1.0000	1.0000	1.0429	1.1400	1.1213	1.0656	1.0847	1.0345
	2003	1.0659	1.0554	1.1351	1.0781	0.9915	1.2151	1.1834	1.2096	1.1695	1.0257
	2004	1.0253	1.0415	1.0684	1.0145	0.9863	1.2459	1.2325	1.2923	1.1864	1.0116
	2005	1.0268	1.0558	1.1279	1.0286	0.9671	1.2793	1.3013	1.4575	1.2203	0.9784
	2006	1.0011	0.9569	1.0528	0.9861	1.0207	1.2807	1.2452	1.5345	1.2034	0.9987
	2007	1.1073	1.0229	1.0484	1.0000	1.0837	1.4181	1.2737	1.6088	1.2034	1.0822
	2008	1.0362	1.0136	1.0233	1.0845	1.0037	1.4693	1.2911	1.6462	1.3051	1.0863
	2009	1.0569	1.2507	0.9036	1.0519	0.9349	1.5529	1.6147	1.4876	1.3729	1.0156
	2010	1.0520	0.9647	1.0891	1.0247	1.0512	1.6336	1.5577	1.6201	1.4068	1.0676
Water transport group											
Water freight	2000						1	1	1	1	1
	2001	0.9771	0.9794	0.7833	1.0000	1.0284	0.9771	0.9794	0.7833	1.0000	1.0284
	2002	1.1097	1.2543	0.8716	1.0000	0.9940	1.0843	1.2284	0.6827	1.0000	1.0222
	2003	1.1699	1.2199	1.0652	1.1667	0.9914	1.2686	1.4985	0.7272	1.1667	1.0134
	2004	0.9977	0.9848	0.8269	1.1429	1.0026	1.2657	1.4758	0.6014	1.3333	1.0160
	2005	0.9903	0.9469	1.0523	0.8750	1.0495	1.2534	1.3975	0.6328	1.1667	1.0663
	2006	0.9296	0.8547	0.9297	1.0000	1.0305	1.1651	1.1945	0.5883	1.1667	1.0988
	2007	0.8830	0.8704	0.9462	1.0000	0.9659	1.0288	1.0397	0.5567	1.1667	1.0614
	2008	1.0647	1.0301	0.8284	1.0000	1.0784	1.0954	1.0709	0.4612	1.1667	1.1446
	2009	0.7666	0.6999	1.6452	1.0000	0.8718	0.8398	0.7495	0.7587	1.1667	0.9979
	2010	1.2991	1.4476	0.6741	1.0000	1.1152	1.0910	1.0850	0.5114	1.1667	1.1128

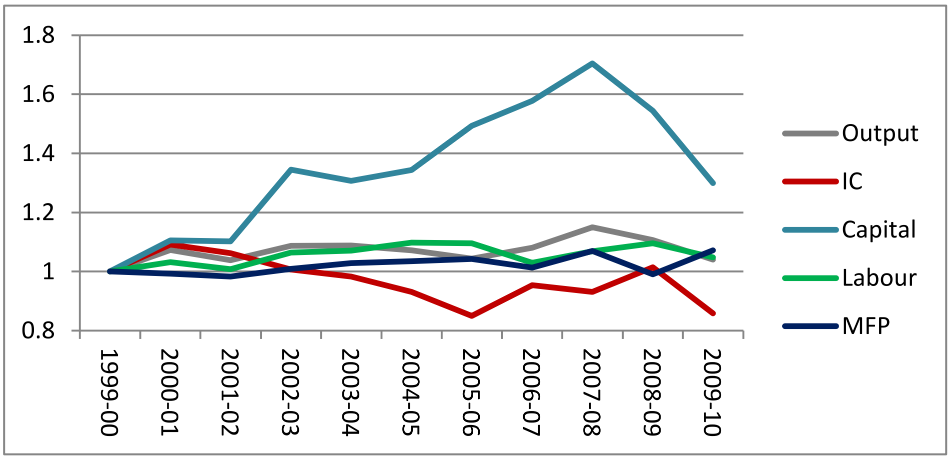
		YOY change					Cumulative change				
Industry	**Year**	**Output**	**IC index**	**Capital index**	**Labour index**	**MFP**	**Output**	**IC index**	**Capital index**	**Labour index**	**MFP**
Water transport services	2000						1	1	1	1	1
	2001	1.0141	1.0231	0.9901	1.1333	0.9705	1.0141	1.0231	0.9901	1.1333	0.9705
	2002	0.9783	0.9259	1.0063	0.8824	1.0556	0.9920	0.9473	0.9963	1.0000	1.0245
	2003	1.1936	1.2746	1.0041	1.2667	0.9744	1.1841	1.2074	1.0003	1.2667	0.9982
	2004	0.9498	0.9117	0.8934	1.0526	1.0073	1.1247	1.1008	0.8937	1.3333	1.0055
	2005	0.9055	0.8339	0.8655	0.9000	1.0585	1.0185	0.9180	0.7735	1.2000	1.0642
	2006	1.0076	1.0533	1.0281	0.8889	1.0032	1.0262	0.9668	0.7953	1.0667	1.0677
	2007	0.7776	0.9071	0.9660	0.6875	0.9114	0.7979	0.8770	0.7682	0.7333	0.9731
	2008	0.9639	0.8745	0.9971	1.0000	1.0427	0.7692	0.7670	0.7660	0.7333	1.0147
	2009	1.0618	1.1027	1.1281	1.0909	0.9621	0.8167	0.8458	0.8641	0.8000	0.9762
	2010	1.2861	1.4451	1.1770	1.0000	1.0110	1.0503	1.2222	1.0171	0.8000	0.9869
Air transport group											
Air support services	2000						1	1	1	1	1
	2001	1.0541	1.2779	1.0943	1.0000	0.8642	1.0541	1.2779	1.0943	1.0000	0.8642
	2002	1.0902	0.8739	1.2301	1.0769	1.1899	1.1493	1.1167	1.3461	1.0769	1.0282
	2003	1.1342	1.2714	1.1187	1.0714	0.9222	1.3035	1.4197	1.5058	1.1538	0.9483
	2004	1.1186	1.0554	0.9835	1.0667	1.0608	1.4581	1.4983	1.4810	1.2308	1.0059
	2005	1.0779	1.1021	1.1233	1.1250	0.9741	1.5717	1.6513	1.6635	1.3846	0.9798
	2006	1.0554	1.0825	1.3856	1.0556	0.9701	1.6588	1.7876	2.3050	1.4615	0.9505
	2007	1.0271	0.9782	1.3207	1.1053	1.0175	1.7037	1.7486	3.0441	1.6154	0.9672
	2008	1.0715	1.0063	1.1457	1.0476	1.0526	1.8256	1.7596	3.4876	1.6923	1.0181
	2009	0.9833	1.1548	0.8723	1.0000	0.8812	1.7952	2.0320	3.0422	1.6923	0.8972
	2010	1.0180	0.8708	0.7275	1.0000	1.1501	1.8275	1.7695	2.2131	1.6923	1.0319

		YOY change					Cumulative change				
Industry	**Year**	**Output**	**IC index**	**Capital index**	**Labour index**	**MFP**	**Output**	**IC index**	**Capital index**	**Labour index**	**MFP**
Other transport groups											
Other transport services	2000						1	1	1	1	1
	2001	1.0056	0.9573	1.0457	0.9697	1.0324	1.0056	0.9573	1.0457	0.9697	1.0324
	2002	1.2488	1.3821	1.0307	1.0313	1.0210	1.2558	1.3231	1.0777	1.0000	1.0540
	2003	1.0386	1.0100	1.1256	1.0909	0.9908	1.3043	1.3364	1.2131	1.0909	1.0443
	2004	0.9977	1.0025	1.0034	1.0278	0.9887	1.3012	1.3396	1.2172	1.1212	1.0325
	2005	1.0009	0.9516	1.0732	1.0000	1.0188	1.3024	1.2748	1.3063	1.1212	1.0519
	2006	0.9588	0.8944	1.0572	1.0000	1.0143	1.2488	1.1401	1.3810	1.1212	1.0669
	2007	1.0151	1.0125	1.0336	0.9730	1.0095	1.2676	1.1544	1.4273	1.0909	1.0771
	2008	0.9379	0.8680	1.0336	0.9722	1.0206	1.1889	1.0020	1.4752	1.0606	1.0993
	2009	1.0704	1.1486	1.0035	1.0857	0.9661	1.2726	1.1509	1.4804	1.1515	1.0620
	2010	0.8702	0.7988	0.8665	0.9474	1.0292	1.1075	0.9194	1.2828	1.0909	1.0930
Pipeline transport	2000						1	1	1	1	1
	2001	0.9864	0.9266	1.0039	1.0000	1.0306	0.9864	0.9266	1.0039	1.0000	1.0306
	2002	1.2789	1.4825	0.8904	1.0000	1.0357	1.2615	1.3736	0.8938	1.0000	1.0673
	2003	1.5650	1.7377	1.4341	1.0000	1.0706	1.9742	2.3870	1.2818	1.0000	1.1426
	2004	0.8549	0.7863	1.1536	1.0000	0.9614	1.6878	1.8768	1.4787	1.0000	1.0985
	2005	1.1956	1.2236	1.0353	1.0000	1.0571	2.0179	2.2964	1.5308	1.0000	1.1612
	2006	1.2718	1.1751	1.5663	1.5000	0.9708	2.5664	2.6984	2.3977	1.5000	1.1273
	2007	1.1207	1.0956	1.1517	1.0000	1.0389	2.8762	2.9564	2.7614	1.5000	1.1712
	2008	1.1418	1.0239	1.3530	1.3333	0.9965	3.2839	3.0271	3.7362	2.0000	1.1671
	2009	1.2119	1.3271	1.0853	1.2500	0.9576	3.9798	4.0173	4.0550	2.5000	1.1177
	2010	1.0095	0.9982	0.9037	1.0000	1.0271	4.0178	4.0099	3.6644	2.5000	1.1480

		YOY change					Cumulative change				
Industry	**Year**	**Output**	**IC index**	**Capital index**	**Labour index**	**MFP**	**Output**	**IC index**	**Capital index**	**Labour index**	**MFP**
Scenic transport	2000						1	1	1	1	1
	2001	1.0975	1.0393	0.9390	1.0000	1.0839	1.0975	1.0393	0.9390	1.0000	1.0839
	2002	1.0971	1.1584	1.0475	1.1000	0.9753	1.2040	1.2040	0.9836	1.1000	1.0571
	2003	1.2408	1.3652	1.2155	1.0909	0.9809	1.4939	1.6436	1.1956	1.2000	1.0370
	2004	0.8874	0.7981	0.9402	1.0000	1.0221	1.3257	1.3118	1.1241	1.2000	1.0599
	2005	1.0242	0.9986	1.1008	1.0000	1.0095	1.3579	1.3100	1.2374	1.2000	1.0699
	2006	0.9466	0.8668	1.1121	1.0000	1.0116	1.2854	1.1355	1.3761	1.2000	1.0823
	2007	1.0291	1.0171	1.0166	1.0000	1.0163	1.3227	1.1549	1.3988	1.2000	1.0999
	2008	1.1375	1.1464	1.1396	1.0833	1.0077	1.5046	1.3240	1.5942	1.3000	1.1084
	2009	0.8647	0.8415	0.8761	0.9231	0.9969	1.3010	1.1142	1.3966	1.2000	1.1050
	2010	0.9792	0.9399	0.7573	0.9167	1.0854	1.2740	1.0472	1.0576	1.1000	1.1993
Postal and courier services	2000						1	1	1	1	1
	2001	0.9915	0.9863	0.9823	1.0065	1.0004	0.9915	0.9863	0.9823	1.0065	1.0004
	2002	1.1211	1.1797	0.9685	0.9806	1.0347	1.1116	1.1635	0.9514	0.9870	1.0351
	2003	0.9789	0.9276	1.0425	0.9934	1.0148	1.0882	1.0793	0.9919	0.9805	1.0504
	2004	1.0620	1.1049	0.9887	0.9868	1.0108	1.1557	1.1926	0.9807	0.9675	1.0618
	2005	0.9834	0.9662	1.0405	1.0000	0.9953	1.1366	1.1523	1.0203	0.9675	1.0568
	2006	0.9476	0.8802	1.0263	0.9732	1.0197	1.0770	1.0142	1.0471	0.9416	1.0776
	2007	1.0305	1.0658	1.0407	0.8897	1.0200	1.1099	1.0810	1.0898	0.8377	1.0991
	2008	0.9878	0.9420	0.9515	0.9845	1.0343	1.0964	1.0183	1.0370	0.8247	1.1368
	2009	0.9140	0.9801	0.8881	0.9685	0.9519	1.0021	0.9981	0.9209	0.7987	1.0821
	2010	0.9527	0.9521	0.9481	0.9268	1.0087	0.9546	0.9503	0.8731	0.7403	1.0915

		YOY change					Cumulative change				
Industry	**Year**	**Output**	**IC index**	**Capital index**	**Labour index**	**MFP**	**Output**	**IC index**	**Capital index**	**Labour index**	**MFP**
Warehousing and storage	2000						1	1	1	1	1
	2001	1.0670	1.0733	1.0009	1.0667	1.0097	1.0670	1.0733	1.0009	1.0667	1.0097
	2002	1.0699	1.1316	1.1231	1.0000	0.9756	1.1416	1.2145	1.1241	1.0667	0.9851
	2003	0.9589	1.0040	1.0169	0.9375	0.9685	1.0946	1.2194	1.1431	1.0000	0.9541
	2004	1.1665	1.2032	1.1180	1.0667	1.0130	1.2769	1.4671	1.2780	1.0667	0.9665
	2005	1.0030	0.9727	1.0019	1.1250	0.9896	1.2807	1.4271	1.2804	1.2000	0.9564
	2006	1.2629	1.1091	1.2157	1.1667	1.1043	1.6175	1.5828	1.5566	1.4000	1.0562
	2007	0.8833	0.9152	0.9267	0.9048	0.9654	1.4288	1.4487	1.4426	1.2667	1.0196
	2008	1.1457	1.1536	1.1492	1.1579	0.9930	1.6369	1.6712	1.6579	1.4667	1.0125
	2009	1.1449	1.0785	1.1290	1.2727	1.0106	1.8742	1.8024	1.8718	1.8667	1.0233
	2010	0.8639	0.7287	0.8914	0.9286	1.0737	1.6191	1.3135	1.6684	1.7333	1.0987

Figure 5.5 Transport sector – growth accounting-based productivity indicators and input indices



From figure 5.5, we see that there was a 7.2% increase in the productivity of the transport sector over the observed 10-year period. However, this growth was not smooth, as seen in the year-on-year (YOY) changes shown in table 5.5 – YOY productivity increased in six of the years and decreased in four of the years. In terms of attribution to factor inputs, the contribution of intermediate inputs growth to output growth was negative (-14.2%). Capital and labour had a positive contribution at 29.9% and 4.8% percent respectively. The residual was 7.2%, which is contribution of productivity growth.

Pursuant to the analytical expression in equation 2.6, the growth accounts can be presented in a format that shows the contribution of intermediate inputs, capital and labour to output growth, which allows the residual to be interpreted as MFP. This is shown in appendix A.

5.2.1 Road transport group

The road freight industry was a significant component of the transport sector, accounting for a little over 21%, on average, of the transport sector GDP in the years 2000–2010. Cumulative productivity growth in the road freight industry, at 12.1%, was higher than the productivity growth in the transport sector as a whole (see figure 5.6). The main driver of output growth in the road freight industry was capital (cumulatively, 29.1%). The contributions of other factor inputs were also positive and sizeable, 15.2% for intermediate inputs and 16.1% for labour.

In comparison to the road freight industry, productivity growth in the road passenger industry was lower, peaking at a little lower than 8.7% in 2009 and then falling to register an overall cumulative productivity growth of 6.8% over the observed 10-year period (see figure 5.6). The road passenger industry accounted for a smaller size of the transport sector (5.6% of transport sector VA over the period 2000–10), but the output growth in this industry was remarkable, over 63% over the observed 10-year period. In the period of analysis, only the air support services industry and the pipeline transport industry (a much smaller base) registered a higher growth rate of output. Growth in capital inputs (62%) was the largest contributor to output growth in the road passenger industry. Labour and intermediate input contributions were also sizeable and economically significant, 55.8% and 40.7% respectively.

Figure 5.6 Road freight – growth accounting-based productivity indicators and input indices

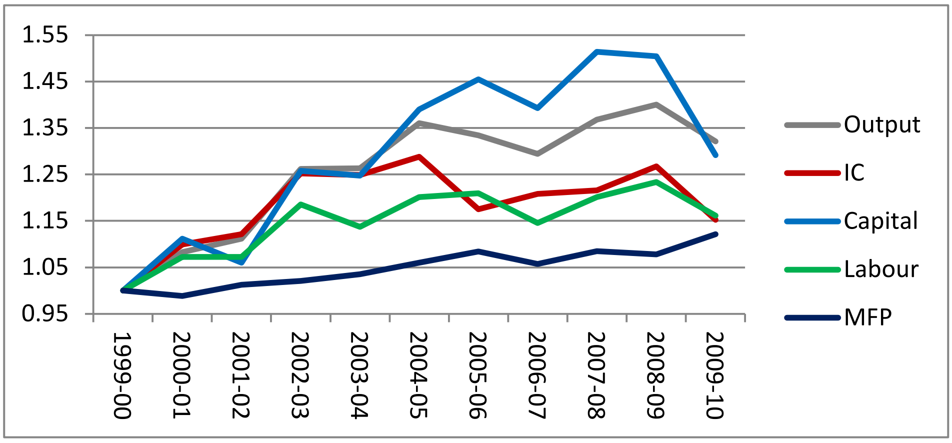
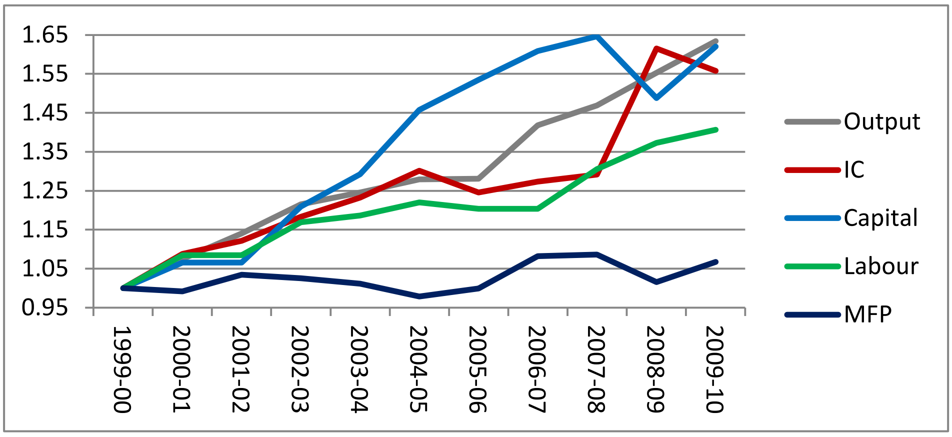


Figure 5.7 Road passenger – growth accounting-based productivity indicators and input indices



5.2.2 Water transport group

The water transport group includes water freight, water passenger and water transport services. The contribution of the water passenger services industry to the transport sector is confidentialised. The other two industries – water freight and water transport services – were not found to be hugely significant in terms of their contribution to the VA of the transport sector. Water transport services accounted for about 2% and water freight a little more than 1% of the transport sector GDP over the period 2000–2010. While these industries were not big components of the transport sector, with a combined employment of 2000 people they were still economically relevant.

The water freight industry registered a cumulative productivity growth of 11.3% over the observed period (see figure 5.8). An important observation in this industry was the large negative contribution of capital growth, cumulatively -49%. There was generally a negative trend for capital growth in this industry. The cumulative contribution of labour growth and intermediate input growth was positive, at 16.7% and 8.5% respectively. Subtracting the input growth from the 9% growth in output yielded the cumulative productivity growth rate of this industry.

The water transport services industry recorded negative productivity growth of 1.3% over the observed period; that is, 0.13% annually (see figure 5.9). This near-zero annual average growth rate was underpinned by significant fluctuations across the years. For example, the YOY productivity growth rate peaked at 5.85% in 2006 but declined to negative 9% in 2008 (see table 5.10). The main contribution to output growth was from growth in intermediate inputs (cumulatively, 22.22%). In contrast, the contribution of capital growth was very low in a cumulative sense (but still positive) at 1.7%. The contribution of labour growth was negative at -20%. The residual was the reported cumulative productivity growth rate of 1.3%.

Figure 5.8 Water freight – growth accounting-based productivity indicators and input indices

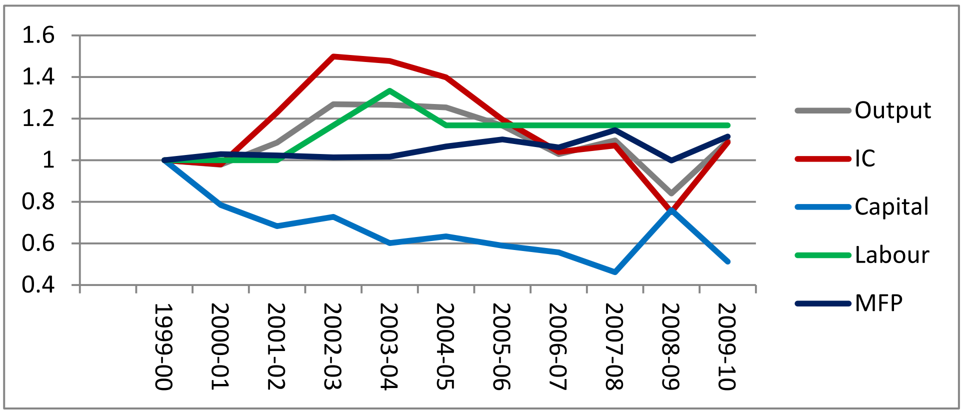
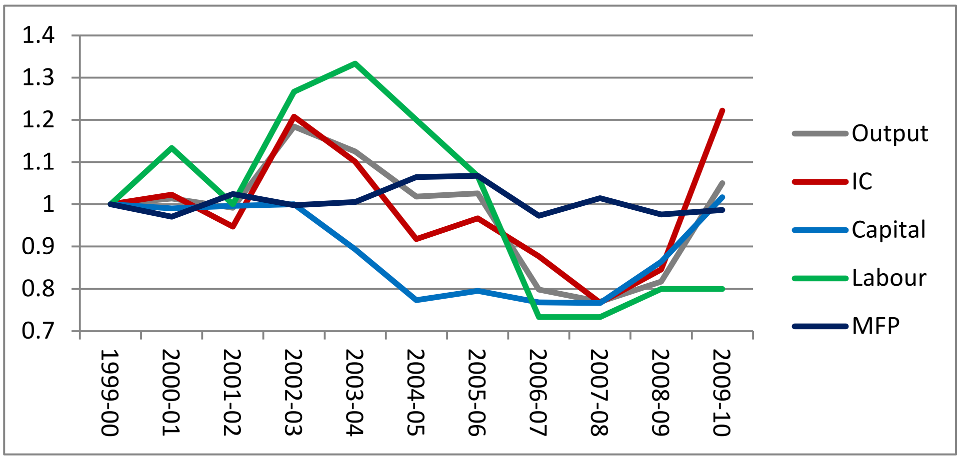


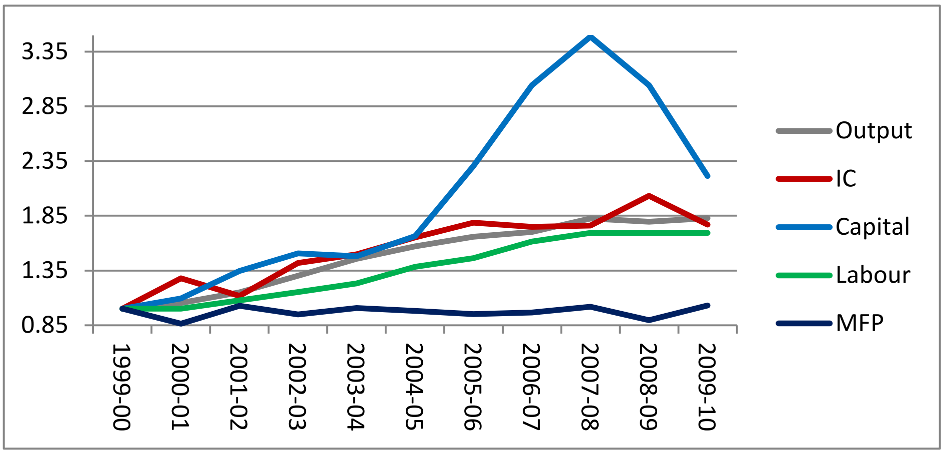
Figure 5.9 Water transport services – growth accounting-based productivity indicators and input indices



5.2.3 Air transport group

The share of the air transport industry in the overall transport sector is confidentialised. The air support services industry accounted for nearly 11.4% of the transport sector GDP over the period 2000-2010. One would expect the air transport industry to be a sizeable contributor to the transport sector, given the size of its support services industry. The cumulative productivity growth in the air support services industry over the observed period was positive (see figure 5.10), but at 3.2% this was lower than that of the broader transport sector. As mentioned earlier, the cumulative output growth air support services industry, which was one of the faster growing areas of the transport sector, was remarkable (83%). The cumulative growth in factor inputs tracked the output growth – intermediate inputs grew at 77% cumulatively, labour growth was 69%, and the cumulative capital growth was 221% (implying an average annual increase of 22%).

Figure 5.10 Air support services – growth accounting-based productivity indicators and input indices



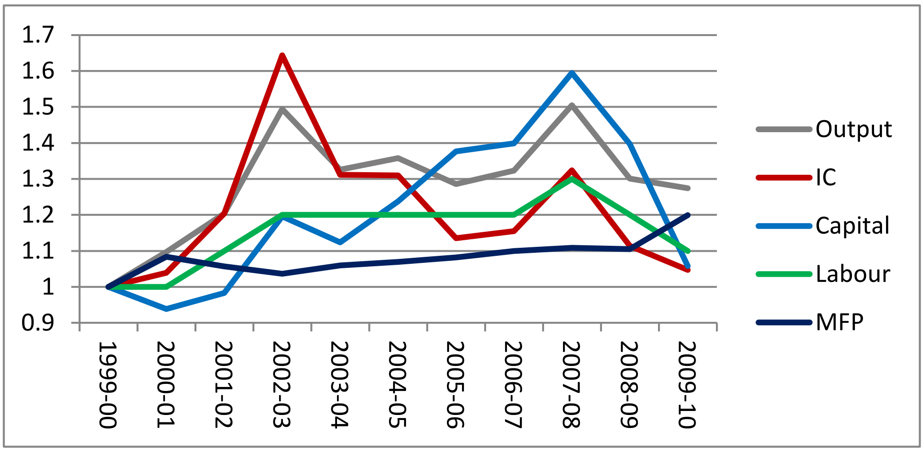
5.2.4 Others

The Others group included other transport services, pipeline transport, scenic transport, postal and courier services, and warehousing and storage services.

In terms of contribution to the transport sector VA, the contribution of the pipeline transport and scenic transport industries in the period 2000-2010 was small, 0.35% and 1.4% respectively. The average transport GDP shares of the warehousing and storage services industry and other transport services industries were higher, at 3.3% and 6% respectively. Within the Others group, the postal and courier services industry, accounting for 15.5% of transport sector GDP, was the largest contributor in terms of VA.

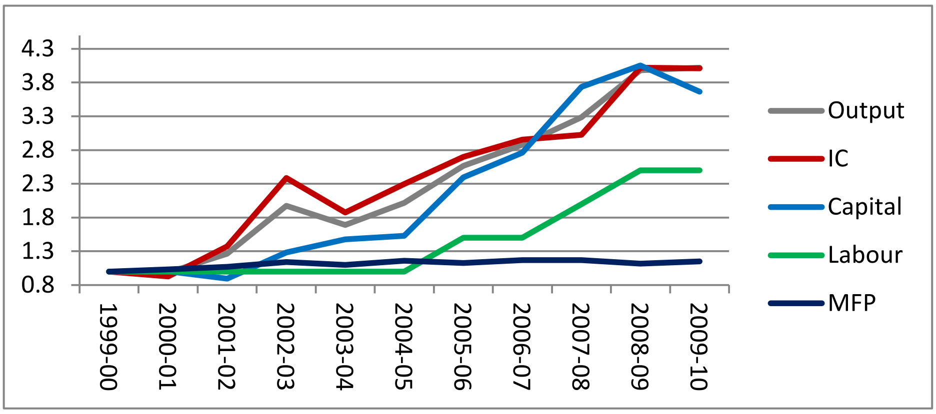
The scenic transport industry recorded the highest rate of productivity growth in the observed period (20% cumulatively). The productivity growth resulted from a lower rate of increase in inputs relative to outputs. Intermediate inputs, capital and labour grew at 4.7%, 5.8% and 10% respectively (see figure 5.11).

Figure 5.11 Scenic transport – growth accounting-based productivity indicators and input indices



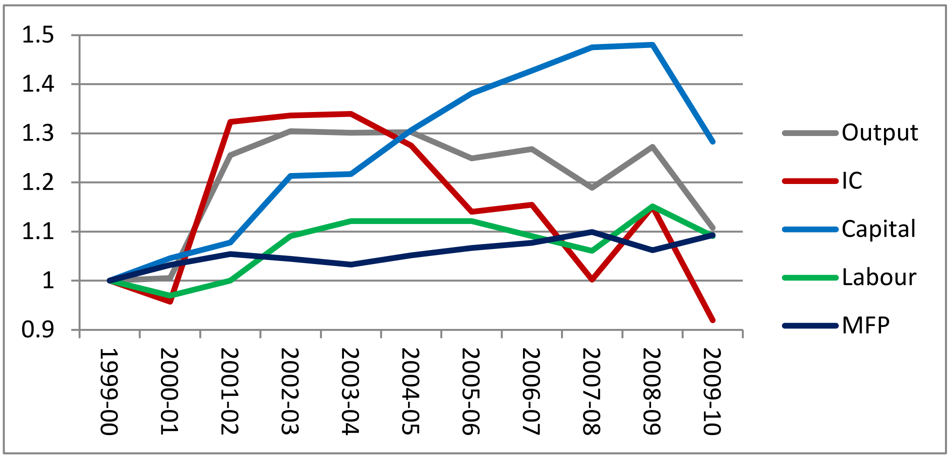
The pipeline transport industry registered the highest rate of output growth in the transport sector, although from a low base (as seen in table 4.4). The cumulative output growth over the period 2000-2010 was more than 300%; ie around 30% annually. The rate of growth of intermediate inputs matched the output growth rate in a cumulative sense. Output and intermediate input growth rates generally moved in tandem across all the years. Cumulative capital growth was 366% and labour growth was 150%. The cumulative residual output growth, which is the estimate of MFP, was 14.8% (see figure 5.12).

Figure 5.12 Pipeline transport – growth accounting-based productivity indicators and input indices



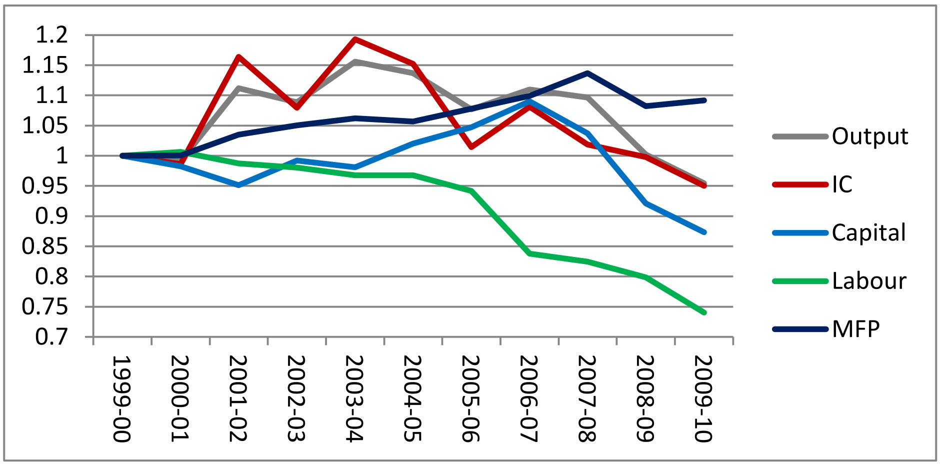
The remaining industries in the Others group registered a positive cumulative productivity growth rate of around 9% (9.3%, 9.2% and 9.9% for other transport services, postal and courier services, and warehousing and storage industries respectively). In the case of other transport services, capital growth rate was sizeable (28.3%, cumulatively). Intermediate input growth and labour growth at -9% and +9% respectively evened out (see figure 5.13).

Figure 5.13 Other transport services – growth accounting-based productivity indicators and input indices



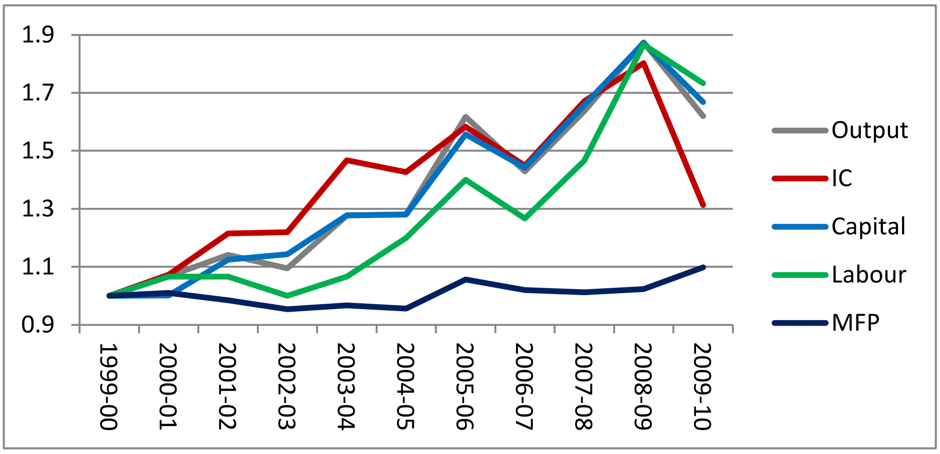
The postal and courier industry was the only transport industry that recorded a decline in output in the observed period. Cumulatively, the output of this industry declined by 4.5%, but when viewed annually, the net decline per year was only 0.45%. The inputs declined at a faster rate (intermediate inputs 5%, capital 12.7% and labour 26%) than the outputs. This resulted in a positive cumulative productivity growth rate of 9.2% for the industry (see figure 5.14).

Figure 5.14 Postal and courier services – growth accounting-based productivity indicators and input indices



The warehousing and storage industry registered a cumulative output growth of around 62% over the observed period. While cumulative capital and labour growth (67% and 73% respectively) matched output growth, intermediate input growth was relatively low, at 31% (cumulatively). The residual cumulative productivity growth was 9.9% (see figure 5.15).

Figure 5.15 Warehousing and storage – growth accounting-based productivity indicators and input indices



5.2.5 Growth accounting-based indicators – summary

The growth accounting framework presents output growth as a summation of growth of factor inputs and growth of productivity. In this section of the report, we applied the growth accounting framework to explain the output growth of sub-industries within the transport sector. Our results revealed significant heterogeneity among the sub-industries in terms of which factor inputs underpinned output growth. For example, in case of the road transport industries and air support services, capital input growth was a sizeable contributor, but the contribution of capital growth was negative in the case of the water transport industries. The results from this section demonstrate that output growth and productivity growth do not always move in tandem, and productivity growth can be low when output growth is high if input growth closely tracks or exceeds output growth (for example, in the air support services industry). Likewise, productivity growth can be high when output growth is low, as long as the input growth rates are even lower (for example, in the postal and courier services). This is because productivity growth in the growth accounting framework is derived as the residual output growth not explained by growth in factor inputs.

Comparing the productivity growth of sub-industries, we found that the road transport group registered a higher rate of productivity growth than the aggregate transport sector (see figure 5.16) – road freight 12% and road passenger 6.7%, compared with the aggregate transport productivity growth rate of 7.2%. In the case of the water transport group, the water freight industry registered a productivity growth that was comparable with road freight, at 11.28%. However, water transport services was one of the few transport industries to register a negative productivity growth rate, although the rate was quite low, at -1.3% (see figure 5.17). In the air transport group, the air transport industry data is confidentialised. The air support services industry had a modest cumulative growth of 3.2% over the observed period (see figure 5.18).

Figure 5.16 Road transport – growth accounting-based productivity indicators

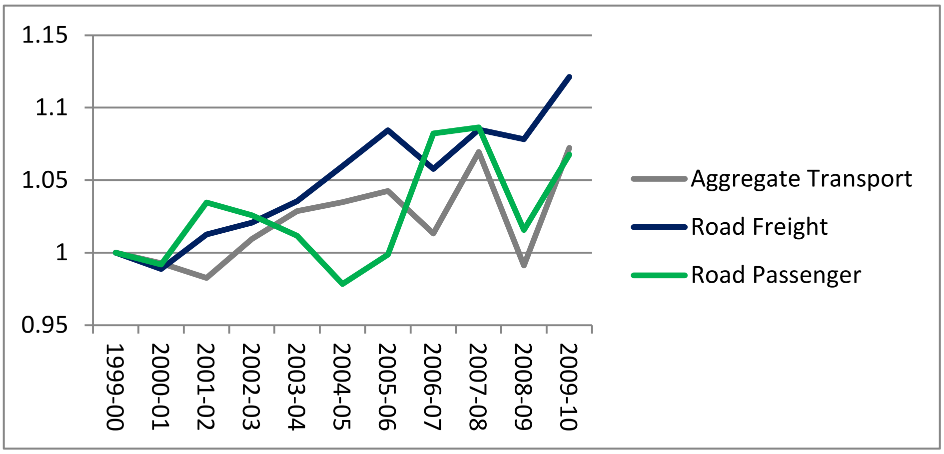


Figure 5.17 Water transport – growth accounting-based productivity indicators

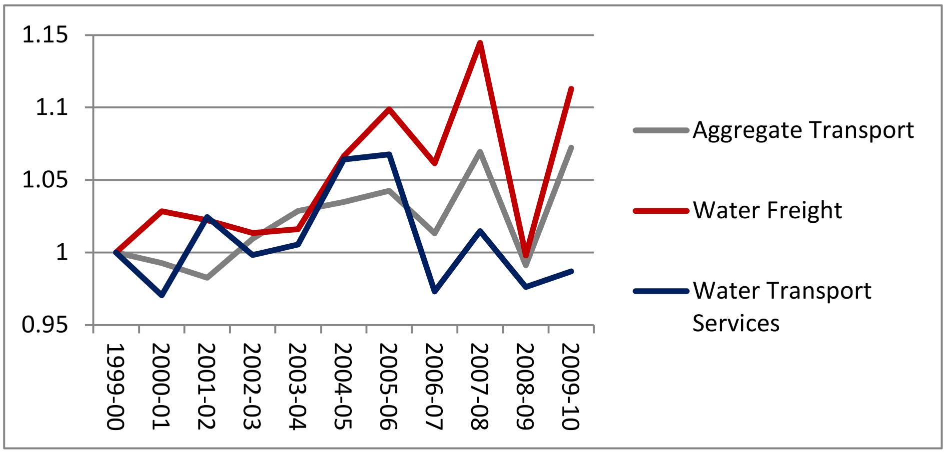
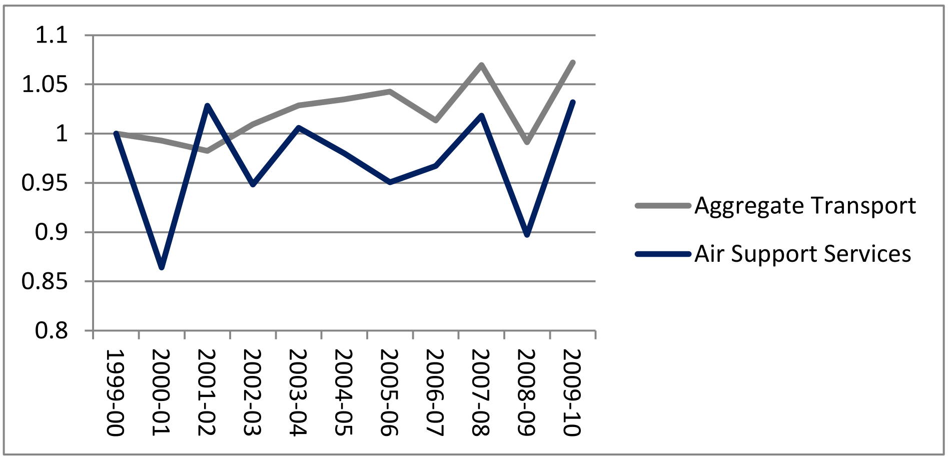
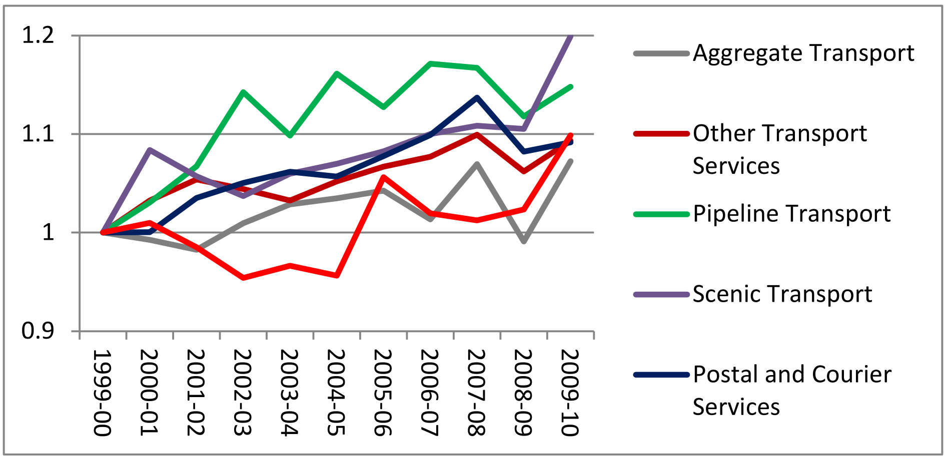


Figure 5.18 Air transport – growth accounting-based productivity indicators



Most of the Others group in the transport sector outperformed the transport sector as a whole in terms of productivity (see figure 5.19). The scenic transport and pipeline transport industries were particularly notable for their higher productivity growth over the observed period (cumulatively 20% and 15% respectively). The warehousing and storage industry was one sub-industry that underperformed relative to the aggregate transport sector for many of the years in the sample, but cumulatively the industry's productivity growth rate, at 9.9%, was higher than the productivity growth rate of the overall transport sector, at 7.2%.

Figure 5.19 Other transport industries – growth accounting-based productivity indicators



5.3 Tornqvist index-based productivity indicators

The Tornqvist index formula approach has been frequently applied to measure the productivity of industries in New Zealand and overseas. With the exception of rail transport (confidentialised), it was possible to compute a Tornqvist index of productivity for all transport industries. The transport industries were categorised under the groups of road, water, air and Others (see table 5.6).

Table 5.6 Grouping of transport industries for the Tornqvist index-based productivity indicator

Broad group	Transport industry	Data confidentialised
Road transport	Road freight	NO
	Road passenger	NO
Water transport	Water freight	NO
	Water passenger services	NO
	Water transport services	NO
Air transport	Air transport	NO
	Air support services	NO
Others	Other transport services	NO
	Pipeline transport	NO
	Scenic transport	NO
	Postal and courier services	NO
	Warehousing and storage	NO
Rail transport	Rail transport	YES

The Tornqvist index number series are presented in table 5.7. The derived productivity series can be presented in two ways: year-on-year (YOY) movements and cumulative movements. Since our focus was on long-term trends, the cumulative series was considered more suitable for the analysis, but since the cumulative series was constructed from the YOY series, we have presented and made reference to the YOY series as well. The presented indices were derived by polling cross-sectional observations for each sub-industry in each year. For the aggregate transport industry, observations across all industries were pooled by year. Thus, there was no need for weightings to be applied. This made the analysis consistent with the IO approach where, due to lack of suitable data, the analysis could not be carried out at the firm level and weighted up.

Table 5.7 Tornqvist index-based productivity indicators

Industry group	Year	GO-based					
		Year-on-year			Cumulative		
		Output	Input	MFP	Output	Input	MFP
Aggregate transport	2000				1	1	1
	2001	1.0724	1.0932	0.9809	1.0724	1.0932	0.9809
	2002	0.9678	0.9759	0.9917	1.0379	1.0669	0.9728
	2003	1.0496	0.9879	1.0624	1.0893	1.0541	1.0335
	2004	1.001	0.9759	1.0258	1.0905	1.0286	1.0601
	2005	0.9826	0.9576	1.0261	1.0715	0.985	1.0878
	2006	0.9737	0.948	1.0271	1.0433	0.9338	1.1173
	2007	1.0357	1.1085	0.9343	1.0806	1.0352	1.0439
	2008	1.0645	0.9966	1.0682	1.1503	1.0316	1.115
	2009	0.9624	1.0503	0.9163	1.107	1.0835	1.0217
	2010	0.9402	0.8453	1.1122	1.0408	0.9159	1.1364

Industry group	Year	GO-based					
		Year-on-year			Cumulative		
		Output	Input	MFP	Output	Input	MFP
Road transport grouping							
Road freight	2000				1	1	1
	2001	1.0827	1.1016	0.9829	1.0827	1.1016	0.9829
	2002	1.0267	1.0084	1.0181	1.1116	1.1109	1.0007
	2003	1.1354	1.1281	1.0065	1.2621	1.2532	1.0072
	2004	1.001	0.9962	1.0048	1.2634	1.2484	1.012
	2005	1.0768	1.0454	1.0301	1.3605	1.305	1.0425
	2006	0.9805	0.9367	1.0467	1.3339	1.2224	1.0912
	2007	0.9702	1.0139	0.957	1.2942	1.2394	1.0442
	2008	1.0572	1.0214	1.035	1.3682	1.2659	1.0808
	2009	1.0236	1.0327	0.9911	1.4005	1.3074	1.0712
	2010	0.9434	0.8992	1.0492	1.3212	1.1756	1.1239
Road passenger	2000				1	1	1
	2001	1.0744	1.0824	0.9927	1.0744	1.0824	0.9927
	2002	1.0611	1.0229	1.0374	1.14	1.1071	1.0297
	2003	1.0659	1.0749	0.9916	1.2151	1.19	1.0211
	2004	1.0253	1.0485	0.9779	1.2459	1.2477	0.9986
	2005	1.0268	1.0748	0.9553	1.2793	1.3411	0.9539
	2006	1.0011	0.9834	1.018	1.2807	1.3189	0.971
	2007	1.1073	1.0305	1.0746	1.4181	1.359	1.0434
	2008	1.0362	1.0165	1.0193	1.4693	1.3815	1.0636
	2009	1.0569	1.1451	0.923	1.5529	1.582	0.9816
	2010	1.052	0.9945	1.0578	1.6336	1.5732	1.0384
Water transport grouping							
Water freight	2000				1	1	1
	2001	0.9771	0.9597	1.0182	0.9771	0.9597	1.0182
	2002	1.1097	1.2228	0.9075	1.0843	1.1735	0.924
	2003	1.1699	1.2109	0.9662	1.2686	1.4209	0.8928
	2004	0.9977	0.9767	1.0214	1.2657	1.3879	0.9119
	2005	0.9903	0.9515	1.0408	1.2534	1.3205	0.9492
	2006	0.9296	0.8583	1.083	1.1651	1.1335	1.0279
	2007	0.883	0.8743	1.0099	1.0288	0.991	1.0382
	2008	1.0647	1.0187	1.0452	1.0954	1.0096	1.0851
	2009	0.7666	0.7452	1.0287	0.8398	0.7523	1.1162
	2010	1.2991	1.3665	0.9507	1.091	1.028	1.0612
Water passenger services	2000				1	1	1
	2001	0.7642	0.7517	1.0166	0.7642	0.7517	1.0166
	2002	0.8633	0.623	1.3859	0.6598	0.4683	1.4089
	2003	1.0539	0.9985	1.0555	0.6954	0.4676	1.487
	2004	0.948	1.0448	0.9073	0.6592	0.4886	1.3492
	2005	0.8869	0.9252	0.9586	0.5846	0.452	1.2933
	2006	0.9497	0.8831	1.0754	0.5552	0.3992	1.3908
	2007	1.0833	1.1475	0.9441	0.6015	0.4581	1.313
	2008	0.9699	0.8848	1.0962	0.5834	0.4053	1.4393

Industry group	Year	GO-based					
		Year-on-year			Cumulative		
		Output	Input	MFP	Output	Input	MFP
	2009	0.9692	1.0803	0.8972	0.5654	0.4378	1.2913
	2010	0.9739	0.8756	1.1123	0.5506	0.3834	1.4363
Water transport services	2000				1	1	1
	2001	1.0141	1.0174	0.9967	1.0141	1.0174	0.9967
	2002	0.9783	0.9393	1.0414	0.992	0.9557	1.038
	2003	1.1936	1.226	0.9736	1.1841	1.1717	1.0106
	2004	0.9498	0.909	1.0449	1.1247	1.065	1.056
	2005	0.9055	0.8385	1.08	1.0185	0.893	1.1405
	2006	1.0076	1.0495	0.9601	1.0262	0.9372	1.0949
	2007	0.7776	0.9157	0.8492	0.7979	0.8582	0.9298
	2008	0.9639	0.8934	1.0789	0.7692	0.7668	1.0031
	2009	1.0618	1.1071	0.9591	0.8167	0.8489	0.9621
	2010	1.2861	1.398	0.9199	1.0503	1.1867	0.8851
Air transport grouping							
Air transport	2000				1	1	1
	2001	1.1062	1.1333	0.9761	1.1062	1.1333	0.9761
	2002	0.8583	0.8861	0.9686	0.9494	1.0042	0.9455
	2003	1.0171	0.9173	1.1088	0.9657	0.9212	1.0483
	2004	0.9694	0.9324	1.0397	0.9361	0.8589	1.0899
	2005	0.9307	0.9052	1.0281	0.8712	0.7775	1.1205
	2006	0.9491	0.919	1.0327	0.8269	0.7145	1.1572
	2007	1.0932	1.1907	0.9181	0.9039	0.8508	1.0624
	2008	1.1119	0.9874	1.1261	1.0051	0.8401	1.1963
	2009	0.911	1.082	0.842	0.9156	0.909	1.0073
	2010	0.9114	0.8001	1.139	0.8345	0.7273	1.1473
Air support services	2000				1	1	1
	2001	1.0541	1.1493	0.9172	1.0541	1.1493	0.9172
	2002	1.0902	1.1111	0.9812	1.1493	1.277	0.9
	2003	1.1342	1.1587	0.9789	1.3035	1.4797	0.881
	2004	1.1186	1.0042	1.1139	1.4581	1.4858	0.9813
	2005	1.0779	1.1169	0.9651	1.5717	1.6595	0.9471
	2006	1.0554	1.2951	0.8149	1.6588	2.1492	0.7718
	2007	1.0271	1.2351	0.8316	1.7037	2.6544	0.6418
	2008	1.0715	1.1182	0.9583	1.8256	2.9681	0.6151
	2009	0.9833	0.9226	1.0658	1.7952	2.7384	0.6556
	2010	1.018	0.7594	1.3406	1.8275	2.0794	0.8789
Others							
Other transport services	2000				1	1	1
	2001	1.0056	0.9653	1.0418	1.0056	0.9653	1.0418
	2002	1.2488	1.3475	0.9267	1.2558	1.3008	0.9654
	2003	1.0386	1.0187	1.0195	1.3043	1.3251	0.9843
	2004	0.9977	1.0025	0.9951	1.3012	1.3284	0.9795
	2005	1.0009	0.9616	1.0409	1.3024	1.2774	1.0195
	2006	0.9588	0.9094	1.0543	1.2488	1.1618	1.0749

Industry group	Year	GO-based					
		Year-on-year			Cumulative		
		Output	Input	MFP	Output	Input	MFP
	2007	1.0151	1.0148	1.0003	1.2676	1.1789	1.0752
	2008	0.9379	0.8861	1.0584	1.1889	1.0447	1.1381
	2009	1.0704	1.1301	0.9471	1.2726	1.1806	1.0779
	2010	0.8702	0.8065	1.079	1.1074	0.9521	1.1631
Pipeline transport	2000				1	1	1
	2001	0.9864	0.9434	1.0456	0.9864	0.9434	1.0456
	2002	1.2789	1.3441	0.9515	1.2615	1.268	0.9948
	2003	1.565	1.6912	0.9254	1.9742	2.1444	0.9206
	2004	0.8549	0.8343	1.0248	1.6878	1.789	0.9434
	2005	1.1956	1.1897	1.0049	2.0179	2.1285	0.9481
	2006	1.2718	1.2364	1.0286	2.5664	2.6316	0.9752
	2007	1.1207	1.1067	1.0126	2.8762	2.9125	0.9875
	2008	1.1418	1.0919	1.0457	3.2839	3.1801	1.0326
	2009	1.2119	1.2653	0.9578	3.9798	4.0238	0.9891
	2010	1.0095	0.9775	1.0328	4.0178	3.9331	1.0215
Scenic transport	2000				1	1	1
	2001	1.0975	1.0151	1.0812	1.0975	1.0151	1.0812
	2002	1.0971	1.1336	0.9678	1.204	1.1507	1.0464
	2003	1.2408	1.3342	0.9299	1.4939	1.5353	0.973
	2004	0.8874	0.8249	1.0758	1.3257	1.2664	1.0468
	2005	1.0242	1.0206	1.0036	1.3579	1.2925	1.0506
	2006	0.9466	0.9237	1.0249	1.2854	1.1938	1.0767
	2007	1.0291	1.017	1.0119	1.3227	1.214	1.0895
	2008	1.1375	1.1445	0.9939	1.5046	1.3895	1.0829
	2009	0.8647	0.8511	1.0159	1.301	1.1826	1.1001
	2010	0.9792	0.8877	1.1031	1.274	1.0498	1.2135
Postal and courier services	2000				1	1	1
	2001	0.9915	0.9857	1.0059	0.9915	0.9857	1.0059
	2002	1.1211	1.1484	0.9763	1.1116	1.132	0.982
	2003	0.9789	0.942	1.0392	1.0882	1.0663	1.0206
	2004	1.062	1.0889	0.9754	1.1557	1.1611	0.9954
	2005	0.9834	0.9755	1.0081	1.1366	1.1326	1.0035
	2006	0.9476	0.8998	1.0531	1.077	1.0191	1.0568
	2007	1.0305	1.062	0.9704	1.1099	1.0823	1.0255
	2008	0.9878	0.9434	1.047	1.0964	1.0211	1.0738
	2009	0.914	0.9662	0.946	1.0021	0.9866	1.0157
	2010	0.9527	0.9516	1.0011	0.9547	0.9388	1.0169
Warehousing and storage	2000				1	1	1
	2001	1.067	1.0553	1.011	1.067	1.0553	1.011
	2002	1.0699	1.1296	0.9472	1.1416	1.1921	0.9576
	2003	0.9589	1.007	0.9522	1.0946	1.2005	0.9118
	2004	1.1665	1.1831	0.986	1.2769	1.4202	0.8991
	2005	1.003	0.9792	1.0243	1.2807	1.3908	0.9209
	2006	1.2629	1.1334	1.1143	1.6175	1.5763	1.0261

Industry group	Year	GO-based					
		Year-on-year			Cumulative		
		Output	Input	MFP	Output	Input	MFP
	2007	0.8833	0.918	0.9622	1.4288	1.4472	0.9873
	2008	1.1457	1.1526	0.9941	1.6369	1.6679	0.9814
	2009	1.1449	1.0909	1.0495	1.8742	1.8196	1.03
	2010	0.8639	0.7702	1.1216	1.6191	1.4015	1.1552

By combining the input and output indices to derive the MFP index, we found there was a 13.7% increase in the productivity of the transport sector over the observed 10-year period. However, this growth was not smooth, as shown in the YOY changes shown in table 5.7 – YOY productivity increases in six of the years and decreases in four of the years. This report does not attempt to reconcile the computed productivity with the official SNZ series, but at the broader 'Division I, Transport, Postal and Warehousing' level, the correlation between the GO-based Tornqvist series reported here and the official statistics is 78%, which is reasonable given the filters we applied.

5.3.1 Road transport group

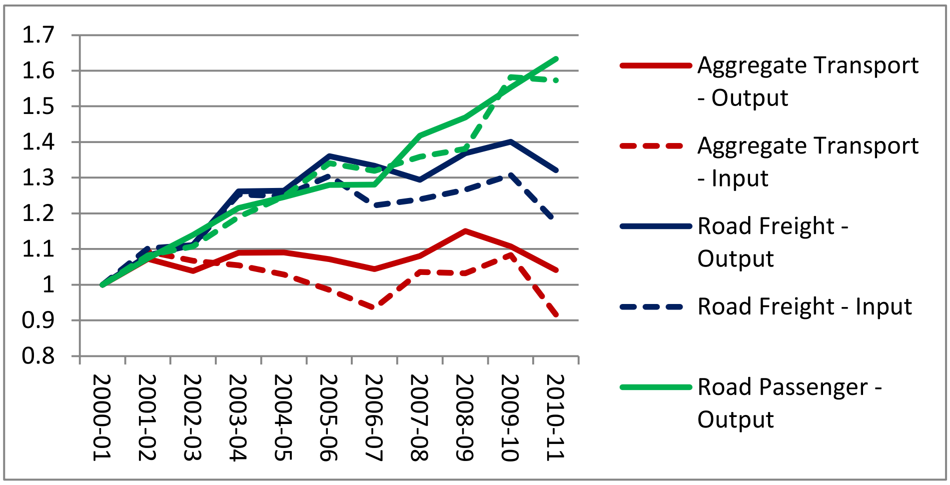
During the period 2000-2010, the road freight industry was a significant component of the transport sector, accounting for a little over 21%, on average, of the transport sector GDP. Productivity growth in the road freight industry was broadly consistent with the productivity growth in the transport sector as a whole (see figure 5.20). The road freight industry was not dominant enough to suppose that the transport sector's productivity trend was largely based on the road freight industry's productivity performance. The productivity growth of the road freight industry over the observed period was around 12.4%. Much of this growth occurred over the second half of the decade; productivity growth in the first part of the decade was more or less flat. This was not the case for the transport sector as a whole.

In comparison, productivity growth in the road passenger industry was subdued, peaking at a little lower than 6.4% in 2009 and then falling to register an overall productivity growth of less than 4% over the observed period (see figure 5.20). The road passenger industry accounted for a smaller proportion of the transport sector (5.6% of transport sector VA over the period 2000-2010). There was very low correlation (4%) between the productivity growth of the road freight and road passenger industries, suggesting that there could have been different factors at play in delivering productivity gains. For example, the road freight industry seemed to be more affected in the recent recession than the road passenger industry.

Figure 5.20 Road transport industries – Tornqvist index-based productivity indicators

Sometimes, looking only at the final productivity series might result in loss of valuable information. As noted earlier, the Tornqvist productivity index is constructed as the ratio of the output and input indices. Insights can be obtained when the output and input indices are separately considered (see figure 5.21).

Figure 5.21 Road transport industries – output and input indices



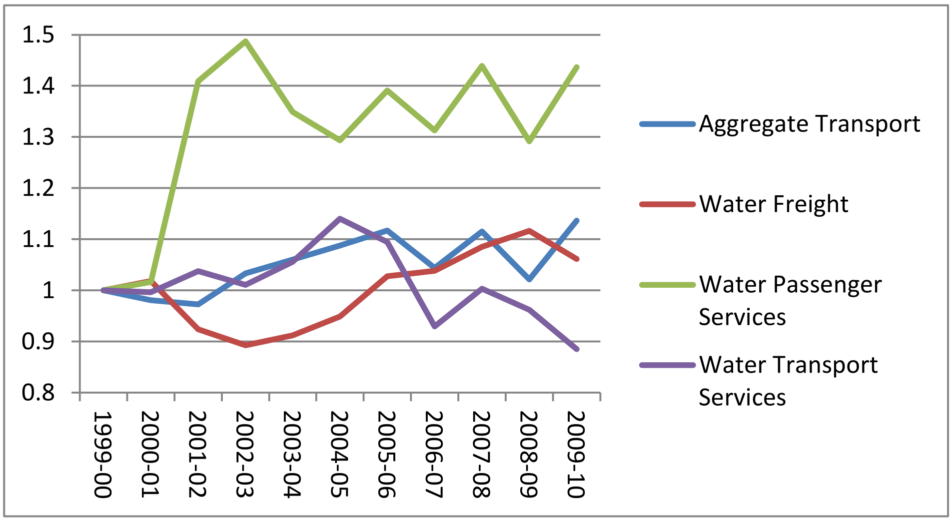
From the Tornqvist perspective, productivity growth is defined as the difference between the rate of change in output and the weighted average of the rates of change in the inputs. Therefore, the larger the gap between the output and the input lines (see figure 5.21), the greater the reported productivity (see,figure 5.20).

Figure 5.20 shows that the road passenger industry had a modest productivity growth of 6.4% over the 10-year period. This modest rate of productivity growth was underpinned by a spectacular rise in both the output and input indices, but since the rise in input index tracked the output index closely, productivity growth was subdued. This rise in the output and input indices was consistent with the increase in GO and inputs of the road passenger industry.

5.3.2 Water transport group

The water transport group included the water freight, water passenger and water transport services. The share of the water passenger services industry to the transport sector is confidentialised. The other two industries - water freight and water transport services - were not significant in terms of their contribution to the VA of the transport sector; water transport services accounted for around 2% and water freight a little more than 1% of the transport sector GDP over the observed period. As mentioned earlier, while these industries were not big components of the transport sector, with a combined employment of 2000 people they were still economically relevant.

Figure 5.22 Water transport industries – Tornqvist index-based productivity indicators



The water transport services industry recorded negative productivity growth of nearly 11.5% over the observed period, most of it during the second half of the period – after peaking at a cumulative productivity growth of 14% in 2006, there was a steady fall in the subsequent years, at 25.5% between 2007 and 2010.

In contrast, the productivity of the water passenger industry was impressive. Over the observed period, the cumulative productivity growth in the industry was 43.6%. Even though the industry in general contracted, as evidenced by the negative growth rates of the output and input indices, the cumulative input series contracted more than the cumulative output series, and the net impact on productivity growth was positive.

Productivity growth in the water freight industry was positive on the whole. Cumulatively, the increase in productivity of the water freight industry over the observed period was a little over 6%. The productivity growth series was not particularly volatile, with decreases in three of the 10 years and increases in the other years. However, the input and output series were volatile.

5.3.3 Air transport group

The share of the air transport industry in the transport sector is confidentialised. The air support services industry accounted for nearly 11.4% of the transport sector GDP over the period 2000-2010. One would expect the air transport industry to be a sizeable contributor to the transport sector, given the size of its support services industry.

Productivity growth in the air transport industry was broadly consistent with productivity growth in the transport sector as a whole. The cumulative productivity growth of the air transport industry over the observed period was 14.7%, lower than the cumulative peak of 20% recorded for the industry in 2009 (see figure 5.23). The productivity growth in this industry was underpinned by shrinking output and input series, with the input series declining faster than the output series (see figure 5.24).

In contrast to the air transport industry, productivity growth in the air services industry was negative. The cumulative decline in productivity over the observed period was 12.1% (see figure 5.23). This decline was underpinned by spectacular growth in the input and output series (see figure 5.24) – the input series more than doubled while the output series increased by over 80%. This was consistent with the summary statistics reported for this industry in table 4.4.

Figure 5.23 Air transport industries – Tornqvist index-based productivity indicators

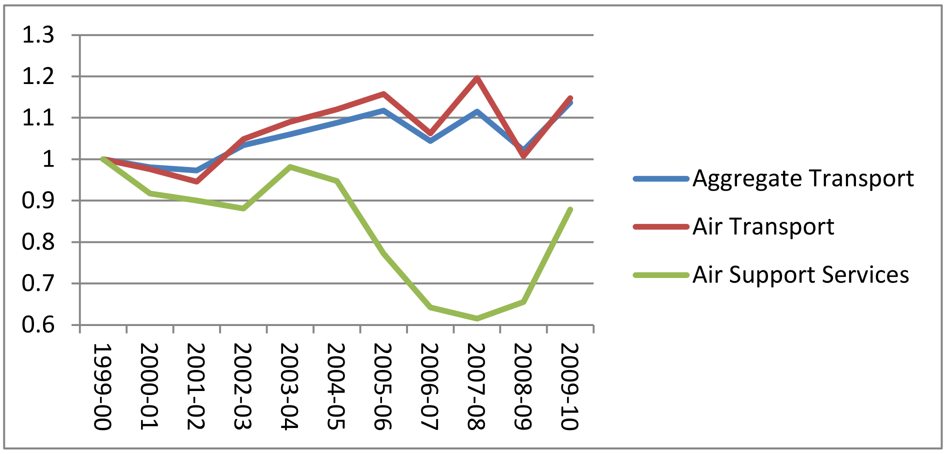
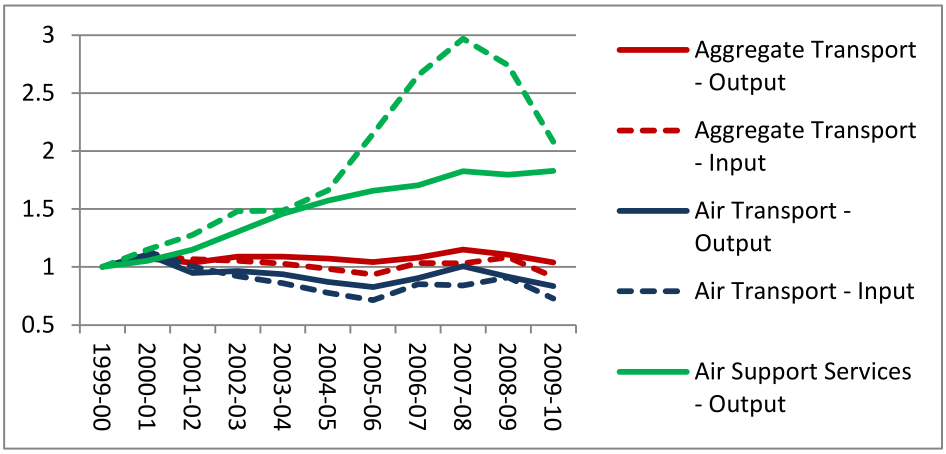


Figure 5.24 Air transport industries – output and input indices



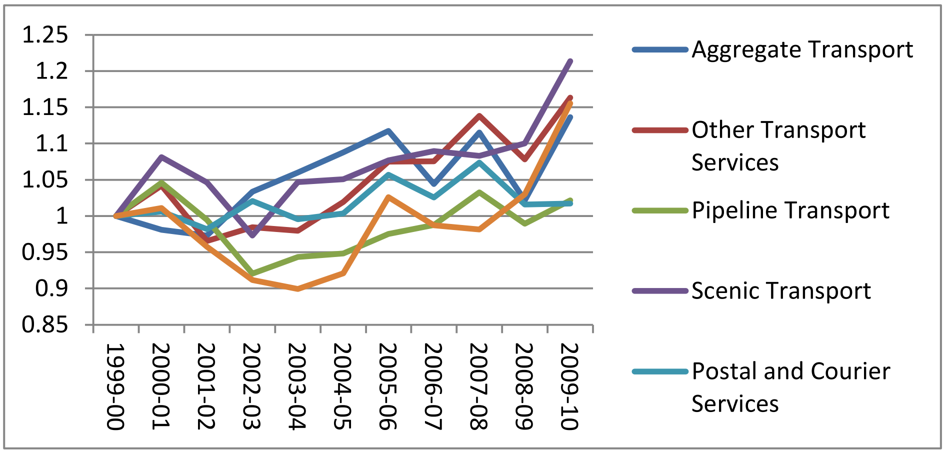
5.3.4 Others

In terms of contribution to the transport sector VA, the contribution of the pipeline transport and scenic transport industries was small, roughly 0.35% and 1.4% respectively. The average transport GDP shares (2000-2010) of the warehousing and storage services industry and other transport services industries were higher, at 3.3% and 6% respectively. Within the Others group, the postal and courier services industry, at 15.5% of the transport sector GDP, was the largest contributor in terms of VA.

In the Others group, the scenic transport industry recorded the highest rate of productivity growth in the observed period (see figure 5.25). The output series grew by over 20% while the input series grew marginally at 4%, the net result being a robust rate of productivity growth of 21.4%. The remaining industries in the Others group to register a strong growth in productivity were other transport services (16.3%) and the warehousing and storage industry (15.5%). In the warehousing and storage industry, both the output and input series rose rapidly (62% rise in output and 40% rise in input), and in the case of the other transport services, the output index increased by 10.7%, while the inputs declined by 4.8%.

The productivity growth rate in the pipeline transport and postal and courier services industry was negligible, at approximately 2.1% and 1.7% respectively. However, although the postal and courier services industry input and output series were also flat, the input and output series of the pipeline transport industry quadrupled.

Figure 5.25 Other transport industries – Tornqvist index-based productivity indicators



5.3.5 Tornqvist index-based indicators – summary

Our results indicated that the productivity growth for the transport sector over the period 2000-2010 was modest – cumulative growth of nearly 13.6% over 10 years. The productivity growth of the larger components of the transport sector, namely the road freight industry and the air transport industry, were similar to that recorded for the transport sector as a whole. The water freight industry reported slightly lower productivity growth, at 6%, but the industry's peak productivity growth touched 12% in the year 2009-2010. Productivity growth in the road passenger industry was low at 4%, but in contrast, the water passenger industry recorded productivity growth of nearly 44%.

Both water transport services and air support services industries registered a negative productivity growth rate of nearly 12%. However, the trends were not similar – while the air support services industry was in a consistent decline before picking up in the last year of observation (2010), the water services industry peaked in the year 2005-2006, with a cumulative productivity growth of 14%, but declined steeply after that. The other transport services industry had a cumulative productivity growth rate of 16%, a little over the cumulative productivity growth rate reported for the aggregate transport sector.

Among other industries making up the transport sector, the postal and courier services industry was a significant contributor in terms of VA, but its productivity growth was negligible.

5.4 Input-output (IO) tables-based productivity indicators

The MoT has generated annual IO tables for New Zealand in the SNZ datalab environment. In this research, these tables were utilised to generate a MFP time series for transport sub-industries. However, due to the change in industrial classifications during the period 1996-2010, MFP series are presented for two separate sub-periods: from 1996 to 2007, and from 2007 to 2010. Despite the overlapping year, it was not possible to merge these series to generate a reasonable and continuous series, due to changes in industry classifications. Significantly, in case of the IO-based approach, the productivity indicators for the rail industry are not confidentialised. The transport industries were categorised under the groups road, water, air and Others. However, in general the way the data is classified means that further disaggregation of these broad groups was not possible. For example, in the ANZSIC 2006-based classification, the whole road transport industry is not disaggregated further (see table 5.8).

Table 5.8 Grouping of transport industries for the IO tables-based productivity indicator

Broad group	Transport industry – ANSZIC 2006	Data confidentialised	Transport industry – ANSZIC 1996	Data confidentialised
Road transport	Road transport	NO	Road freight	NO
			Road passenger	NO
			Services to road transport	NO
Water transport	Water transport	NO	Water transport	NO
Air transport	Air and space transport	NO	Air transport	NO
Others	Scenic and sightseeing transport	NO	Postal and courier services	NO
	Other transport	NO		
	Postal and courier pick-up and delivery services	NO		
	Transport support services	NO		
	Warehousing and storage services	NO		

The ANZSIC 2006-based series was a short panel of four years. This was a constraint in terms of drawing inferences. However, as the panel's length increased, indicators based on the IO approach were increasingly useful. The IO productivity indicators are presented in tables 5.9–5.12. We emphasised the GO-based productivity indicators, while noting that the GO-based indicators and the VA-based ones were reasonably similar. The VA-based indicators are presented in appendix C (tables C.1 and C.2).

Table 5.9 IO productivity indicators, GO-based, for the period 2007-2010, as per ANZSIC 2006 classification system (YOY)

Industry	2007	2008	2009	2010
Road transport	1.0000	0.9786	0.9932	1.0097
Rail transport	1.0000	0.9256	0.9923	1.0063
Water transport	1.0000	1.1180	0.9447	1.0618
Air and space transport	1.0000	1.0271	0.8513	1.0442
Scenic and sightseeing transport	1.0000	1.0263	0.9920	1.0310
Other transport	1.0000	1.0154	1.0001	0.9884
Postal and courier pick-up and delivery services	1.0000	1.0025	0.9981	1.0079
Transport support services	1.0000	1.0213	1.0003	1.0042
Warehousing and storage services	1.0000	1.0071	0.9997	0.9885

Table 5.10 IO productivity indicators, GO-based, for the period 2007-2010, as per ANZSIC 2006 classification system (cumulative)

Industry	2007	2008	2009	2010
Road transport	1.0000	0.9786	0.9720	0.9814
Rail transport	1.0000	0.9256	0.9184	0.9242
Water transport	1.0000	1.1180	1.0562	1.1214
Air and space transport	1.0000	1.0271	0.8744	0.9131
Scenic and sightseeing transport	1.0000	1.0263	1.0181	1.0497
Other transport	1.0000	1.0154	1.0155	1.0037
Postal and courier pick-up and delivery services	1.0000	1.0025	1.0006	1.0086
Transport support services	1.0000	1.0213	1.0216	1.0259
Warehousing and storage services	1.0000	1.0071	1.0068	0.9953

Table 5.11 IO productivity indicators, GO-based, for the period 1997-2007, as per ANZSIC 1996 classification system (cumulative)

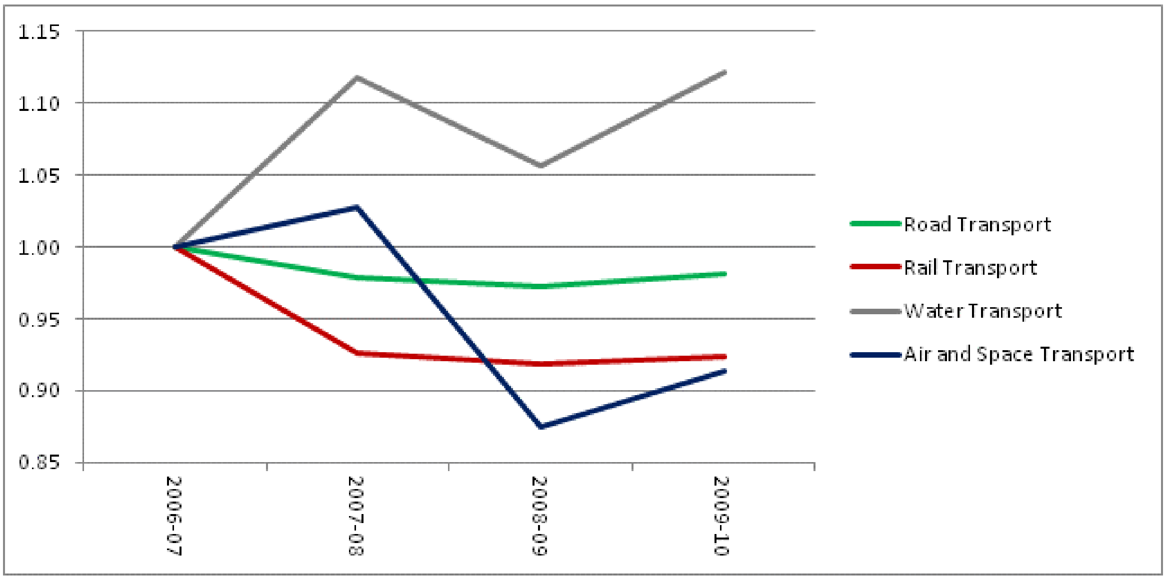
Industry	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Road freight transport	1.0000	1.0321	1.0452	1.0778	1.1051	1.0962	1.0789	1.0497	1.0645	1.0761	1.0732
Road passenger transport	1.0000	0.9961	0.9944	0.9847	0.9981	0.9732	0.9593	0.9470	0.9618	0.9621	0.9490
Services to road transport	1.0000	1.0091	1.0024	0.9913	0.9853	0.9863	0.9750	0.9668	0.9895	1.0072	1.0086
Rail transport	1.0000	1.0468	1.0528	1.0733	1.1050	1.1277	1.1690	1.2036	1.1656	1.2222	1.1861
Water transport	1.0000	1.0272	0.9804	0.9835	0.9420	0.9297	1.0163	1.1205	1.1470	1.1365	1.1210
Air transport	1.0000	0.9809	0.9561	0.9739	0.9534	0.9266	0.9825	0.9899	1.0387	1.0676	1.0311
Postal and courier services	1.0000	1.0035	1.0092	1.0118	1.0440	1.0716	1.0979	1.1129	1.1495	1.1258	1.1159

Table 5.12 IO productivity indicators, GO-based, for the period 1997-2007, as per ANZSIC 1996 classification system (YOY)

Industry	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Road freight transport	1.0000	1.0321	1.0127	1.0312	1.0253	0.9920	0.9842	0.9729	1.0141	1.0108	0.9973
Road passenger transport	1.0000	0.9961	0.9983	0.9902	1.0136	0.9750	0.9857	0.9872	1.0156	1.0003	0.9864
Services to road transport	1.0000	1.0091	0.9934	0.9890	0.9940	1.0010	0.9886	0.9916	1.0234	1.0180	1.0014
Rail transport	1.0000	1.0468	1.0058	1.0194	1.0296	1.0205	1.0366	1.0296	0.9684	1.0486	0.9705
Water transport	1.0000	1.0272	0.9545	1.0032	0.9577	0.9870	1.0931	1.1025	1.0237	0.9909	0.9863
Air transport	1.0000	0.9809	0.9748	1.0186	0.9789	0.9719	1.0603	1.0075	1.0493	1.0278	0.9658
Postal and courier services	1.0000	1.0035	1.0057	1.0026	1.0319	1.0264	1.0246	1.0136	1.0329	0.9794	0.9912

As per the IO productivity indicator, the road and rail transport industries experienced a cumulative productivity decline over the observed period, although there was a subtle revival in the last year, 2010 (see figure 5.26). The road transport industry accounted for 32% of the transport sector GDP while the rail industry accounted for 3%.[18] There was a lot more volatility in the productivity series for air and water transport industries, which accounted for 13% and 5% of the transport sector GDP respectively. Both industries registered a significant productivity increase in 2008 (11.8% for water and 2.7% for air). In the subsequent year, 2009, both industries recorded a massive fall; a YOY fall of 5.5% in the case of water transport and a fall of 14.9% in case of the air transport industry. In 2010, there was again a pick up in productivity for these two industries - the water transport industry reached a cumulative productivity high of 1.12, which implies a 12% increase over the 2007 base period. However, the productivity of the air transport industry remained 9% below its 2007 productivity index value.

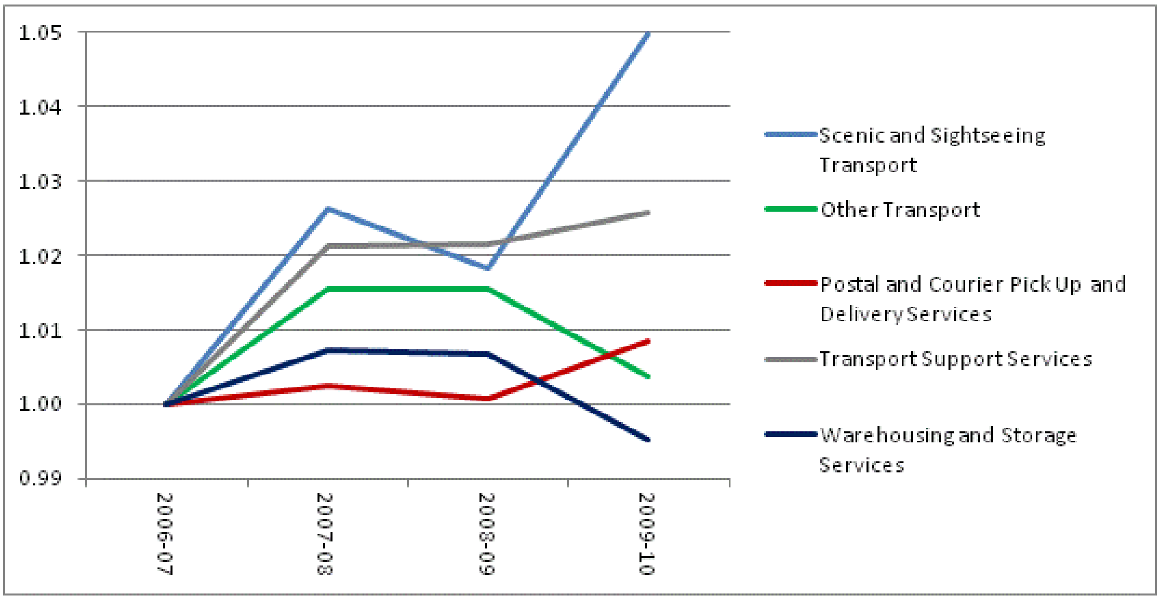
Figure 5.26 Road, water, rail and water transport GO-based cumulative productivity 2007-2010, IO approach (2006-07=1)



The Others group was a significant component of the transport sector. The cumulative productivity growth of sub-industries in this group is presented in figure 5.27. In terms of VA, this group made up 43% of the transport sector, with transport support services making up 30% of the transport sector GDP. Relative to road, air, water and rail industries, the industries in the Others group remained fairly stable. The cumulative productivity increase for the transport services industry over the observed period was 2.6%. The cumulative productivity increase in case of the other transport industry and postal and courier industry was even more subdued, at less than 1%. The scenic and sightseeing industry was relatively small, but it had a robust cumulative increase of 5% in the observed period. The only industry in the Others group to record a cumulative productivity fall was warehousing, but the decline was marginal, at about 0.5%.

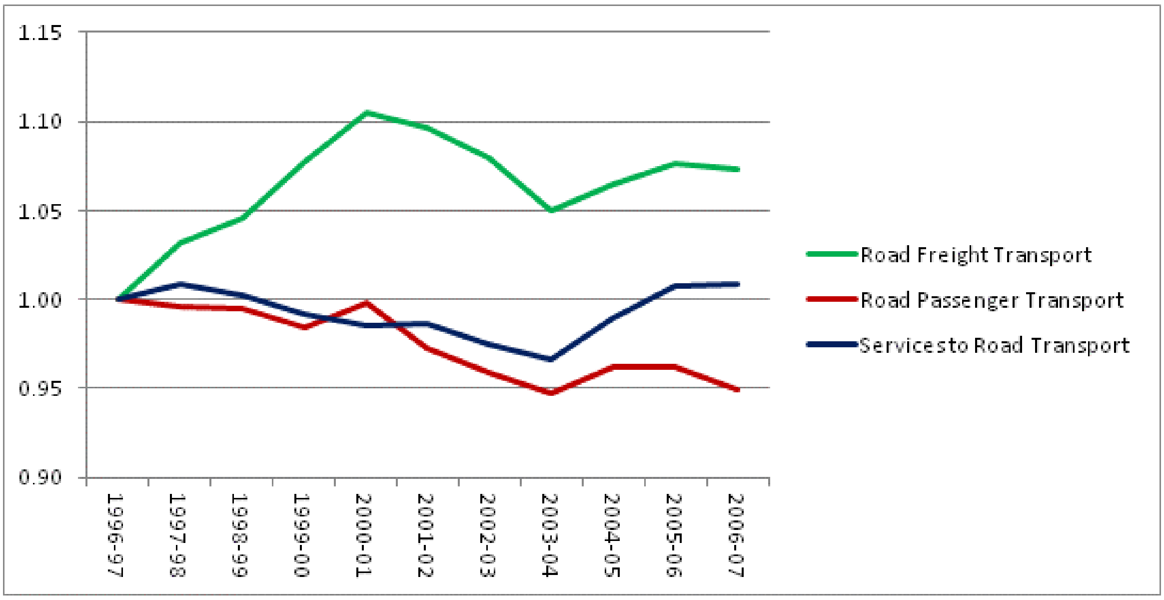
18 This was based on the publicly available IO tables for the year 2006-2007. The IO tables for the other years are confidentialised.

Figure 5.27 Other transport GO-based cumulative productivity 2007-2010 – IO approach (2006-2007=1)



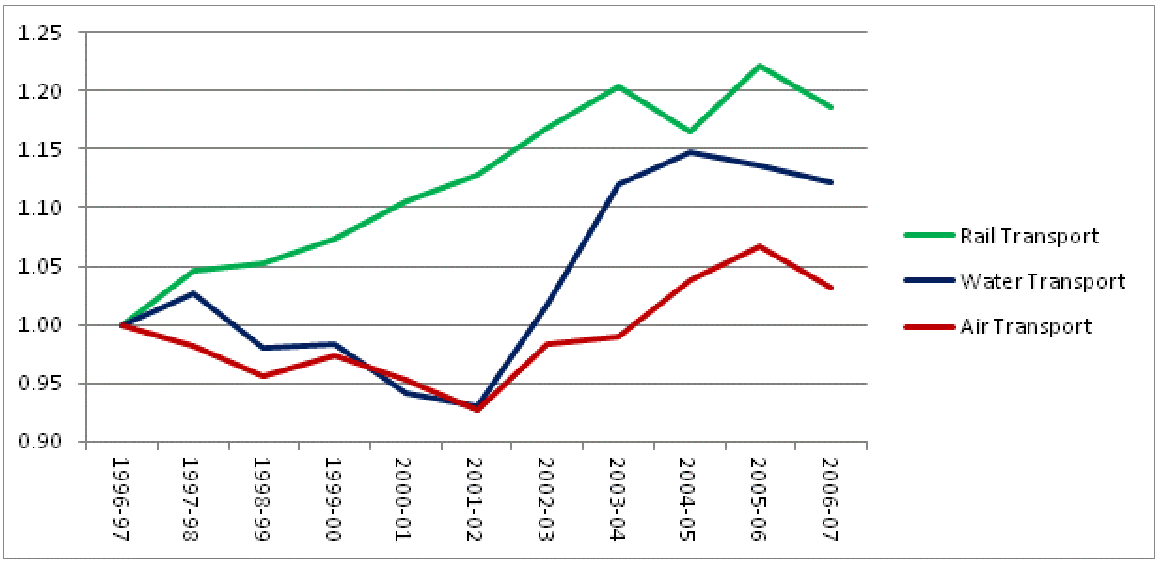
In the road transport group, only the road freight industry became more productive over the period 1996-2007 (see figure 5.28). The cumulative productivity increase is 7.3%, while the peak of 9.6% was reached in 2002. For most of the initial years, the YOY productivity change in the services to road transport industry was negative. This contributed to a general decline, although the trend reversed in 2005, after which productivity growth increased. But both the early decline and later increases were marginal, resulting in negligible cumulative productivity growth over the period. In contrast, the productivity of the road passenger industry consistently declined, to reach a cumulative index score of 95% relative to the 1996-1997 base period.

Figure 5.28 Road transport GO-based cumulative productivity 1996-2007, IO approach (2006-2007=1)



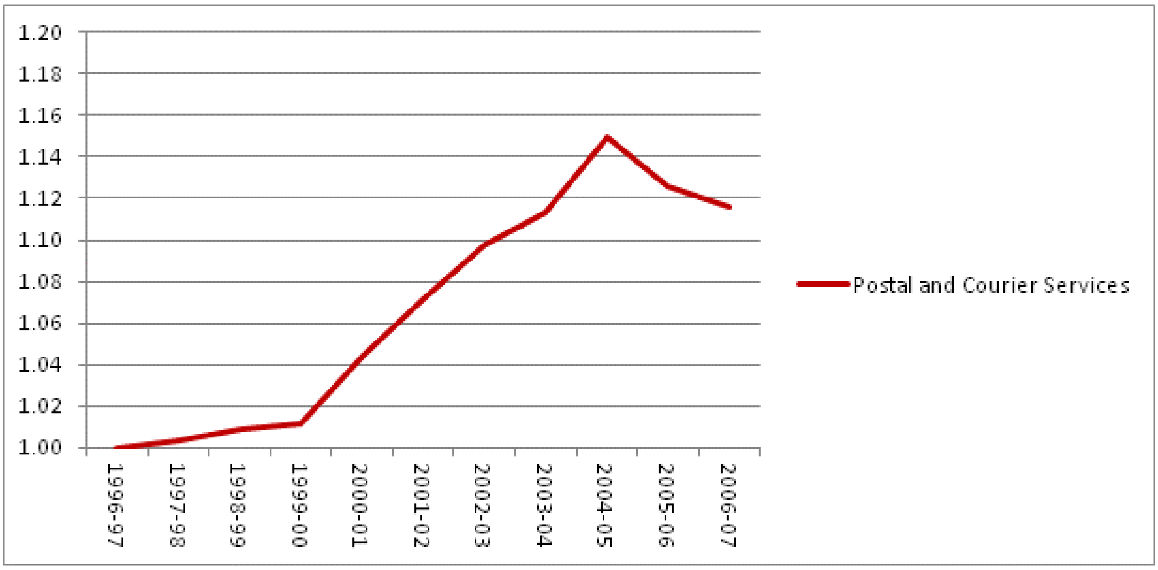
The rail industry's productivity increased rapidly over the period 1996-2007. This aligns with the period where rail services were privately owned. The cumulative productivity increase was 18.6%, having reached a peak of 22% in 2006 (see figure 5.29). The water transport industry's productivity also increased over the observed period, reaching a cumulative index of 1.12 (12% productivity growth) (see figure 5.30). In contrast, cumulative productivity growth in the air transport industry was modest, at 3%, although productivity peaked at 6.8% in 2006 (see figure 5.29).

Figure 5.29 Rail, water and air transport GO-based cumulative productivity 1996-2007, IO approach (2006-2007=1)



The postal and courier services industry was a large component of the transport sector. The industry had robust productivity growth over the observed period, peaking at 15% in 2005 and reaching 11.5% in 2007, the last year of observation (see figure 5.30).

Figure 5.30 Other transport GO-based cumulative productivity 1996-2007, IO approach (2006-2007=1)



5.5 Malmquist index-based productivity indicators

Productivity indicators computed using the Malmquist index number formula can be decomposed into two mutually exclusive and exhaustive components: TC (shifts in the frontier) and technical EC (catching up with the frontier). We exploited this characteristic of the Malmquist index and separated out the TC and EC effects. We used the parametric (SFA) to compute the Malmquist index.[19] As with the Tornqvist results, the transport industries were categorised under the groups road, water, air and Others (see table 5.13).

Table 5.13 Grouping of transport industries for the Malmquist index-based productivity indicator

Broad group	Transport industry	Data confidentialised
Road transport	Road freight	NO
	Road passenger	NO
Water transport	Water freight	NO
	Water passenger services	NO
	Water transport services	NO
Air transport	Air transport	NO
	Air support services	NO
Others	Other transport services	NO
	Pipeline transport	NO
	Scenic transport	NO
	Postal and courier services	NO
	Warehousing and storage	NO
Rail transport	Rail transport	YES

Unlike the other approaches, the Malmquist index is computed at the firm level. This means that to obtain sub-industry-specific productivity indicators, the derived productivity estimates had to be weighted up. We used firm share in the sub-industry's GO as the weight, which varied by year. The Malmquist index-based productivity indicators are presented in table 5.14 (GO-based indicators). In general, the results (shown in table 5.14) suggested a slight negative correlation (-13%) between TC and EC measures. This was a common observation and was partly due to the fact that the firms could lag behind in adopting new technology.

19 We also computed the Malmquist index based on the DEA method. The results are presented in appendix E.

Table 5.14 Malmquist index-based productivity indicators – SFA model

Industry group	Year	GO-based					
		YOY			Cumulative		
		TC	EC	MFP change	TC	EC	MFP change
Aggregate transport	2000				1	1	1
	2001	1.0036	0.9978	1.0012	1.0036	0.9978	1.0012
	2002	1.0062	0.9969	1.0030	1.0098	0.9947	1.0042
	2003	1.0063	1.0020	1.0083	1.0162	0.9967	1.0125
	2004	1.0070	1.0005	1.0074	1.0234	0.9972	1.0201
	2005	1.0068	1.0024	1.0092	1.0304	0.9996	1.0294
	2006	1.0068	1.0064	1.0133	1.0374	1.0060	1.0431
	2007	1.0065	0.9950	1.0015	1.0441	1.0010	1.0446
	2008	1.0055	1.0057	1.0113	1.0499	1.0067	1.0564
	2009	1.0056	0.9863	0.9917	1.0558	0.9929	1.0475
	2010	1.0062	1.0091	1.0151	1.0624	1.0020	1.0634
Road transport grouping							
Road freight	2000				1	1	1
	2001	1.0179	0.9934	1.0111	1.0179	0.9934	1.0111
	2002	1.0178	1.0070	1.0249	1.0360	1.0003	1.0363
	2003	1.0178	0.9990	1.0168	1.0545	0.9992	1.0537
	2004	1.0176	1.0046	1.0224	1.0731	1.0039	1.0773
	2005	1.0175	1.0272	1.0452	1.0919	1.0312	1.1259
	2006	1.0173	1.0091	1.0265	1.1108	1.0405	1.1558
	2007	1.0173	0.9920	1.0092	1.1300	1.0322	1.1664
	2008	1.0172	1.0081	1.0254	1.1494	1.0406	1.1961
	2009	1.0173	1.0016	1.0189	1.1692	1.0422	1.2186
	2010	1.0174	1.0195	1.0372	1.1895	1.0625	1.2640
Road passenger	2000				1	1	1
	2001	1.0163	0.9990	1.0152	1.0163	0.9990	1.0152
	2002	1.0165	0.9992	1.0158	1.0331	0.9982	1.0313
	2003	1.0165	0.9926	1.0090	1.0502	0.9908	1.0405
	2004	1.0165	0.9953	1.0117	1.0675	0.9861	1.0526
	2005	1.0162	0.9936	1.0098	1.0848	0.9798	1.0629
	2006	1.0161	0.9998	1.0159	1.1023	0.9797	1.0798
	2007	1.0170	0.9997	1.0166	1.1210	0.9794	1.0978
	2008	1.0163	1.0182	1.0349	1.1393	0.9972	1.1361
	2009	1.0164	0.9958	1.0121	1.1580	0.9930	1.1498
	2010	1.0168	1.0105	1.0275	1.1774	1.0034	1.1814
Water transport grouping							
Water freight	2000				1	1	1
	2001	1.0168	0.9945	1.0110	1.0168	0.9945	1.0110
	2002	1.0179	0.9986	1.0165	1.0349	0.9931	1.0276
	2003	1.0187	0.9827	1.0011	1.0543	0.9759	1.0288
	2004	1.0190	0.9930	1.0120	1.0744	0.9691	1.0411
	2005	1.0181	1.0293	1.0478	1.0938	0.9975	1.0908
	2006	1.0180	1.0094	1.0273	1.1136	1.0069	1.1206

Industry group	Year	GO-based					
		YOY			Cumulative		
		TC	EC	MFP change	TC	EC	MFP change
	2007	1.0180	1.0083	1.0262	1.1336	1.0152	1.1499
	2008	1.0188	1.0518	1.0716	1.1549	1.0678	1.2323
	2009	1.0176	0.9174	0.9334	1.1752	0.9796	1.1503
	2010	1.0172	1.1285	1.1482	1.1954	1.1055	1.3207
Water passenger services	2000				1	1	1
	2001	1.0180	0.8537	0.8716	1.0180	0.8537	0.8716
	2002	1.0193	1.1439	1.1611	1.0376	0.9766	1.0121
	2003	1.0172	0.9969	1.0139	1.0555	0.9735	1.0261
	2004	1.0211	0.9223	0.9403	1.0778	0.8979	0.9648
	2005	1.0197	0.9557	0.9746	1.0990	0.8581	0.9403
	2006	1.0153	0.9840	0.9984	1.1158	0.8443	0.9388
	2007	1.0208	1.0861	1.1061	1.1390	0.9170	1.0384
	2008	1.0186	0.9933	1.0115	1.1602	0.9109	1.0504
	2009	1.0172	0.8864	0.9017	1.1801	0.8074	0.9471
	2010	1.0159	1.0261	1.0400	1.1988	0.8285	0.9850
Water transport services	2000				1	1	1
	2001	0.9780	1.0097	0.9876	0.9780	1.0097	0.9876
	2002	0.9779	1.0483	1.0251	0.9565	1.0585	1.0124
	2003	0.9781	0.9930	0.9713	0.9355	1.0511	0.9834
	2004	0.9777	1.0024	0.9801	0.9147	1.0536	0.9638
	2005	0.9778	1.0323	1.0094	0.8944	1.0877	0.9729
	2006	0.9779	1.0106	0.9882	0.8746	1.0992	0.9613
	2007	0.9793	0.9790	0.9589	0.8565	1.0761	0.9219
	2008	0.9800	1.0289	1.0084	0.8393	1.1072	0.9296
	2009	0.9802	1.0057	0.9858	0.8227	1.1135	0.9163
	2010	0.9796	1.0340	1.0129	0.8059	1.1514	0.9281
Air transport grouping							
Air transport	2000				1	1	1
	2001	0.9901	0.9988	0.9888	0.9901	0.9988	0.9888
	2002	0.9902	0.9982	0.9884	0.9804	0.9970	0.9773
	2003	0.9908	1.0040	0.9947	0.9713	1.0009	0.9722
	2004	0.9915	1.0038	0.9953	0.9631	1.0047	0.9676
	2005	0.9904	0.9960	0.9863	0.9539	1.0006	0.9544
	2006	0.9904	1.0063	0.9967	0.9447	1.0070	0.9512
	2007	0.9901	0.9983	0.9884	0.9353	1.0052	0.9402
	2008	0.9903	1.0050	0.9953	0.9263	1.0102	0.9357
	2009	0.9901	0.9880	0.9781	0.9171	0.9981	0.9153
	2010	0.9904	1.0012	0.9916	0.9083	0.9993	0.9076
Air support services	2000				1	1	1
	2001	0.9822	0.9918	0.9744	0.9822	0.9918	0.9744
	2002	0.9839	1.0044	0.9884	0.9665	0.9962	0.9630
	2003	0.9855	1.0069	0.9924	0.9524	1.0031	0.9557
	2004	0.9840	1.0259	1.0096	0.9372	1.0291	0.9649

Industry group	Year	GO-based					
		YOY			Cumulative		
		TC	EC	MFP change	TC	EC	MFP change
	2005	0.9837	0.9969	0.9807	0.9219	1.0260	0.9463
	2006	0.9851	0.9844	0.9697	0.9082	1.0100	0.9176
	2007	0.9874	0.9824	0.9698	0.8967	0.9922	0.8899
	2008	0.9885	1.0041	0.9924	0.8865	0.9963	0.8831
	2009	0.9862	0.9954	0.9815	0.8742	0.9917	0.8668
	2010	0.9854	1.0590	1.0440	0.8615	1.0502	0.9049
Others							
Other transport services	2000				1	1	1
	2001	1.0146	1.0128	1.0276	1.0146	1.0128	1.0276
	2002	1.0160	0.9931	1.0089	1.0309	1.0058	1.0368
	2003	1.0159	1.0049	1.0208	1.0473	1.0107	1.0583
	2004	1.0162	0.9876	1.0036	1.0642	0.9983	1.0621
	2005	1.0146	1.0135	1.0281	1.0797	1.0117	1.0920
	2006	1.0158	1.0200	1.0360	1.0968	1.0319	1.1313
	2007	1.0155	1.0145	1.0301	1.1138	1.0468	1.1654
	2008	1.0148	0.9872	1.0018	1.1303	1.0334	1.1675
	2009	1.0146	1.0123	1.0270	1.1467	1.0461	1.1990
	2010	1.0146	0.9725	0.9867	1.1635	1.0173	1.1830
Pipeline transport	2000				1	1	1
	2001	1.0360	0.9969	1.0329	1.0360	0.9969	1.0329
	2002	1.0374	0.9903	1.0272	1.0748	0.9872	1.0610
	2003	1.0356	1.0029	1.0384	1.1131	0.9901	1.1018
	2004	1.0335	1.0280	1.0622	1.1503	1.0178	1.1703
	2005	1.0324	1.0020	1.0344	1.1876	1.0198	1.2106
	2006	1.0335	1.0185	1.0524	1.2274	1.0387	1.2739
	2007	1.0361	1.0069	1.0429	1.2717	1.0458	1.3286
	2008	1.0393	1.0094	1.0493	1.3217	1.0556	1.3941
	2009	1.0330	1.0141	1.0473	1.3653	1.0705	1.4601
	2010	1.0339	1.0155	1.0499	1.4115	1.0872	1.5330
Scenic transport	2000				1	1	1
	2001	1.0125	1.0214	1.0342	1.0125	1.0214	1.0342
	2002	1.0128	0.9834	0.9958	1.0255	1.0044	1.0299
	2003	1.0126	0.9921	1.0046	1.0384	0.9964	1.0346
	2004	1.0125	1.0063	1.0189	1.0514	1.0027	1.0542
	2005	1.0128	0.9976	1.0104	1.0649	1.0003	1.0652
	2006	1.0130	0.9870	0.9998	1.0787	0.9873	1.0650
	2007	1.0131	1.0020	1.0151	1.0929	0.9892	1.0811
	2008	1.0123	1.0173	1.0298	1.1063	1.0063	1.1133
	2009	1.0125	1.0139	1.0267	1.1202	1.0203	1.1430
	2010	1.0128	0.9962	1.0089	1.1345	1.0164	1.1531
Postal and courier services	2000				1	1	1
	2001	1.0489	0.9901	1.0385	1.0489	0.9901	1.0385
	2002	1.0492	0.9728	1.0205	1.1005	0.9632	1.0597

Industry group	Year	GO-based					
		YOY			Cumulative		
		TC	EC	MFP change	TC	EC	MFP change
	2003	1.0490	1.0030	1.0522	1.1545	0.9661	1.1151
	2004	1.0487	0.9836	1.0314	1.2107	0.9503	1.1501
	2005	1.0480	0.9799	1.0268	1.2688	0.9312	1.1810
	2006	1.0475	1.0068	1.0547	1.3291	0.9376	1.2455
	2007	1.0471	0.9881	1.0345	1.3917	0.9265	1.2885
	2008	1.0468	1.0015	1.0484	1.4569	0.9279	1.3509
	2009	1.0467	0.9523	0.9967	1.5250	0.8837	1.3464
	2010	1.0468	0.9705	1.0156	1.5963	0.8576	1.3674
Warehousing and storage	2000				1	1	1
	2001	1.0156	1.0169	1.0329	1.0156	1.0169	1.0329
	2002	1.0157	0.9933	1.0089	1.0316	1.0101	1.0420
	2003	1.0150	0.9902	1.0051	1.0471	1.0003	1.0473
	2004	1.0146	1.0043	1.0190	1.0623	1.0046	1.0672
	2005	1.0146	0.9992	1.0138	1.0778	1.0038	1.0819
	2006	1.0147	1.0071	1.0220	1.0937	1.0109	1.1056
	2007	1.0141	0.9929	1.0068	1.1091	1.0037	1.1132
	2008	1.0147	1.0221	1.0372	1.1254	1.0259	1.1546
	2009	1.0148	1.0089	1.0238	1.1420	1.0350	1.1821
	2010	1.0146	1.0240	1.0391	1.1587	1.0599	1.2283

5.5.1 Road transport group

The road freight industry accounted for a little over 21%, on average, of the transport sector GDP during the period 2000-2010. Historically, this industry has been the largest component of the transport sector. Using the Malmquist index to measure productivity, we found that the productivity growth of the road freight industry during the observed period was higher than that of the aggregate transport sector. The cumulative productivity growth in the road freight industry was 26.4% (see figure 5.31). In contrast, the 10-year cumulative productivity growth in the transport sector was relatively low, at 6.3%. In terms of the decomposition of productivity growth in the road freight industry, both EC and TC contributed - cumulative TC was 19% and cumulative EC was 6.3% (see figure 5.32). The Malmquist index for the road passenger industry showed a robust cumulative productivity growth of 18.1% over the observed 10-year period (see figure 5.31). The overall productivity growth rate in this industry occurred mainly because of a significant outward shift of the production frontier - the cumulative TC was 17.7% (see figure 5.32). In contrast, the change in efficiency for the road passenger industry was only marginally positive (cumulative EC of 0.3%).

Figure 5.31 Road transport industries – Malmquist index-based productivity indicators

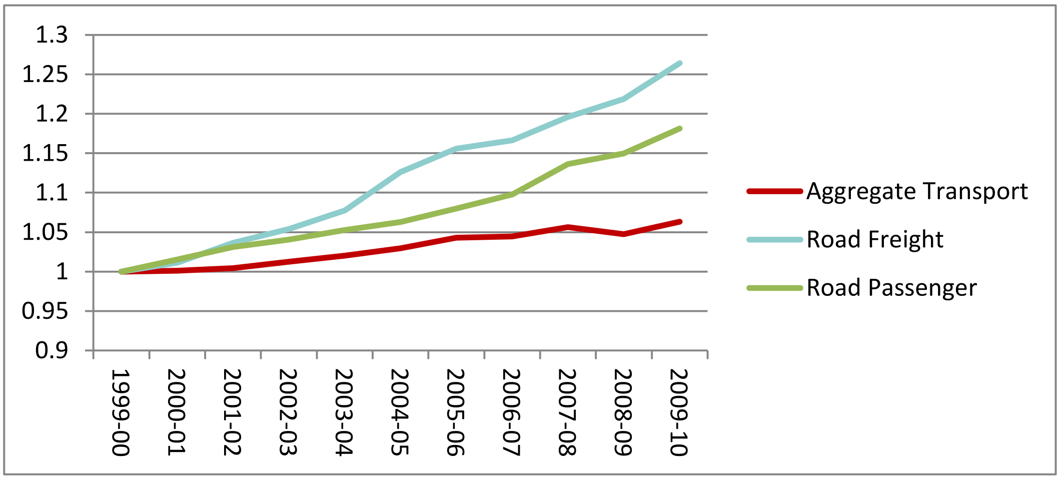
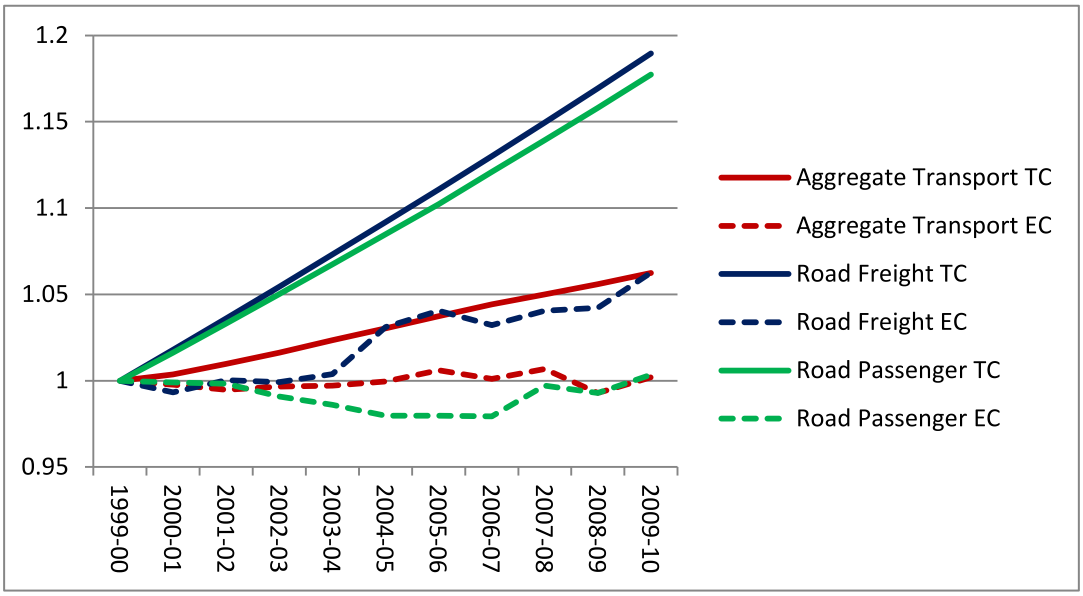


Figure 5.32 Road transport industries – TC and EC

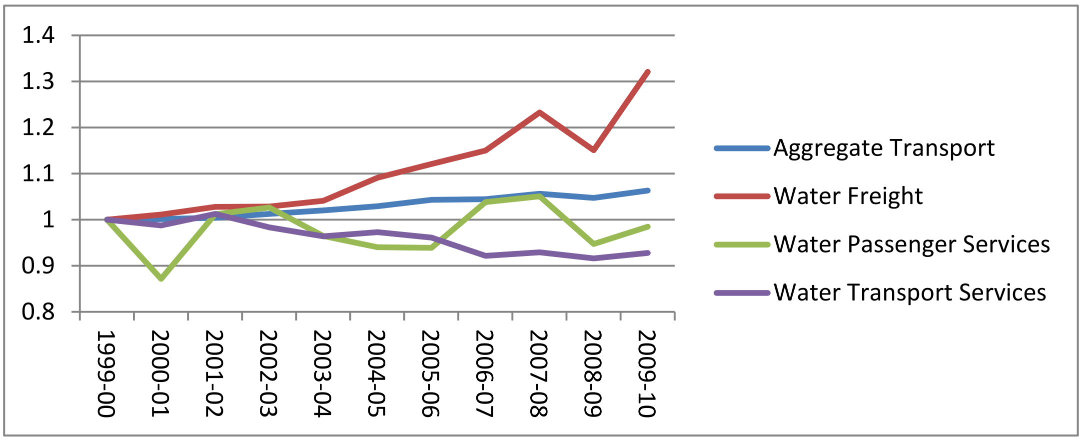


5.5.2 Water transport group

The water transport group included the water freight, water passenger and water transport services industries. The share of the water passenger services industry within the transport sector is confidentialised. The other two industries - water freight and water transport services - were not significant in terms of their contribution to the VA of the transport sector. Water transport services accounted for around 2%, and water freight a little more than 1%, of the transport sector GDP over the period 2000-2010. While these industries were not big components of the transport sector, with a combined employment of 2000 people they were still economically relevant.

Over the period 2000-2010, the water transport services industry recorded negative productivity growth of nearly 7.2% (see figure 5.33). The observed fall in productivity was mainly driven by a fall in TC (-19.4%). The cumulative efficiency gain during the same period was impressive, at 15.1%, but since the increase in efficiency was lower than the fall in TC, the change in MFP was negative. In contrast, the productivity of the water freight industry was impressive. Over the period 2000–2010, the cumulative productivity growth in the industry was 32.1%. This growth in productivity was a result of increases in both efficiency (10.6% cumulative) and TC (19.5% cumulative). On the whole, productivity growth in the water passenger industry was slightly negative (-1.5%). This was underpinned by a positive growth in TC (19.9% cumulative) and a negative change in efficiency (-17.2%).

Figure 5.33 Water transport industries – Malmquist index-based productivity indicators



5.5.3 Air transport group

The contribution of the air transport industry to the transport sector is confidentialised. Over the period 2000-2010, the air support services industry accounted for nearly 11.4% of the transport sector GDP. As mentioned earlier, one would expect the air transport industry to be a sizeable contributor to the transport sector, given the size of its support services industry.

Based on the Malmquist index, cumulative productivity growth in the air transport industry over the period 2000-2010 period was negative, at -9.2% (see figure 5.34). This fall was driven mainly by a cumulative TC decline of -9.2%. Cumulative EC was close to 0 (see figure 5.35). Productivity growth in the air services industry was similar (-9.5%) when viewed cumulatively (see figure 5.34). However, this was underpinned by a positive cumulative growth in efficiency of 5% and a large cumulative negative growth rate in TC of -13.9% (see figure 5.35).

Figure 5.34 Air transport industries – Malmquist index-based productivity indicators

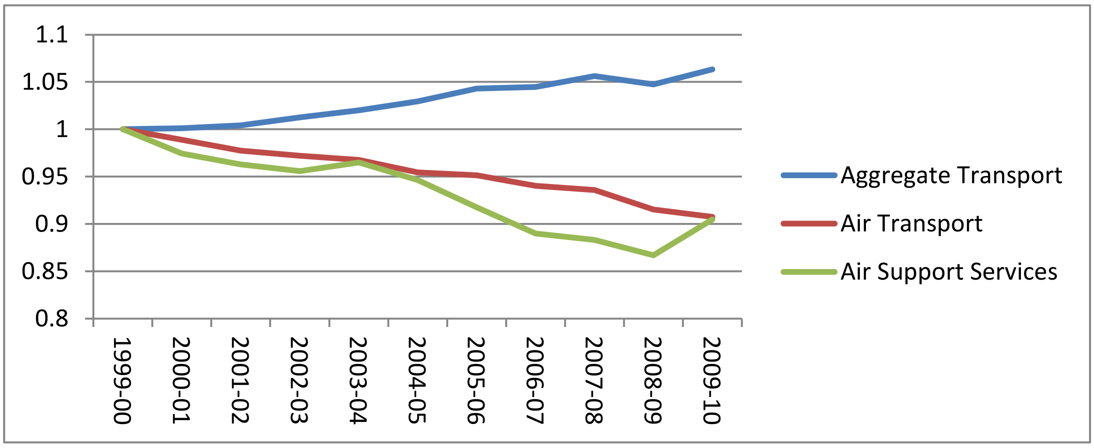
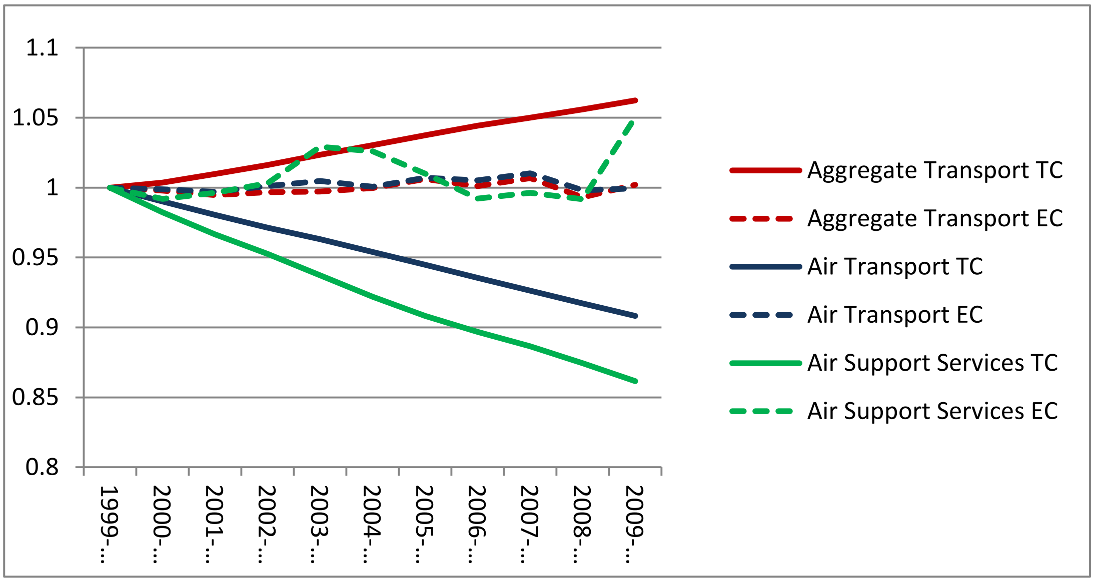


Figure 5.35 Air transport industries – TC and EC

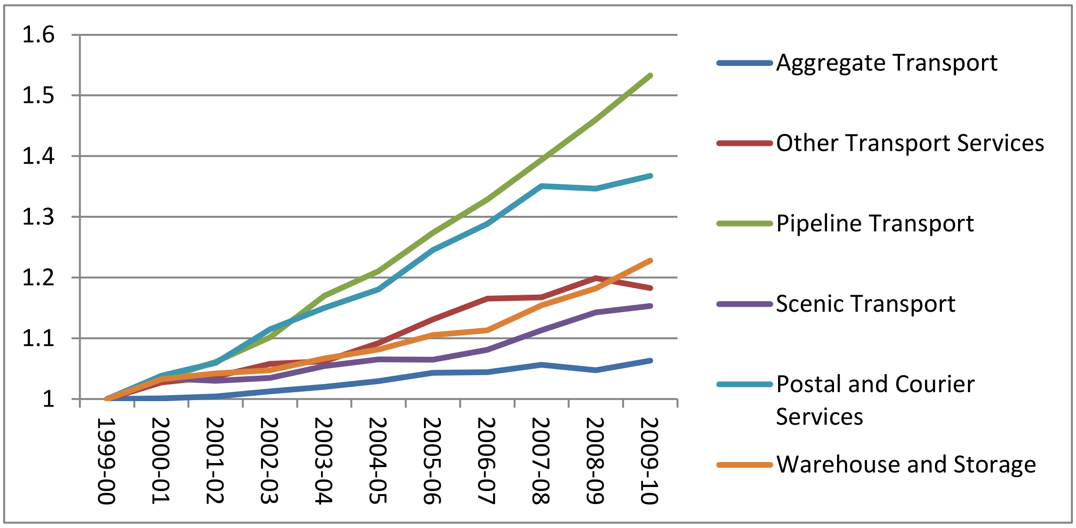


5.5.4 Other transport group

In terms of contribution to the transport sector VA, the contribution of the pipeline transport and scenic transport industries over the period 2000-2010 was small, roughly 0.35% and 1.4% respectively. The average transport GDP shares of the warehousing and storage services industry and other transport services industries were higher, at 3.3% and 6% respectively. Within the Others group, the postal and courier services industry, accounting for at 15.5% of transport sector GDP, was the largest contributor in terms of VA.

In the Others group, the pipeline transport industry recorded the highest rate of productivity growth in the observed period (see figure 5.36). The 10-year cumulative productivity growth was 53.3%, driven mainly by a robust increase in TC; cumulative growth of 41.2%. The cumulative increase in efficiency in the pipeline industry was modest, at 8.7%. The postal and courier services industry also recorded an impressive cumulative growth in TC, 59.6%. However, this was somewhat negated by a decrease in the industry's efficiency; a cumulative efficiency decrease of 14.2%. Nonetheless, the large increase in TC ensured that cumulative productivity growth of the postal and courier services industry was still high, at 36.7%. The scenic transport, other transport services, and warehousing and storage industries registered a cumulative productivity growth of 15.3%, 18.3 and 22.8% respectively (see figure 5.36). The productivity increases in all of these three industries came on the back of relatively high rates of TC and modest rates of EC.

Figure 5.36 Other transport industries – Malmquist index-based productivity indicators



5.5.5 Malmquist index-based indicators - summary

The main idea underlying the application of the Malmquist index was to obtain an indicator of productivity that could be computed without using price information. Moreover, the Malmquist index allowed for decomposing the productivity index into two mutually exclusive and exhaustive components: ECs and TCs. Our Malmquist index-based results indicated that over the period 2000-2010, the cumulative 10-year productivity growth for the transport sector was 6.3%. The growth in productivity came mainly on the back of TC, while EC was minimal at the sector level.

However, there were large differences between sub-industries. The pipeline transport, postal and courier services, water freight, road freight, and warehousing and storage industries were the top performers in terms of productivity. In all of these industries, productivity growth was driven by TC, although EC also contributed to growth (with the exception of postal and courier services, where the growth in efficiency was negative). There was a reasonable increase in productivity in the road passenger, other transport services and scenic transport services industries. Once again, the MFP growth for these industries also came from TC, and annual EC was close to zero. Three industries - water transport services, air transport and air support services -registered a negative cumulative growth rate in MFP; TC was negative and underpinned the negative growth in productivity

5.5.6 Firm-specific influencers of (in)efficiency

Table 5.15 presents the inefficiency model; the full model results are presented in appendix D. The firm concentration ratio (conc ratio) captures the market share of the top five firms in the industry. Generally speaking, if the market power is concentrated in the hands of few players, the level of competition in the market can be considered low. With a few exceptions, the coefficient on the conc ratio is statistically significant. Where the sign on the coefficient is negative, it implies a decrease in inefficiency. Conversely, where the sign on the coefficient is positive, it implies an increase in inefficiency (ie an decrease in efficiency). In this research, except in the cases of road freight, other transport services and scenic transport, higher market concentration was associated with higher levels of inefficiency. Increases in the value of the Herfindahl index (Herf index) generally indicate a decrease in competition. Across all the industries, we found that the coefficient of the Herf index was negatively signed (except for postal and courier services, where the coefficient was positively signed but not statistically significant). This meant a decrease in competition was associated with increases in the efficiency of the firms. These results are intuitive and are consistent with the extant literature - there is nothing surprising or even novel about these findings. However, the analysis provides an example of how efficiency models could be used in the IDI environment in the future to develop insights regarding factors that determine the efficiency of transport sector firms.

Table 5.15 Inefficiency model

Inefficiency model	Intercept	Time	Conc ratio	Herf index
Aggregate transport	-14.6725***	0.0770***	5.2721***	-2.9488***
Road freight	-13.3959***	-0.0188***	-99.9769***	-24.2385
Road passenger	-9.5038**	0.1614*	74.2928**	-13.3901*
Water freight	-0.7760**	-0.0263**	3.5385***	-8.6342***
Water passenger services	-0.8350**	0.1129***	1.1758*	-4.6941***
Water transport services	0.2942	-0.0271	1.2389	-8.4930***
Air transport	-1.4741***	0.0423	0.5409	-4.1530***
Other transport services	-11.4435***	-0.0369	-74.6509***	-7.3769
Pipeline transport	0.3366	-0.0482**	0.3779	-8.5753**
Scenic transport	0.4037**	0.0127	-2.2836***	-4.0887
Postal and courier services	-26.9428***	0.3661***	29.8989***	0.0064
Warehousing and storage	-0.6319***	-0.0355*	4.1922***	-7.7795***

Notes:

*** significant at 1%

** significant at 5%

* significant at 10%.

6 Conclusions and recommendations

As outlined in the first chapter of this report, this research was commissioned by the Transport Agency to analyse productivity in the transport sector, at the sub-industry level, and to develop a software/tool that could be used by the Transport Agency and the MoT to update the productivity statistics when more current data becomes available. The applied software packages are open source and have been submitted to the Transport Agency and MoT.

To meet these objectives, we carried out the following tasks:

1. Computed a labour productivity indicator for various transport sector sub-industries.
2. Computed productivity for various transport sector sub-industries using the growth accounting framework and attributed output growth to measured inputs – capital, labour and intermediate inputs, and productivity.
3. Computed productivity for various transport sector sub-industries by applying the Tornqvist index and separately identified the growth in the input and output indices.
4. Calculated productivity using the input-output (IO) tables-based approach and identified the contribution of factor inputs.
5. Computed productivity for various transport sector sub-industries by applying the Malmquist index at the firm level and decomposed productivity changes into technical changes (TCs) and efficiency changes (ECs).
6. Explored firm-specific influencers of TC and EC.
7. Developed a user manual to allow the productivity indicators to be updated. The manual has been submitted to the NZ Transport Agency and MoT.

For the productivity indicators we developed by using the growth accounting approach, the Tornqvist index and the Malmquist index, we used data from the Statistics NZ (SNZ) longitudinal business database (LBD) - this is part of the SNZ's Integrated Data Infrastructure (IDI) and contains data collected by SNZ for the national accounts. For the productivity indicators we developed using the IO approach, we used data from the IO tables developed by the MoT in the LBD environment.

The productivity analyses were undertaken at the ANZSIC group level (three digits) covering the following industries within the transport sector:

- road freight
- road passenger
- services to road transport
- water freight
- water passenger
- water transport services
- air transport
- air support services
- other transport services

- pipeline transport
- scenic transport
- postal and courier services
- warehousing and storage
- rail transport.

We found that not all the indicators of productivity conveyed the same story (see table 5.16 following). Some variation in the results was expected, as the time frame of analysis, data and the weightings applied were different. However, even though the various computed productivity indicators were spectacularly different in magnitude, there were qualitative similarities. In table 5.16, the direction of movement is aligned across the indicators (highlighted in pale grey).

In most sub-industries, the IO-based indicators were not reconcilable with the other indicators. In theory, the IO tables-based approach is simply a Tornqvist index, but in this exercise the data used for the IO-based analysis was different. It could not be determined if all of the variations in the results can be explained by the differences in the data. The two closest sets of indicators were the growth accounting and the Tornqvist indicators. This is not surprising, as they were both computed using the same data and aggregation methods. The main point of difference between the two approaches was that the growth accounting approach used a fixed input weight. The Malmquist index is different in the sense that it is a parametric approach and the analysis is firm specific. However, the Malmquist indicators were qualitatively aligned with the growth accounting and Tornqvist indicators. In general, but not always, the Malmquist indicators suggested a higher level of productivity growth than the other indicators.

At the beginning of this research, it was believed that repeating this exercise once every couple of years or so in order to update the productivity indicators would be useful. However, we are now of the opinion that it would not be particularly useful to repeat this exercise in the same form, because little policy-relevant insight would be gained by calculating productivity using several methods that are fundamentally the same. Indeed, it would only be confusing to have different indicators in the public arena. Even though there are reasons for the spectacular differences in results across indicators, they would probably be lost in the general commentary. We believe the productivity of sub-industries can be adequately computed using only the Tornqvist index number formula. As discussed earlier, some of the other methods, such as growth accounting and the IO-based approaches, are simply a form of the Tornqvist index. However, we do recommend complementing the Tornqvist-based indicators with analysis based on Malmquist index number approaches. This is because the Malmquist index approach is able to distinguish between TC and EC and also sheds light on the firm-specific determinants of productivity.

Therefore, we recommend that the Transport Agency and its partners conduct the following research in the immediate to short term – it would be most useful to conduct these projects soon because the cleaned data and the relevant software codes have been prepared and placed in the SNZ's MoT/NZ Transport Agency Transport Productivity project folder.

1 *Identifying firm-specific determinants of efficiency:* In this report, we have noted that the Malmquist index offers the possibility of distinguishing between TC and EC components of productivity. Following the comments of an internationally renowned peer reviewer, we enhanced the scope of the report to include Malmquist productivity indicators computed using the stochastic frontier approach (SFA). Specifically, we applied an SFA model known as the 'Battesse and Coeli (1995) model', which has been applied extensively in the international literature on transport efficiency and productivity. The model has a remarkable statistical property in that it allows concurrent examination of the firm-specific determinants of efficiency in the productivity equation. Most statistical models do not possess

this property. As an illustration in this report, we demonstrated how market competition influences the efficiency of individual transport operators. However, market competition is one among many variables that could potentially impact upon a firm's productivity. From a policy standpoint, it is desirable to have a closer look at productivity determinants at the firm level because of the differences between transport operators at this level. As a result of this research and the insights offered by the Transport Agency and the MoT, we believe that undertaking microdata-based research on the firm-specific determinants of EC and TC would significantly enhance the outputs produced as part of the productivity project.

2 *Bringing together transport-sector-relevant data from the IDI:* This research project was made possible only by securing access to SNZ's IDI. The IDI is a relational database comprising administrative data (eg tax returns and CUSTOMS) and survey data (eg the Business Operations Survey, R&D Survey, Annual Enterprise Survey, International Trade in Services Survey, and Royalty Survey, etc). Since the brief for this project was to measure the productivity of transport sub-industries from firm-level data, we used only sources of data that were relevant to constructing factor input and GO series. The gamut of information available in the IDI is vast and it would be fair to say that we have merely scratched the surface. The IDI offers an avenue to better understand the performance of the sector as a whole and the performance of firms in sectors on several dimensions, including exports, foreign direct investment, R&D expenditures, innovation, information and communications technology (ICT) use, international engagement, business practices and financing arrangements. In the past, SNZ has developed a dashboard of IDI indicators for the local government.[20] We were able to leverage our IDI expertise to develop a transport-sector-specific dashboard. We believe this would improve the level of understanding of the economic performance of the transport sector within the Transport Agency and the MoT, and improve the quality of information that is available for decision making. A dashboard could offer the following indicators: indicators of business performance of firms aligned to the transport sector, including firm births, deaths, summary measures of output, value added (VA), employment, exports, foreign direct investment, R&D, select measures of innovation, business practices, business performance, financing arrangements and ICT use (including broadband use). The exact outputs would have to be worked through with SNZ in order to satisfy the confidentiality requirements. Examples of policy-relevant questions that could be answered using the dashboard include the following:

Q1. What proportion of firms in the transport sector are foreign owned, both overall and by sub-sector? What is the proportion of foreign ownership in these firms, by sector?

Q2. What proportion of firms in the transport sector undertake R&D, both overall and by sector? What is the magnitude of R&D expenditure of these firms, both overall and by sector?

Q3. What proportion of firms in the transport sector undertake some form of innovation, both overall and by sub-sector?

Q4. What is the level of ICT use by firms in the transport sector, both overall and by sub-sector? What proportion of firms in the transport sector are broadband enabled? What proportion of broadband-enabled firms has access to 'fast broadband'?

Q5. What is the proportion of high-growth firms (eg defined as firms with at least 10 full-time equivalent employees and that have achieved growth in FTEs or turnover of at least 20% per year over the previous three years) in the transport sector, both overall and by sub-sector?

20 For example, http://www.stats.govt.nz/browse_for_stats/economic_indicators/gdp/regional-economic-indicator.aspx

Q6. What is the rate of growth of businesses in the transport sector, both overall and by sub-sector, by size of employment (accommodating false births and deaths)?

3 *Constructing productivity using a production function approach:* This would use a production function-based econometric approach to measure productivity of transport sector sub-industries. We have done some preliminary work on this approach (as part of checking the reliability of other indicators) and the results have been made available to the Transport Agency, Productivity Commission (PC) and MoT.

Our recommendations for future work in the medium term to long term include:

- *Constructing suitable price deflators*: Peer reviews of this report have suggested that price deflators may have played an important role in the derived results. To obtain better indicators of productivity, it is important to use disaggregated price deflator series. To our best knowledge, price deflator series at a high level of industry disaggregation are currently not available – constructing them would be a useful exercise.
- *Constructing productivity series using the data envelopment analysis (DEA):* The peer reviewers suggested that Malmquist indices derived using the DEA could potentially produce better measures of output. We know that one major problem in productivity analyses of transport sub-industries is the lack of suitable price deflators. In the DEA, one could use quantities (number of passenger-kilometres, number of freight-tonne-kilometres, etc). Specifically, the DEA would allow imposing shadow prices on these outputs and constructing an alternative output quantity indicator. The required data for this is not available in the IDI, but sub-industry-specific studies could use other sources of data.
- *Accommodating firm dynamics in the analysis:* Devine et al (2012) documented preliminary evidence that there is an association between dynamics from firm entry, expansion, shrinking and exit that influence firm and industry performance, and that productivity growth is driven by these factors. This was not included in the scope for this research project. Future work could consider such dynamics.

Table 5.16 Summary of productivity indicators

Industry	Labour productivity (2000-2010)	Growth accounting (2000-2010)	Tornqvist index (2000-2010)	Malmquist index (2000-2010) (SFA model)	IO approach (1996-2007)[a]	IO approach (2007-2010)[a]
Transport sector	+11.2%	+7.2%	+13.6%	+6.3%	NA[b]	NA
Road freight[c]	+16.2%	+12.1%	+12.4%	+26.4%	+7.3%	+1.9%
Road passenger[c]	+10.1%	+6.8%	+3.8%	+18.1%	-5.1%	+1.9%
Services to road transport[c]	NA	NA	NA	NA	+0.9%	+1.9%
Water freight[d]	-21.4%	+11.3%	+6.1%	+32.1%	+12.1%	+12.1%
Water passenger[d]	C[e]	NA	+43.6%	-1.5%	+12.1%	+12.1%
Water transport services[d]	+7.6%	-1.3%	-11.5%	-7.2%	+12.1%	+12.1%
Air transport[f]	C	NA	+14.7%	-9.2%	+3.1%	+8.7%
Air support services[f]	+8.22%	+3.2%	-12.1%	-9.5%	+3.1%	+8.7%
Other transport services	+18.7%	+9.3%	+16.3%	+18.3%	NA	+0.4%
Pipeline transport	+20.7%	+14.8%	+2.2%	+53.3%	NA	NA
Scenic transport	+25.2%	+19.9%	+21.4%	+15.3%	NA	-5%
Postal and courier services	+15.1%	+9.2%	+1.7%	+36.7%	+11.6%	+0.9%
Warehousing and storage	+3.7%	+9.9%	+15.5%	+22.8%	NA	-0.5%
Rail transport	C	NA	NA	NA	+18.6%	+7.6%

a) The IO-based statistics are presented separately for each time period as the industry classifications do not match.

b) NA = not applicable.

c) Road transport for the IO approach.

d) Water transport combines water freight, passenger and transport services for the IO approach.

e) C = confidentialised.

f) Air transport combines air transport and air transport services for the IO approach.

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Appendix A Growth decomposition

Industry	Year	Output growth	IC contribution	Capital contribution	Labour contribution	Residual (MFP)
Aggregate transport	2000					
	2001	1.0724	0.6391	0.2074	0.2340	0.0081
	2002	0.9678	0.5697	0.1868	0.2216	-0.0102
	2003	1.0470	0.5553	0.2288	0.2398	0.0230
	2004	1.0011	0.5720	0.1823	0.2281	0.0187
	2005	0.9850	0.5544	0.1928	0.2328	0.0050
	2006	0.9737	0.5345	0.2083	0.2265	0.0044
	2007	1.0357	0.6572	0.1981	0.2131	-0.0327
	2008	1.0645	0.5714	0.2026	0.2355	0.0551
	2009	0.9624	0.6383	0.1699	0.2328	-0.0785
	2010	0.9402	0.4956	0.1577	0.2170	0.0699
Road transport group						
Road freight	2000	1.0827	0.6317	0.2010	0.2624	-0.0124
	2001	1.0267	0.5858	0.1724	0.2447	0.0238
	2002	1.1354	0.6417	0.2145	0.2704	0.0088
	2003	1.0010	0.5728	0.1793	0.2347	0.0141
	2004	1.0768	0.5926	0.2015	0.2586	0.0242
	2005	0.9805	0.5244	0.1892	0.2463	0.0206
	2006	0.9702	0.5906	0.1732	0.2316	-0.0251
	2007	1.0572	0.5780	0.1965	0.2567	0.0259
	2008	1.0236	0.5990	0.1796	0.2512	-0.0063
	2009	0.9434	0.5222	0.1552	0.2303	0.0357
	2010					
Road passenger	2000					
	2001	1.0744	0.6251	0.1927	0.2654	-0.0088
	2002	1.0611	0.5921	0.1808	0.2447	0.0435
	2003	1.0659	0.6063	0.2052	0.2638	-0.0095
	2004	1.0253	0.5984	0.1932	0.2482	-0.0144
	2005	1.0268	0.6066	0.2039	0.2517	-0.0354
	2006	1.0011	0.5497	0.1904	0.2413	0.0197
	2007	1.1073	0.5877	0.1895	0.2447	0.0854
	2008	1.0362	0.5824	0.1850	0.2654	0.0034
	2009	1.0569	0.7185	0.1634	0.2574	-0.0824
	2010	1.0520	0.5542	0.1969	0.2507	0.0501
Water transport group						
Water freight	2000					
	2001	0.9771	0.5709	0.1251	0.2574	0.0238
	2002	1.1097	0.7312	0.1392	0.2574	-0.0180
	2003	1.1699	0.7111	0.1701	0.3003	-0.0116
	2004	0.9977	0.5741	0.1320	0.2942	-0.0026

Industry	Year	Output growth	IC contribution	Capital contribution	Labour contribution	Residual (MFP)
	2005	0.9903	0.5520	0.1680	0.2252	0.0451
	2006	0.9296	0.4982	0.1484	0.2574	0.0255
	2007	0.8830	0.5074	0.1511	0.2574	-0.0328
	2008	1.0647	0.6004	0.1323	0.2574	0.0746
	2009	0.7666	0.4080	0.2627	0.2574	-0.1614
	2010	1.2991	0.8438	0.1076	0.2574	0.0902
Water transport services	2000					
	2001	1.0141	0.5964	0.1581	0.2917	-0.0321
	2002	0.9783	0.5397	0.1607	0.2271	0.0508
	2003	1.1936	0.7430	0.1603	0.3261	-0.0358
	2004	0.9498	0.5314	0.1426	0.2710	0.0048
	2005	0.9055	0.4861	0.1382	0.2317	0.0496
	2006	1.0076	0.6140	0.1641	0.2288	0.0007
	2007	0.7776	0.5288	0.1542	0.1770	-0.0824
	2008	0.9639	0.5098	0.1592	0.2574	0.0375
	2009	1.0618	0.6428	0.1801	0.2808	-0.0419
	2010	1.2861	0.8424	0.1879	0.2574	-0.0016
Air transport group						
Air support services	2000					
	2001	1.0541	1.0182	0.0406	0.1661	-0.1708
	2002	1.0902	0.6963	0.0456	0.1789	0.1694
	2003	1.1342	1.0130	0.0415	0.1780	-0.0982
	2004	1.1186	0.8409	0.0365	0.1772	0.0640
	2005	1.0779	0.8781	0.0417	0.1869	-0.0287
	2006	1.0554	0.8625	0.0514	0.1754	-0.0339
	2007	1.0271	0.7794	0.0490	0.1836	0.0151
	2008	1.0715	0.8018	0.0425	0.1740	0.0532
	2009	0.9833	0.9201	0.0324	0.1661	-0.1353
	2010	1.0180	0.6938	0.0270	0.1661	0.1311
Other transport group						
Other transport services	2000					
	2001	1.0056	0.5580	0.1669	0.2496	0.0310
	2002	1.2488	0.8057	0.1646	0.2655	0.0131
	2003	1.0386	0.5888	0.1797	0.2808	-0.0107
	2004	0.9977	0.5844	0.1602	0.2646	-0.0115
	2005	1.0009	0.5547	0.1713	0.2574	0.0175
	2006	0.9588	0.5213	0.1688	0.2574	0.0113
	2007	1.0151	0.5902	0.1650	0.2505	0.0094
	2008	0.9379	0.5060	0.1650	0.2503	0.0166
	2009	1.0704	0.6696	0.1602	0.2795	-0.0389
	2010	0.8702	0.4657	0.1383	0.2439	0.0224
Pipeline transport	2000					

Industry	Year	Output growth	IC contribution	Capital contribution	Labour contribution	Residual (MFP)
	2001	0.9864	0.5401	0.1603	0.2574	0.0285
	2002	1.2789	0.8642	0.1421	0.2574	0.0152
	2003	1.5650	1.0129	0.2290	0.2574	0.0656
	2004	0.8549	0.4583	0.1842	0.2574	-0.0450
	2005	1.1956	0.7133	0.1653	0.2574	0.0596
	2006	1.2718	0.6850	0.2501	0.3861	-0.0494
	2007	1.1207	0.6387	0.1839	0.2574	0.0407
	2008	1.1418	0.5968	0.2160	0.3432	-0.0143
	2009	1.2119	0.7736	0.1733	0.3218	-0.0567
	2010	1.0095	0.5818	0.1443	0.2574	0.0260
Scenic transport	2000					
	2001	1.0975	0.6058	0.1499	0.2574	0.0843
	2002	1.0971	0.6753	0.1672	0.2832	-0.0286
	2003	1.2408	0.7958	0.1941	0.2808	-0.0299
	2004	0.8874	0.4652	0.1501	0.2574	0.0147
	2005	1.0242	0.5821	0.1757	0.2574	0.0089
	2006	0.9466	0.5053	0.1775	0.2574	0.0064
	2007	1.0291	0.5929	0.1623	0.2574	0.0164
	2008	1.1375	0.6683	0.1819	0.2789	0.0084
	2009	0.8647	0.4906	0.1399	0.2376	-0.0034
	2010	0.9792	0.5479	0.1209	0.2360	0.0745
Postal and courier services	2000					
	2001	0.9915	0.5443	0.1723	0.2745	0.0004
	2002	1.1211	0.6510	0.1699	0.2674	0.0328
	2003	0.9789	0.5119	0.1829	0.2709	0.0132
	2004	1.0620	0.6098	0.1735	0.2691	0.0097
	2005	0.9834	0.5332	0.1825	0.2727	-0.0050
	2006	0.9476	0.4858	0.1800	0.2654	0.0164
	2007	1.0305	0.5882	0.1826	0.2426	0.0171
	2008	0.9878	0.5199	0.1669	0.2685	0.0326
	2009	0.9140	0.5409	0.1558	0.2641	-0.0468
	2010	0.9527	0.5255	0.1663	0.2527	0.0081
Warehousing and storage	2000					
	2001	1.0670	0.5983	0.2012	0.2577	0.0099
	2002	1.0699	0.6308	0.2258	0.2416	-0.0282
	2003	0.9589	0.5597	0.2044	0.2265	-0.0317
	2004	1.1665	0.6707	0.2247	0.2577	0.0134
	2005	1.0030	0.5422	0.2014	0.2717	-0.0124
	2006	1.2629	0.6182	0.2444	0.2818	0.1185
	2007	0.8833	0.5102	0.1863	0.2185	-0.0317
	2008	1.1457	0.6431	0.2310	0.2797	-0.0081
	2009	1.1449	0.6012	0.2269	0.3074	0.0094
	2010	0.8639	0.4062	0.1792	0.2243	0.0542

Appendix B Tornqvist index – VA-based indicators of productivity

Industry	Year	YOY			Cumulative		
		Output	Input	MFP	Output	Input	MFP
Aggregate transport	2000				1	1	1
	2001	0.9512	1.1059	0.8601	0.9512	1.1059	0.8601
	2002	1.0318	0.996	1.0359	0.9815	1.1016	0.891
	2003	1.2307	1.2257	1.0041	1.208	1.3502	0.8947
	2004	1.0657	0.9718	1.0966	1.2874	1.3121	0.9812
	2005	0.9894	1.0244	0.9658	1.2737	1.3441	0.9476
	2006	0.9517	1.1109	0.8567	1.2122	1.4932	0.8118
	2007	0.945	1.0565	0.8945	1.1455	1.5775	0.7261
	2008	1.1154	1.0805	1.0323	1.2777	1.7046	0.7496
	2009	0.8356	0.906	0.9223	1.0677	1.5444	0.6913
	2010	1.0927	0.841	1.2992	1.1666	1.2988	0.8982
Road transport grouping							
Road freight	2000				1	1	1
	2001	1.0043	1.1115	0.9035	1.0043	1.1115	0.9035
	2002	1.0849	0.9535	1.1378	1.0895	1.0598	1.028
	2003	1.1569	1.1866	0.975	1.2605	1.2576	1.0023
	2004	1.0296	0.9918	1.0381	1.2978	1.2473	1.0405
	2005	1.0868	1.1143	0.9753	1.4104	1.3898	1.0148
	2006	0.9694	1.0465	0.9263	1.3672	1.4545	0.94
	2007	0.9256	0.9577	0.9665	1.2655	1.393	0.9084
	2008	1.05	1.0868	0.9661	1.3288	1.514	0.8777
	2009	1.0437	0.9934	1.0506	1.3868	1.504	0.9221
	2010	0.9726	0.8587	1.1327	1.3488	1.2914	1.0444
Road passenger	2000				1	1	1
	2001	1.0198	1.0657	0.9569	1.0198	1.0657	0.9569
	2002	1.1248	1	1.1248	1.147	1.0656	1.0764
	2003	1.0744	1.135	0.9466	1.2323	1.2096	1.0188
	2004	1.0305	1.0684	0.9645	1.2699	1.2923	0.9827
	2005	0.975	1.1279	0.8645	1.2382	1.4575	0.8495
	2006	0.9675	1.0528	0.919	1.1979	1.5345	0.7806
	2007	1.2019	1.0484	1.1464	1.4398	1.6088	0.895
	2008	1.0083	1.0233	0.9854	1.4517	1.6462	0.8819
	2009	0.9302	0.9037	1.0293	1.3504	1.4876	0.9077
	2010	1.1373	1.0891	1.0442	1.5357	1.6201	0.9479
Water transport grouping							
Water freight	2000				1	1	1
	2001	0.9121	0.7833	1.1644	0.9121	0.7833	1.1644
	2002	0.9668	0.8716	1.1092	0.8818	0.6827	1.2916
	2003	1.0785	1.0652	1.0125	0.951	0.7272	1.3077
	2004	1.0688	0.827	1.2924	1.0165	0.6014	1.6902
	2005	1.0097	1.0523	0.9595	1.0263	0.6329	1.6217

Industry	Year	YOY			Cumulative		
		Output	Input	MFP	Output	Input	MFP
	2006	0.9318	0.9297	1.0023	0.9563	0.5884	1.6254
	2007	0.9299	0.9462	0.9827	0.8893	0.5567	1.5973
	2008	1.0248	0.8284	1.2371	0.9114	0.4612	1.976
	2009	0.9277	1.6451	0.5639	0.8455	0.7588	1.1143
	2010	1.0898	0.6741	1.6167	0.9215	0.5115	1.8015
Water passenger services	2000				1	1	1
	2001	0.8156	0.8668	0.9409	0.8156	0.8668	0.9409
	2002	1.0536	0.4385	2.4029	0.8592	0.3801	2.2609
	2003	1.1141	1.0406	1.0706	0.9573	0.3955	2.4205
	2004	0.8702	0.967	0.8999	0.833	0.3824	2.1783
	2005	0.8174	0.9079	0.9003	0.6809	0.3472	1.9612
	2006	0.9694	0.9575	1.0124	0.6601	0.3325	1.9854
	2007	0.9611	0.9561	1.0052	0.6344	0.3179	1.9957
	2008	1.0662	1.0114	1.0541	0.6764	0.3215	2.1038
	2009	0.8442	0.9575	0.8817	0.571	0.3078	1.8548
	2010	1.0398	0.7398	1.4056	0.5937	0.2277	2.6071
Water transport services	2000				1	1	1
	2001	0.9712	0.9901	0.9809	0.9712	0.9901	0.9809
	2002	1.0485	1.0062	1.042	1.0183	0.9963	1.0221
	2003	1.1383	1.0041	1.1336	1.1591	1.0004	1.1587
	2004	0.9943	0.8934	1.1129	1.1525	0.8937	1.2896
	2005	0.9347	0.8655	1.0799	1.0772	0.7735	1.3926
	2006	0.9212	1.0281	0.896	0.9923	0.7953	1.2478
	2007	0.6865	0.9659	0.7107	0.6812	0.7682	0.8868
	2008	1.0045	0.9971	1.0074	0.6843	0.766	0.8934
	2009	1.0593	1.1281	0.939	0.7249	0.8641	0.8389
	2010	1.1223	1.177	0.9535	0.8135	1.017	0.7999
Air transport grouping							
Air transport	2000				1	1	1
	2001	0.8806	1.2036	0.7317	0.8806	1.2036	0.7317
	2002	0.8952	0.9269	0.9658	0.7883	1.1156	0.7066
	2003	1.5738	1.4007	1.1236	1.2406	1.5626	0.794
	2004	1.0896	0.9338	1.1668	1.3518	1.4591	0.9264
	2005	0.927	0.9303	0.9964	1.2531	1.3574	0.9231
	2006	0.8932	1.0177	0.8776	1.1192	1.3815	0.8102
	2007	0.8504	0.9327	0.9117	0.9518	1.2886	0.7386
	2008	1.3264	1.0505	1.2626	1.2624	1.3536	0.9326
	2009	0.5503	0.8465	0.6501	0.6947	1.1458	0.6063
	2010	1.3841	0.8728	1.5858	0.9615	1.0001	0.9615
Air support services	2000				1	1	1
	2001	0.9985	1.0943	0.9125	0.9985	1.0943	0.9125
	2002	1.1553	1.2301	0.9392	1.1536	1.3461	0.857
	2003	1.1082	1.1187	0.9906	1.2784	1.5058	0.849
	2004	1.1373	0.9835	1.1564	1.454	1.481	0.9818
	2005	1.0655	1.1233	0.9486	1.5493	1.6635	0.9313

Industry	Year	YOY			Cumulative		
		Output	Input	MFP	Output	Input	MFP
	2006	1.0299	1.3856	0.7433	1.5957	2.305	0.6923
	2007	1.0425	1.3207	0.7894	1.6635	3.0441	0.5465
	2008	1.0733	1.1457	0.9369	1.7855	3.4875	0.512
	2009	0.9542	0.8723	1.0939	1.7038	3.0422	0.5601
	2010	1.0539	0.7275	1.4488	1.7957	2.2131	0.8114
Others							
Other transport services	2000				1	1	1
	2001	1.0096	1.0457	0.9655	1.0096	1.0457	0.9655
	2002	1.0647	1.0307	1.033	1.0749	1.0777	0.9974
	2003	1.1196	1.1256	0.9946	1.2034	1.2131	0.992
	2004	1.0412	1.0034	1.0377	1.253	1.2172	1.0294
	2005	1.0397	1.0732	0.9688	1.3027	1.3063	0.9973
	2006	0.9304	1.0572	0.8801	1.212	1.3809	0.8777
	2007	1.058	1.0336	1.0236	1.2823	1.4273	0.8984
	2008	0.9839	1.0336	0.952	1.2617	1.4752	0.8553
	2009	0.9902	1.0035	0.9867	1.2493	1.4804	0.8439
	2010	1.0193	0.8665	1.1763	1.2734	1.2827	0.9927
Pipeline transport	2000				1	1	1
	2001	1.0004	1.0039	0.9966	1.0004	1.0039	0.9966
	2002	1.1414	0.8904	1.2819	1.1419	0.8938	1.2775
	2003	1.364	1.4341	0.9511	1.5575	1.2818	1.215
	2004	0.9822	1.1536	0.8514	1.5297	1.4787	1.0345
	2005	1.1135	1.0353	1.0755	1.7033	1.5308	1.1127
	2006	1.266	1.5663	0.8083	2.1565	2.3977	0.8994
	2007	1.1764	1.1517	1.0215	2.5369	2.7613	0.9187
	2008	1.2145	1.353	0.8977	3.0812	3.7361	0.8247
	2009	1.1367	1.0853	1.0474	3.5025	4.0549	0.8638
	2010	1.0117	0.9037	1.1195	3.5434	3.6644	0.967
Scenic transport	2000				1	1	1
	2001	1.1044	0.939	1.1761	1.1044	0.939	1.1761
	2002	1.0812	1.0475	1.0322	1.1941	0.9836	1.214
	2003	1.1257	1.2155	0.9262	1.3442	1.1956	1.1243
	2004	1.0071	0.9402	1.0712	1.3538	1.1241	1.2044
	2005	1.0162	1.1008	0.9231	1.3757	1.2374	1.1118
	2006	0.9513	1.1121	0.8554	1.3086	1.3761	0.951
	2007	1.0531	1.0166	1.036	1.3782	1.3988	0.9852
	2008	1.0758	1.1396	0.944	1.4826	1.5941	0.9301
	2009	0.9137	0.8761	1.043	1.3547	1.3966	0.97
	2010	1.0045	0.7573	1.3264	1.3608	1.0576	1.2866
Postal and courier services	2000				1	1	1
	2001	0.9518	0.9823	0.9689	0.9518	0.9823	0.9689
	2002	1.107	0.9685	1.1429	1.0536	0.9514	1.1073
	2003	1.032	1.0425	0.9899	1.0873	0.9919	1.0962
	2004	1.0445	0.9887	1.0565	1.1358	0.9807	1.1581
	2005	0.9676	1.0405	0.93	1.099	1.0204	1.077

Industry	Year	YOY			Cumulative		
		Output	Input	MFP	Output	Input	MFP
	2006	0.9393	1.0262	0.9153	1.0322	1.0472	0.9858
	2007	1.0113	1.0407	0.9717	1.0439	1.0898	0.9579
	2008	0.9797	0.9515	1.0296	1.0227	1.037	0.9862
	2009	0.8798	0.8881	0.9906	0.8997	0.9209	0.977
	2010	0.9427	0.9481	0.9943	0.8482	0.8731	0.9714
Warehousing and storage	2000				1	1	1
	2001	1.0118	1.0009	1.0109	1.0118	1.0009	1.0109
	2002	1.05	1.1231	0.9349	1.0624	1.1241	0.9451
	2003	0.9098	1.0169	0.8948	0.9667	1.1431	0.8457
	2004	1.154	1.118	1.0322	1.1155	1.278	0.8729
	2005	0.9985	1.0019	0.9966	1.1138	1.2804	0.8699
	2006	1.335	1.2157	1.0981	1.4869	1.5566	0.9552
	2007	0.8634	0.9267	0.9316	1.2837	1.4426	0.8899
	2008	1.0603	1.1492	0.9226	1.3611	1.6579	0.821
	2009	1.2836	1.129	1.137	1.7472	1.8718	0.9334
	2010	1.0027	0.8914	1.1249	1.752	1.6684	1.0501

Appendix C IO tables approach – VA-based indicators of productivity

Table C.1 IO productivity indicators, VA-based, for the period 2008-2010, as per ANZSIC 2006 classification system (YOY)

Industry	2008	2009	2010
Road transport	0.9691	0.9710	1.0297
Rail transport	0.9112	0.9765	1.0312
Water transport	1.1175	0.9428	1.0576
Air and space transport	1.0179	0.7756	1.0633
Scenic and sightseeing transport	1.0261	0.9816	1.0337
Other transport	1.0053	0.9872	0.9930
Postal and courier pick-up and delivery services	1.0032	0.9898	1.0118
Transport support services	1.0182	0.9961	1.0031
Warehousing and storage services	1.0056	0.9871	0.9932

Table C.2 IO productivity indicators, VA-based, for the period 2007-2010, as per ANZSIC 2006 classification system (cumulative)

Industry	2007	2008	2009	2010
Road transport	1.0000	0.9691	0.9410	0.9690
Rail transport	1.0000	0.9112	0.8899	0.9176
Water transport	1.0000	1.1175	1.0536	1.1143
Air and space transport	1.0000	1.0179	0.7895	0.8394
Scenic and sightseeing transport	1.0000	1.0261	1.0073	1.0412
Other transport	1.0000	1.0053	0.9925	0.9855
Postal and courier pick-up and delivery services	1.0000	1.0032	0.9930	1.0048
Transport support services	1.0000	1.0182	1.0142	1.0173
Warehousing and storage services	1.0000	1.0056	0.9927	0.9859

Appendix D Production function parameters – stochastic frontier approach (SFA)

Based on the equation (estimated separately for each industry):

$$\ln y_{it} = \beta_0 + \sum_{n=1}^{N} \beta_n \ln x_{nit} + \frac{1}{2} \sum_{n=1}^{N} \sum_{j=1}^{N} \beta_{nj} \ln x_{nit} \ln x_{nit} + \sum_{n=1}^{N} \beta_{tn} t \ln x_{nit} + \beta_t t + \frac{1}{2} \beta_{tt} t^2 + v_{it} - u_{it} \,,$$

i=1,2,...,I , t=1,2,...,T,

Translog function vector	Aggregate transport	Road		Water			Air	Others				
		Freight	Passenger	Freight	Passenger services	Transport services	Air transport	Other transport services	Pipeline transport	Scenic transport	Postal & courier services	Warehousing & storage
Intercpt	11.852	11.949	10.582	13.276	13.845	13.078	14.853	14.293	15.220	12.652	10.587	13.069
M	- 0.671	- 0.787	- 0.563	- 1.082	- 1.274	- 0.737	- 0.887	- 1.198	- 0.706	- 0.940	- 0.454	- 0.740
K	- 0.144	0.072	- 0.228	0.658	- 0.087	0.094	- 0.541	0.183	- 0.609	- 0.250	- 0.021	- 0.249
L	2.004	1.885	2.267	1.251	4.687	1.591	3.019	2.222	1.719	3.038	1.058	2.059
T	0.067	0.037	0.036	- 0.032	0.208	- 0.026	0.065	- 0.018	- 0.013	- 0.007	0.034	0.033
M2	- 0.018	- 0.001	0.000	- 0.001	- 0.002	0.002	0.000	0.000	- 0.002	0.000	- 0.001	- 0.002
K2	- 0.142	0.072	0.065	0.073	0.083	0.067	0.078	0.085	0.083	0.089	0.038	0.073
L2	0.026	0.019	0.026	- 0.029	- 0.006	0.008	0.050	0.006	0.075	0.027	- 0.004	0.033
T2	- 0.017	0.080	0.090	0.021	0.232	0.014	0.142	0.074	0.002	0.141	0.031	0.072
MK	0.082	- 0.025	- 0.010	- 0.013	0.026	- 0.026	- 0.025	- 0.017	- 0.064	- 0.017	0.020	- 0.026
ML	0.038	- 0.144	- 0.175	- 0.136	- 0.334	- 0.118	- 0.148	- 0.167	- 0.100	- 0.245	- 0.076	- 0.145
MT	- 0.001	0.002	- 0.000	0.002	0.000	- 0.001	- 0.003	0.004	0.005	0.000	- 0.001	- 0.002
KL	0.001	0.002	- 0.017	0.082	- 0.050	0.037	- 0.103	0.011	- 0.027	- 0.009	- 0.000	- 0.012

Translog	Aggregate	Road		Water			Air	Others				
KT	- 0.003	- 0.003	- 0.003	- 0.000	- 0.007	0.003	- 0.000	- 0.003	- 0.002	0.003	- 0.001	0.002
LT	0.002	0.001	0.004	0.005	- 0.020	- 0.005	- 0.002	0.003	0.007	- 0.007	0.007	- 0.003
Sigma2	3.281	3.569	1.055	0.272	0.182	0.291	0.342	4.669	0.161	0.110	3.711	0.183
gamma	0.983	0.993	0.951	1.000	1.000	0.920	0.773	0.995	0.818	0.344	0.988	0.807

Appendix E Malmquist index-based productivity indicators computed using the non-parametric DEA

Limited by the availability of the data in the LBD and methodological constraints, the analysis for this research project covered the period 2005-2010. Although data from 2000-2010 was available, the DEA-based Malmquist index required a balanced panel of firms that were live across the entire period. This meant that there was a trade-off between the cross section and time dimensions. If we opted in favour of using the entire time series, the number of cross-sectional observations (firms) would have dropped dramatically; essentially only firms that were live for all 10 years would have been present in the sample. This would not have allowed a reasonable capture of the transport sector. At the other end of the spectrum, using two years data would have allowed us to pick up a large chunk of the firms in our sample, but the analysis would have effectively become cross-sectional (the first year would have been lost while reporting the growth rate).

We examined the trade-offs between these two spectrums and opted in favour of an analytical window that covered the period 2005-2010. We believe that this was a major restriction. Generally, the entry and exit of firms is an important contributor to productivity growth, so a balanced panel excludes important information. The limited time period also hampered the comparison across the different measures. Therefore, this analysis has been relegated to the appendix (see table E.1) and should be read only for an illustration of how DEA could be applied to compute the productivity of transport sub-industries. The DEA model we used assumed constant returns to scale.

Table E.1 Malmquist index formula-based productivity indicators (GO indicators)

Industry	Year	YOY			Cumulative		
		EC	TC	MFP change	EC	TC	MFP change
Aggregate transport	2005				1	1	1
	2006	1.068	0.953	1.017	1.0680	0.9530	1.0170
	2007	1.044	0.945	0.987	1.1150	0.9006	1.0038
	2008	0.991	1.026	1.017	1.1050	0.9240	1.0208
	2009	0.981	0.981	0.963	1.0840	0.9064	0.9831
	2010	0.956	1.071	1.024	1.0363	0.9708	1.0067
Road transport grouping							
Road freight	2005				1	1	1
	2006	0.982	1.027	1.009	0.9820	1.0270	1.0090
	2007	1.042	0.938	0.977	1.0232	0.9633	0.9858
	2008	0.985	1.034	1.019	1.0079	0.9961	1.0045
	2009	0.971	1.004	0.975	0.9787	1.0001	0.9794
	2010	1.031	0.994	1.025	1.0090	0.9941	1.0039
Road passenger	2005				1	1	1
	2006	1.017	1.014	1.032	1.0170	1.0140	1.0320
	2007	0.973	1.041	1.013	0.9895	1.0556	1.0454
	2008	1.058	0.947	1.002	1.0469	0.9996	1.0475
	2009	0.92	1.084	0.997	0.9632	1.0836	1.0444
	2010	0.91	1.145	1.042	0.8765	1.2407	1.0882

Industry	Year	YOY			Cumulative		
		EC	TC	MFP change	EC	TC	MFP change
Water transport grouping							
Water transport services	2005				1	1	1
	2006	0.951	1.036	0.985	0.9510	1.0360	0.9850
	2007	1.068	0.861	0.919	1.0157	0.8920	0.9052
	2008	0.833	1.228	1.023	0.8461	1.0954	0.9260
	2009	1.094	0.927	1.014	0.9256	1.0154	0.9390
	2010	0.94	0.997	0.937	0.8700	1.0124	0.8798
Air transport grouping							
Air transport	2005				1	1	1
	2006	0.95	1.141	1.085	0.9500	1.1410	1.0850
	2007	1.016	0.986	1.002	0.9652	1.1250	1.0872
	2008	1.011	0.982	0.992	0.9758	1.1048	1.0785
	2009	1.015	0.95	0.964	0.9905	1.0495	1.0396
	2010	0.861	1.236	1.065	0.8528	1.2972	1.1072
Air support services	2005				1	1	1
	2006	1.054	1.003	1.057	1.0540	1.0030	1.0570
	2007	1.076	0.838	0.902	1.1341	0.8405	0.9534
	2008	1.058	1.015	1.074	1.1999	0.8531	1.0240
	2009	0.899	0.992	0.892	1.0787	0.8463	0.9134
	2010	0.965	1.135	1.095	1.0409	0.9605	1.0001
Others							
Other transport services	2005				1	1	1
	2006	1.131	0.924	1.045	1.1310	0.9240	1.0450
	2007	0.985	0.997	0.982	1.1140	0.9212	1.0262
	2008	1.012	1.049	1.061	1.1274	0.9664	1.0888
	2009	0.99	0.965	0.956	1.1161	0.9325	1.0409
	2010	0.985	1.032	1.017	1.0994	0.9624	1.0586
Pipeline transport	2005				1	1	1
	2006	1.004	0.983	0.987	1.0040	0.9830	0.9870
	2007	1.025	0.986	1.011	1.0291	0.9692	0.9979
	2008	0.996	1.001	0.997	1.0250	0.9702	0.9949
	2009	0.952	1.046	0.996	0.9758	1.0148	0.9909
	2010	1.02	0.969	0.989	0.9953	0.9834	0.9800
Scenic transport	2005				1	1	1
	2006	0.941	1.076	1.013	0.9410	1.0760	1.0130
	2007	1.045	0.942	0.984	0.9833	1.0136	0.9968
	2008	0.947	1.067	1.01	0.9312	1.0815	1.0068
	2009	1.084	0.921	0.998	1.0095	0.9961	1.0047
	2010	0.977	1.054	1.03	0.9862	1.0499	1.0349
Postal and courier services	2005				1	1	1
	2006	1.035	0.982	1.016	1.0350	0.9820	1.0160
	2007	1.006	0.964	0.97	1.0412	0.9466	0.9855
	2008	0.945	1.117	1.056	0.9839	1.0574	1.0407
	2009	0.829	1.134	0.94	0.8157	1.1991	0.9783

Industry	Year	YOY			Cumulative		
		EC	TC	MFP change	EC	TC	MFP change
	2010	1.167	0.879	1.026	0.9519	1.0540	1.0037
Warehousing and storage	2005				1	1	1
	2006	1.018	1.008	1.026	1.0180	1.0080	1.0260
	2007	0.951	1.135	1.079	0.9681	1.1441	1.1071
	2008	1.034	0.98	1.013	1.0010	1.1212	1.1214
	2009	0.989	0.921	0.911	0.9900	1.0326	1.0216
	2010	1.072	0.958	1.027	1.0613	0.9893	1.0492