**Contribution of transport productivity to economic growth in New Zealand**

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**Abstract**

In response to the recent economic recession, governments worldwide have been using infrastructure as a means to accelerate the rate of economic growth. The key question is: how much do transport and transport infrastructure contribute to the growth of the economy? While there are many economic analyses on the economic benefits from specific infrastructure investment projects, these analyses seldom look at the overall effects from a national perspective. The purpose of this paper is to gain a better understanding of the economic impacts of transport and transport infrastructure in New Zealand using: (a) input-output approaches; and (b) a time series analysis.

The first part of the paper utilises the input-output tables for 1996, 2003 and 2007 to estimate the multi-factor productivity (MFP) for the transport industry at a disaggregated level, using both a gross output-based MFP measure and a value-added-based MFP measure. Our analysis found that the transport industry as a whole displayed productivity gains over the periods from 1996 to 2003 and to 2007. ‘Water and air transport’ sub-group shows the highest productivity gains from 2003 to 2007. Efficient use of labour inputs has been a major driver for the estimated improvements for the transport industry as a whole and for its industry sub-groups.

The second part of the paper attempts to separately identify the relative contribution from productive road infrastructure capital stock to economic growth. The econometric analysis is carried out using data from 1972 to 2009. Our analysis found that increase in net productive road infrastructure capital stock can enhance New Zealand Gross Domestic Product.

Key words: Transport and economic growth, multi-factor productivity, Economic impacts of road infrastructure

## 1 Introduction

New Zealand’s ‘transport and storage’ industry contributes to about five percent of Gross Domestic Product (GDP), and the total employment for this industry also makes up of five percent of total employment in New Zealand. The ratio of labour to capital (based on earnings) has been between 1.5 and 2.5 during last decade. To fund a large transport programme, road users are levied via fixed and variable charging such as road user charges, fuel excise duties and vehicle registration fees. During the year ended June 2010, approximately $2.5 billion of revenue was generated by road users. Around 80 percent of this revenue is allocated to the construction and maintenance of highways and local roads. This expenditure represents approximately 1.4 percent of total gross national expenditure.

Transport plays an important role in the economy by facilitating the movements of people and goods. However, its actual contribution to economic growth and productivity has not been fully understood. Statistics New Zealand (SNZ) publishes labour, capital and multi-factor productivity indicators for ‘transport and storage’ as one industry. Ideally these measures should be disaggregated by mode (air, sea, road and rail) and movement type (people and freight) to better understand the contributions that various transport services make to the economy and over time.

Productivity is a measure of how efficiently inputs (capital, labour and intermediate inputs) are being used to produce outputs. Productivity is commonly defined as a ratio of a volume measure of output to a volume measure of input. An improvement in the level of productivity indicates resources are better utilised to generate outputs.

Section 2 of the paper estimates the multi-factor productivity (MFP) for the transport industry to understand whether there have been changes in productivity performance of the New Zealand transport industry over time. In section 3, we summarise the result of the time series analysis of the relative contributions from productive road infrastructure capital stock to economic growth. Section 4 includes a summary of the major findings and conclusions.

**2 Input-output analysis**

This section looks at three MFP measures[[1]](#footnote-1) based on input-output tables to understand the changes in productivity performance of the New Zealand transport industry at a sub-industry level over time.

* 1. ***Methodology***
		1. *OECD’s gross-output-based measure*

This measure estimates MFP based on growth in gross output in relation to change in labour, capital and intermediate inputs. Under this approach, MFP for individual industries and the whole economy could be calculated using expressions (1) and (2). (Source: OECD, 2001).

$MFP\_{industry j}(go)=\frac{go\_{j}(qty index)}{ic\_{j}(qty index)^{ W\_{j}^{ic/go}(avg)}\* va\_{j}(qty index)^{ W\_{j}^{va/go}(avg)}}$(1)

$MFP\_{economy}(go)=\prod\_{j=1}^{n}MFP\_{j}(go)^{w\_{j}(domar)}$ (2)

where *go* = gross output; *va* = Value-added; *domar* = domar weights; ‘*w* ‘denotes weights; ‘*j’* denotes industry and ‘*avg’* denotes average. *‘qty index’*  is derived by deflating respective variables by their price indices.

* + 1. *OECD’s value-added-based measure*

The value-added-based approach uses similar information as the gross-output-based approach. However, under the value-added approach, information on gross output and intermediate consumption are used for generating the price index for value-added but not for estimating the MFP explicitly. In brief, the MFP for individual industries and the whole economy are given by expressions (3) and (4) (Source: OECD, 2001).

$MFP\_{industry j}(va)=\frac{va\_{j}\left(qty index\right)}{l\_{j}\left(qty index\right)^{w\_{j}^{l}\left(avg\right)}\*k\_{j}\left(qty index\right)^{w\_{j}^{k}\left(avg\right)} }$ (3)

$MFP\_{economy}\left(va\right)= \sum\_{j=1}^{n}w\_{j}^{va}\*MFP\_{j}(va)$ (4)

where *‘l’* denotes labour and ‘*k’* denotes capital.

* + 1. *Miller and Blair’s gross-output-based measure*

The third approach utilises the definition of productivity measure discussed in Miller and Blair (2009), as shown in equation (5) below, to separately identify the relative contributions of various input factors.

$MFP\_{industry j}=-(da\_{ij}+ dv\_{j})$ (5)

where *da* = difference between technical coefficients in input-output table between year 1 and year 0; and *dv* = difference between value-added coefficients in Input-Output table between year 1 and year 0.

* 1. ***Data***

The datasets required include (i) input-output tables with the desired levels of disaggregation; (ii) labour and capital incomes; and (iii) relevant price indices.

* + 1. *Input-Output tables*

Three input-output tables are available for the years 1996, 2003 and 2007[[2]](#footnote-2). However, different industry sub-groupings have been used by SNZ in the three data sets and there is no obvious overlap between the 1996 table and the 2003 and 2007 tables. To enable consistent comparisons of the results, we have focused the analysis on the 2003 and 2007 data, which were aggregated into three transport sub-groups, namely: ‘road and rail transport’, ‘water and air transport’, and ‘services to transport’. In a separate analysis, all transport sub-groups were combined as one industry (labelled as ‘all transport industries’) to enable comparison with other industries. The latter analysis utilised the data for the three periods.

* + 1. *Labour and capital income*

Compensations of employees in the input-output tables were taken as labour income. The remaining part of the value-added, which is essentially the operating surplus, is taken as the capital income. As described in OECD (2001), taxes (net of subsidies) and imports were proportionately assigned between labour income and capital income. Although OECD recommends an adjustment to allow for gross mixed income earned by households, we have not made any adjustment in that regard due to unavailability of data in the published supply-use and input-output tables.

* + 1. *Price indices*

As there is no published price index available for each of the aggregated industries used in the analysis, the weighted average price index of individual sub-industries for each aggregated industry has been used. In situations where it was not possible to calculate an appropriate price index, the price index for a similar industry was used. In cases where there is no match of industry, we have used the average price index of all industries as the proxy price index for the required industry.

***Results***

The key results are briefly discussed below.

* + 1. *Productivity gains for “all transport” group*

Figure 1 shows the estimated productivity estimates based on the two OECD approaches. This shows there has been a steady increase in productivity from 1996 to 2007 under both approaches[[3]](#footnote-3).

**Figure 1 Transport productivity – all transport industries**



* + 1. *Productivity changes for transport sub-groups*

From the analysis that looks at the productivity estimates for the three transport sub-groups, we found all three sub-groups had shown productivity gains, both from 1996 to 2003 and from 2003 to 2007. Figure 2 shows the transport industry as a whole has been performing better when compared with other industries in the economy except for the agriculture, forestry, fishing and mining industries.

**Figure 2 Productivity changes by industry (2003 to 2007)**



**Table 1 Productivity changes by industry (2003 to 2007)**

|  |  |
| --- | --- |
| **Industry** | **Multi-factor productivity****% change from 2003** |
| **GO based MFP** | **VA based MFP** |
| Agriculture, forestry and mining | 7.09% | 17.34% |
| Manufacturing | -3.25% | -6.62% |
| Building construction services | -3.40% | -10.74% |
| Non-building construction | -3.36% | -9.34% |
| Trade | 0.51% | 0.97% |
| Accommodation restaurants | 0.57% | 1.25% |
| **Road and rail transport** | **1.35%** | **3.78%** |
| **Water and air transport** | **3.84%** | **10.31%** |
| **Services to transport** | **3.55%** | **5.91%** |
| Finance, insurance and legal services | 1.60% | 2.99% |
| Central and local government | 1.07% | 2.17% |
| Education | 0.38% | 0.54% |
| Health and community care services | 0.43% | 0.68% |
| Recreation | 0.54% | 1.10% |

Table 1 shows that, within the transport industry, the ‘water and air transport’ sub-group has the highest productivity gain from 2003 (estimated at between 3.8 and 10.3 percent). The manufacturing industry, building construction industry and non-building construction industry have all shown productivity losses during the period from 2003 to 2007. Non-building construction includes a large number of asset types such as construction of bridges, roads, utility-related infrastructures and other public amenity facilities. Therefore, we cannot clearly conclude whether the level of productivity for the road construction industry has improved or fallen.

* + 1. *Productivity changes by input type*

Analysis of contributions of productivity change by individual input is based on the method discussed by Miller & Blair (2009)[[4]](#footnote-4).

For the transport industry as a whole, the main source of productivity gains from 1996 to 2003 had been due to more efficient use of labour inputs (see Figure 3a). For the period from 2003 to 2007, both labour and capital inputs had been efficiently used, but the efficiency in the use of capital inputs was higher (see Figure 3b).

**Figure 3 Productivity changes by input type – all transport services (2003 to 2007)**

(a) (b)

 

**Figure 4 Productivity changes by input type – transport sub-groups (2003-2007)**



Productivity gains from 2003 to 2007 mainly came from better use of labour inputs in respect of the ‘road and rail transport’ sub-group and ‘water and air transport’ sub-group (see Figure 4). On the other hand, productivity gains in the ‘services to transport’ sub-group is due to better use of intermediate and capital inputs.

* 1. ***Limitations of the input-output analysis***

Most of the limitations are related to the lack of data and are summarised below.

* Due to changes in industry classifications by SNZ over time, we are only able to divide transport into three sub-groups. It would be preferable if such data can be disaggregated among eight transport sub-groups, namely: road passenger, road freight, rail passenger, rail freight, air passenger, air freight, water passenger and water freight.
* As supply-use and input-output tables are only available for specific years, we are unable to measure year-to-year productivity changes based on the input-output approaches.
* Price data has been a major concern to carry out comprehensive productivity analysis. For most industry sub-groups, price data were not available. Therefore, we have used either weighed aggregate price series or aggregate price index for all industries as proxies.

**3. Time series analysis**

This section looks at the empirical evidence of the contribution of transport infrastructure investment to New Zealand’s GDP. The analysis is based on the aggregate production function (APF) approach, which allows the contribution of output growth to be broken down by input type.

1. ***The model***

One of the earliest APF studies is by Ashauer (1989), who finds the contribution of infrastructure input to economic growth to be large (with output elasticity of between 0.4 and 0.5). Later studies find the output elasticity to be much smaller (eg Munnel (1990) and Garcia-Mila and McGuire (1992) find an elasticity of between 0.05 and 0.06). On the other hand, some studies find public infrastructure investment to have a small negative impact on economic growth (Brian, 2005 and Preston and Holvad, 2005). The functional form (a Cobb-Douglas function) of the APF is shown in equation (6).

$Y\_{t}=A\_{t}R\_{t}^{β1}K\_{t}^{β2}L\_{t}^{β3}$ (6)

where *Y* is the GDP in constant price; *A* is a parameter that captures any shift in the production function over time that is not incorporated in a specific factor of production; *R* is the productive road infrastructure capital stock in constant price; *K* is the productive non-road capital stock in constant price; *L* is the employee count; ’s are the parameters representing returns to scale and *t* denotes time period.

The term *At* can be viewed as a measure of the multi-factor productivity. It measures the spill-over effects from other factors of production; efficiency gains from diffusion of knowledge and better management methods of production techniques and the efficiency and effectiveness gains from utilising the capital stock already existing in the economy.

Several variations of the APF have been used in the literature to overcome the well-known methodological deficiencies, such as non-stationarity. We use an error correction model (ECM) for this analysis as there are evidences that the dependent and independent variables are cointegrated[[5]](#footnote-5). Equation (6) has been modelled in double logarithm form. The long run equation is shown in equation (7).

 $lnY\_{t}=α+δtrend +β\_{1}lnR\_{t}+β\_{2}lnK\_{t}+β\_{3}lnL\_{t}+ε\_{t}$ (7)

where *t* is the error term.

The parameters in equation (7) refer to the output elasticities of various inputs. For a Cobb-Douglas assumption of a unitary elasticity of substitution, the sum of the betas should equal to one. In this paper, we relax this assumption. The first term of equation (6), *ln*(*At*), is captured by the constant term and a trend term is added as the dependent variable is trended. The short run dynamics (or the error correction equation) is shown in equation (8).

$∆lnY\_{t}=a+b\_{0}\left(ε\_{t-1}\right)+b\_{1}\left(∆lnR\_{t}\right)+b\_{2}\left(∆lnK\_{t}\right)+b\_{3}\left(∆lnL\_{t}\right)+u\_{t}$ (8)

where *ut* is the error term.

1. ***Data***

This analysis includes annual data from 1972 to 2009. All data used in this analysis were sourced from SNZ and Reserve Bank of New Zealand. All values are in 1995/96 prices.

Some calculation was required to generate the net productive road infrastructure capital stock from year 1990 onwards. Such measure is different from road infrastructure expenditure because part of such expenditure is used to maintain or restore existing roads and therefore would have little effect on the level of productive capital stock. There are also efficiency losses due to under-utilisation (such as during off-peak periods and at rural locations). Following SNZ’s perpetual inventory method, we accumulate the investment flows and apply depreciation[[6]](#footnote-6), efficiency and discount parameters[[7]](#footnote-7) to derive estimates of productive road infrastructure capital stock from 1990 to 2009.

1. ***Results***

The adjusted-R2 for the long run model is 0.99 and the model satisfies the requirements of all appropriate diagnostic tests[[8]](#footnote-8). Our analysis found that the long run output elasticity of productive road infrastructure capital stock is 0.41 (p-value <0.01). This means for every one percent increase in productive road infrastructure capital stock, output will increase by 0.41 percent.

The estimated output elasticity of labour is 0.92 (p-value < 0.01) and that of productive non-road infrastructure capital stock is -0.34 (p-value < 0.01). The higher contribution from labour inputs is consistent with the results obtained from the input-output analyses. The negative effect of non-road capital stock implies some of these capital stocks might have hindered economic growth due to resources being tied up in less efficient areas.

The short run model[[9]](#footnote-9) has an adjusted-R2 value of 0.7. Results show that capital stock levels do not have significant impacts on GDP in the short run.

However, when applying the causality test for ECM errors found there are some feedback effects. In other words, we found the direction of causality between each independent variable and the dependent variable goes both ways. This is not surprising because better utilisation of capital and labour inputs can induce economic growth but as an economy grows it also generates demand for extra capital and labour inputs.

**4. Summary and conclusions**

In response to the recent economic recession, governments worldwide have been using infrastructure as a means to accelerate the rate of economic growth. The key question is: how much do transport and transport infrastructure contribute to the growth of the economy?

The paper looks into several input-output-related productivity measures and conducts time series analysis to gain a better understanding of the economic impacts of transport and transport infrastructure in New Zealand.

Our analysis shows the transport industry as a whole has shown some productivity gains over time but the gains in early years (from 1996 to 2003) was originated mostly from better utilisation of labour inputs. In the subsequent period (from 2003 to 2007), better capital utilisation only started to occur for the ‘services to transport’ sub-group. In terms of productivity gains from transport infrastructure investment, the input-output approach did not shed much light on this because we do not have transport infrastructure construction as a separate industry. However, our econometric analysis did find a positive contribution from productive road infrastructure capital stock to GDP.

The above results have important policy implications. Firstly, there is a need to encourage better capital utilisation for all transport industry sub-groups. Secondly, well-targeted transport infrastructure investment can enhance economic growth if such investment can increase the level of net productive road infrastructure capital stock.

There are opportunities to expand this research in a number of areas. Firstly, it would be useful to further disaggregate transport industries into smaller sub-groups to better understand how individual transport services contribute to the economy. Secondly, to help identify trends in productivity changes, it would be necessary to develop a time series measure of productivity indicators, preferably at the industry sub-group level. Finally, as the econometric approach adopted may not be appropriate for data with feedback effects, further research on other approaches to handle such effects is needed.

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1. For details, please refer to OECD (2001) and Miller and Blair (2009). [↑](#footnote-ref-1)
2. Input-output table for 1996 was available from SNZ. Input-output tables for 2003 and 2007 were derived from SNZ’s published supply-use tables using the methods described in the UN manual for compilation of input-output tables (UN 2009). All input-output and supply-use tables are for years ending March. [↑](#footnote-ref-2)
3. Our results are different from SNZ’s result of a decline in productivity from 2003 to 2007. There may be several reasons for such difference. For example, the differences in data definitions and the level of industry disaggregation might have affected the overall productivity estimates. Further investigation into the reasons behind such difference is required. [↑](#footnote-ref-3)
4. The analysis is based on input-output tables in nominal terms. Further investigation is required to obtain relevant price indices to convert the results in real terms. [↑](#footnote-ref-4)
5. Based on augmented Dickey-Fuller unit root test, we verified that each of the series Y, R, K and L is non-stationary in levels but stationary in first difference. The unit root tests include intercept and time trend as each of the series is trended. Johansen cointegration test confirms these series are cointegrated of order one. Augmented Dickey-Fuller test on the error correction term confirms the long run equation is stationary. [↑](#footnote-ref-5)
6. Productive stock brought forward from previous period is depreciated using a straight-line reducing balance approach based on a mean asset life of 75 years. [↑](#footnote-ref-6)
7. This analysis extends the downward trend in SNZ’s efficiency factor of 68 percent in 1972 reducing to 57 percent in 1989. The estimated efficiency factor gradually reduces to 54 percent by 2009. [↑](#footnote-ref-7)
8. This includes White test for heteroskedasticity of the error correction equation and Autocorrelation tests. [↑](#footnote-ref-8)
9. The short run model satisfies the standard properties of the residuals. The error correction term has a value of -0.44, meaning 44 percent of the gap between long run trend and the short run dynamic measures will be closed in one period. [↑](#footnote-ref-9)