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Contribution of transport to economic growth and productivity 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.

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. Preliminary analysis suggests 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 increases 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 about five percent of Gross Domestic Product (GDP), and the total employment for this industry also makes up 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 the 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 (SNZ 2010a). 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.

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 applies input-output analysis to estimate multi-factor productivity (MFP) for the transport industry. In section 3, a time series analysis was carried out to estimate the relative contribution of road infrastructure to economic growth. Section 4 concludes the paper.

2. Input-output analysis

This section looks at three MFP measures[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.

2.1 Methodology

2.1.1 OECD's gross-output-based measure

This measure estimates MFP[2] 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) below (Source: OECD, 2001).

$$MFP_{industry\ j}(go) = \frac{go_j(qty\ index)}{ic_j(qty\ index)^{W_j^{ic}} * va_j(qty\ index)^{W_j^{va}}} \quad (1)$$

[1] For details, please refer to OECD (2001) and Miller and Blair (2009).
[2] MFP can be described as Törnqvist MFP index as it uses Törnqvist quantity index method. Törnqvist quantity index is the weighted geometric average of its components.

$$MFP_{economy}(go) = \prod_{j=1}^{n} MFP_j(go)^{w_j(domar)} \quad (2)$$

Where go = gross output; va = value-added; ic = intermediate inputs; $domar$ = domar weights[3]; w^{ic} denotes weight for intermediate inputs; w^{va} denotes weight for value-added; j denotes industry; and $qty\ index$ is derived by deflating movements of respective variables by movement of their price indices. Weights for intermediate inputs and value-added are the averages (over two periods) of the respective shares of inputs (in current prices) in gross output.

Following the OECD (2001) approaches, Törnqvist quantity index formula was used in this analysis. After obtaining the indirect quantity (volume) indices, Törnqvist quantity index formula was used to obtain an index of combined inputs for each industry. The steps involved are summarised in the OECD (2001) report.

2.1.2 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) below (Source: OECD, 2001).

$$MFP_{industry\ j}(va) = \frac{va_j(qty\ index)}{l_j(qty\ index)^{w_j^l} * k_j(qty\ index)^{w_j^k}} \quad (3)$$

$$MFP_{economy}(va) = \sum_{j=1}^{n} w_j^{va} * MFP_j(va) \quad (4)$$

where l denotes labour and k denotes capital; va = value-added; w denotes weight for labour and capital inputs; j denotes industry; and $qty\ index$ is derived by deflating movements of respective variables by movement of their price indices. Weights for labour and capital inputs are the averages (over two periods) of the respective shares of inputs (in current prices) in value-added.

Again, as recommended in OECD (2001), Törnqvist quantity index formula was used in this analysis.

2.1.3 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.

[3] Domar (1961 cited in OECD 2001) showed that economy-wide rates of MFP changes can be expressed as a weighted sum of industry-specific MFP growth. 'Domar weights' are the ratio of each sub-industry's gross output to its value-added. They reflect the combined effects of productivity growth within individual industries and the induced effects on those downstream industries that benefit from more efficiently produced intermediate inputs.

$$MFP_{industry\ j} = -(da_{ij} + dv_j) \quad (5)$$

Where da is the difference between technical coefficients in input-output tables relating to period 0 and 1. Technical coefficients are calculated by dividing each cell in the inter-industry transaction table by the gross output of respective industries. Similarly, dv is the difference of value added coefficients of input-output tables relating to period 0 and 1. Value-added coefficients are calculated by dividing the value-added of each industry by the gross output of respective industries.

2.2 Data

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

2.2.1 Input-Output tables

Three input-output tables are available for the years 1996, 2003 and 2007[4]. 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.

2.2.2 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 the unavailability of data.

2.2.3 Intermediate inputs

Intermediate inputs are goods and services produced within the industry or by other industries to be used as inputs in the production process. Intermediate inputs (consumption) consist of the value of goods and services consumed as inputs by a process of production (UN, 2008). Intermediate inputs for each industry are sourced from input-output tables.

[4] 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.

2.2.4 Price indices

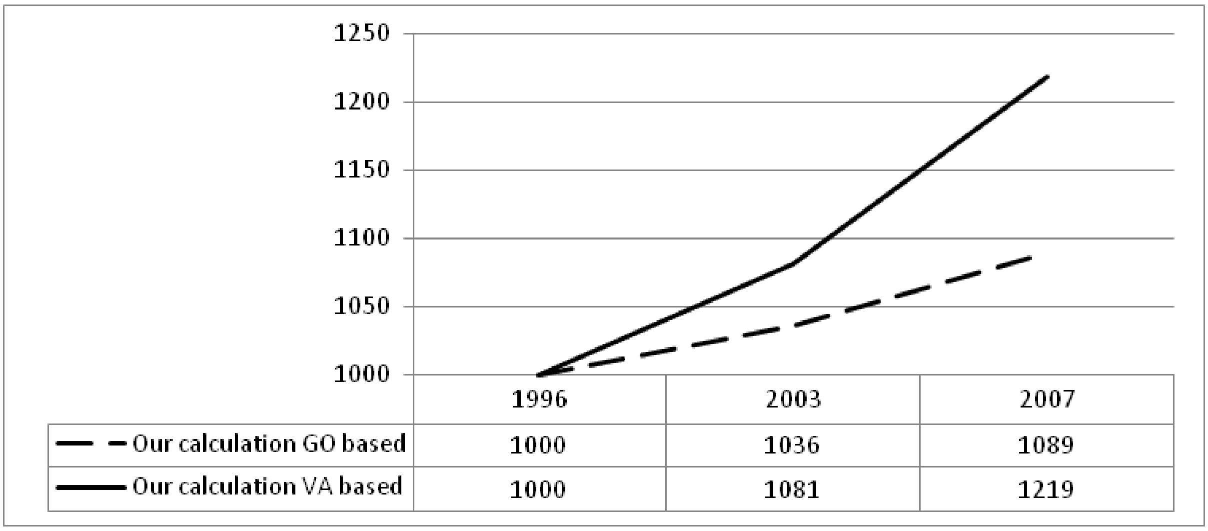
As there is no published price index available for each of the aggregated industries used in the analysis, the weighted average price index of individual sub-industries for each aggregated industry has been used. In situations where such an approach was not possible, the price index for a similar industry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

2.3 Results

2.3.1 Productivity gains for 'all transport industries' 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.

Figure 1 Transport productivity for all transport industries (1996 = 1000)



	1996	2003	2007
Our calculation GO based	1000	1036	1089
Our calculation VA based	1000	1081	1219

Our results are different from SNZ's result of a decline in productivity from 2003 to 2007. The following factors could have influenced the results.

(i) There are different ways to measure labour and capital inputs. SNZ uses data on hours paid as labour volume series and capital stock data to derive capital volume series. The MFP approaches adopted in this paper are based on information from input-output tables. In accordance with OECD (2001), we used compensation of employees (ie wages and salaries paid to employees) as labour income and operating surplus as the capital income.

(ii) SNZ's MFP is based on GDP, labour and capital in constant prices (using chain volume series). As the input-output tables are available only in current prices, we have to convert the data in constant prices based on published price indices and, in some cases, proxy price indices for the industries where there were no proper price indices.

It is uncertain which of the above factors has the most influence. Further investigation would be required.

2.3.2 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 from 2003 to 2007 (Table 1). Due to inconsistency in industry classifications for the 1996 and 2003 input-output tables, productivity changes from 1996 to 2003 cannot be determined at the industry sub-group level. For the years from 2003 to 2007, the transport industry as a whole outperformed other industries in the economy except for the agriculture, forestry, fishing and mining industries.

Table 1 Productivity changes by industry (2003 to 2007)

	Multi-factor productivity % change from 2003	
Industry	**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%

Within the transport industry, the 'water and air transport' sub-group had 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 had 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 had improved or fallen.

Table 1 shows large differences in the two sets of MFP estimates reflecting the differences in both the input and output measures used under the two approaches. VA-based MFP uses value-added as the output measure and considers only labour and capital inputs. On the other hand, GO-based MFP uses gross output as the output measure and considers intermediate inputs in addition to labour and capital inputs. As noted in OECD (2001), *"there is a direct link between an industry's value-added based MFP growth and its gross-output based MFP growth. More specifically, the former differs from the latter by a factor that equals the ratio of an industry's gross output over its value added."*

2.3.3 Productivity changes by input type

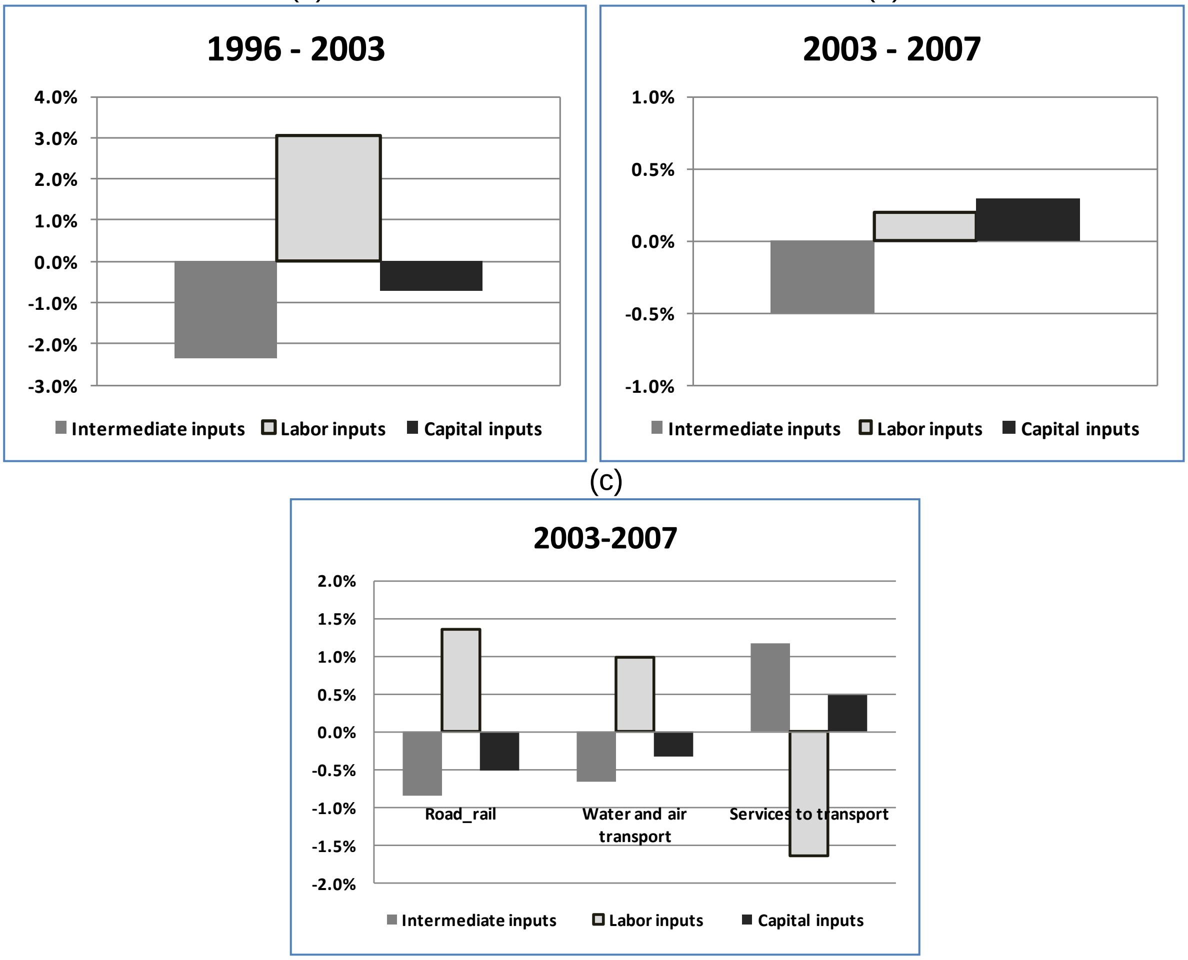
Analysis of contributions of productivity change by individual input is based on the method discussed by Miller & Blair (2009)[5]. For all transport industries combined, the main source of productivity gains from 1996 to 2003 were due to more efficient use of labour inputs (see

[5] The analysis is based on input-output tables in nominal terms. Further investigation is required to obtain relevant price indices to conduct the analysis in real terms.

Figure 2a). 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 2b).

Figure 2 Productivity changes by input type

(a) (b)



For transport industry sub-groups, 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 (Figure 2c). On the other hand, productivity gains in the ‘services to transport’ sub-group is due to better use of intermediate and capital inputs.

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 an error correction modelling technique which allows identification of both the long and short run dynamics of the economy.

3.1 The model

Past empirical studies found mixed results about the contribution of public infrastructure to the economy. For example, Ashauer (1989) found public infrastructure input has an output elasticity of between 0.4 and 0.5, compared to less than 0.1 estimated by Munnell (1990) and

Garcia-Mila and McGuire (1992). Other studies found public infrastructure investment has a small negative impact on economic growth (Brian, 2005 and Preston and Holvad, 2005).

This analysis is based on a Cobb-Douglas type aggregate production function (APF), as shown in equation (6).

$$Y_t = A_t R_t^{\beta 1} K_t^{\beta 2} L_t^{\beta 3} \quad (6)$$

Where Y is the GDP in constant price; A is a technological 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[6] in constant price; K is the productive non-road capital stock[6] in constant price; L is the employee count (at the national level); β's are the parameters representing returns to scale and t denotes time period.

The Cobb-Douglas form of production functions is widely used to represent the relationship of inputs to an output. Under this production function, if the sum of all the β's is equal to one the production function has constant returns to scale. If the sum of all the β's is less than one, the returns to scale are decreasing (and vice versa).

The term A_t 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 capital and labour inputs 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)[7] for this analysis as there is evidence that the dependent and independent variables are cointegrated[8]. Equation (6) has been modelled in double logarithm form to display the long run relationship. This is shown in equation (7).

$$lnY_t = \alpha + \delta trend + \beta_1 lnR_t + \beta_2 lnK_t + \beta_3 lnL_t + \varepsilon_t \quad (7)$$

Where ε_t is the error term.

The constant term (α) and the trend term in equation (7) are used to capture the technological progress over time (ie A_t). The rest of the parameters refer to the output elasticities of various inputs. To test the returns to scale econometrically, we have not restricted the sum of the β's to equal to one. The short run dynamics is shown in equation (8).

[6] The productive capital stock is a measure of the volume of the capital services produced by fixed assets, making allowance for the decline in efficiency as the assets age.
[7] The principle behind an ECM is that there often exists a long-run equilibrium relationship between two economic variables but there may be disequilibrium in the short run. The ECM aims to reconcile short-run and long-run behaviours. It consists of an equation that describes the long-run equilibrium and an equation that relates the changes in the dependent variable to the changes in other variables as well as the gap between the variables in the previous period (ie the short run model). An ECM is used in this paper to relate changes in national output with changes in capital and labour inputs.
[8] Based on the Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) unit root tests, we verified that each of the series Y, R, K and L is non-stationary in levels but stationary in first difference (see Table A1 in the Appendix). The Johansen cointegration test confirms these series are cointegrated of order one (see Table A2 in the Appendix). ADF and PP tests on the error correction term confirm the long run equation is stationary (see Table A3 in the Appendix).

$$\Delta lnY_t = a + b_0(\varepsilon_{t-1}) + \sum_{j=0}^{2} b_{1j}(\Delta lnR_{t-j}) + \sum_{j=0}^{2} b_{2j}(\Delta lnK_{t-j}) + \sum_{j=0}^{2} b_{3j}(\Delta lnL_{t-j}) + u_t \quad (8)$$

Where u_t is the error term and j is the number of lags.

3.2 Data

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

Some calculation was required to generate the net productive road infrastructure capital stock from 1990 onwards. A key feature of infrastructure capital is that existing stock will deteriorate due to aging and some assets also became obsolete and retired from service over time. In an attempt to capture SNZ's perpetual inventory method (SNZ, 2010b), SNZ's gross capital stock for 1989 was used as the initial stock level. By accumulating net investment flows (in constant prices) to the initial stock, we obtain the gross capital stock from 1990 to 2009. A retirement factor[9] and an age-efficiency adjustment[10] are applied to calculate the consumption of fixed capital and adjust for efficiency decline in assets. The resulting estimates form the net productive capital stock.

3.3 Results

Table 2 tabulates the results of the long and short run models. The adjusted-R^2 for the long run model is 0.99 and the model satisfies the requirements of all appropriate diagnostic tests[11]. 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). On the other hand, the estimated output elasticity of productive non-road infrastructure capital stock is -0.34 (p-value < 0.01). This implies some investment has hindered economic growth due to resources being tied up in less efficient areas.

[9] Productive stock brought forward from previous period is depreciated using a reducing balance approach based on a mean asset life of 75 years (this is an average of those used by SNZ of 110 years for central government roads and 58 years for local government roads).

[10] Most capital goods lose productiveness as they age, and so exhibit some form of efficiency loss. When deterioration is just offset by new investment, the current-period productiveness of the capital stock remains unchanged. Age-efficiency adjustment is necessary to estimate the flow of the 'quantity' of capital services. SNZ's implied hyperbolic age-efficiency factor for all road capital stock was 68 percent in 1972 reducing to 57 percent in 1989. This analysis extends SNZ's profile and the estimated age-efficiency gradually reduces to 54 percent by 2009.

[11] This includes White test for heteroskedasticity of the error correction equation and Autocorrelation tests.

Table 2 Summary of regression results

Variables	Long run model	*p-value*	Short run model	*p-value*
α	4.3366	*0.002*	0.0172	*0.076*
ε_{t-1}			-0.3855	*0.038*
$Trend_t$	0.0196	*0.000*		
R_t	0.4136	*0.003*		
ΔR_{t-1}			-1.4549	*0.112*
ΔR_{t-2}			1.9875	*0.055*
K_t	-0.3408	*0.002*		
ΔK_{t-1}			0.7163	*0.013*
ΔK_{t-2}			-0.8572	*0.005*
L_t	0.9223	*0.000*		
ΔL_t			1.0045	*0.000*
ΔL_{t-1}			-0.3696	*0.056*
Adjusted R^2	**0.99**		**0.71**	

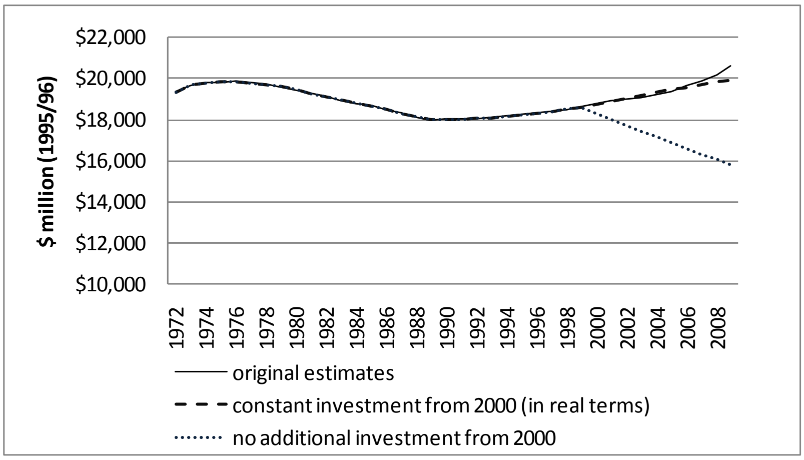
Note: Subscript represents time period. An '*Δ*' denotes change in the variable between two periods.

The short run model[12] has an adjusted-R^2 value of 0.71. Results show that the levels of road infrastructure capital stock and labour in previous years have a net positive impact on GDP in the short run. On the other hand, the past levels of other capital stock have a net negative impact on GDP. This further reinforces the observed long run relationship.

White test for heteroskedasticity of the error correction equation found the model to be homoskedastic. Autocorrelation tests show the model is not serial correlated. However, 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.

Based on the estimated ECM equations, we estimated the likely effects of road infrastructure investments on GDP under two hypothetical scenarios. The first scenario assumes no additional road infrastructure investments have taken place from 2000. The second scenario assumes road infrastructure investments have remained the same (in real terms) from 2000. Results show that total GDP from 2000 to 2009 would have been 2.5 and 0.9 percent lower under the two scenarios respectively.

Figure 3 Productive road infrastructure capital stock



[12] 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.

Table 3 Likely effects of reduction in road infrastructure investment on GDP

Scenario	Estimates of effects on total GDP (1995/96 $) from 2000 to 2009
No additional road infrastructure investments from 2000	-2.5%
Constant road infrastructure investment (in real terms) from 2000	-0.9%

4. Summary and conclusions

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 had shown productivity gains over time. The gains in early years (from 1996 to 2003) 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. Based on the time series analysis, we estimated that if road infrastructure investment has not increased at the same rate as in recent years, total GDP from 2000 to 2009 would have been slightly lower.

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. Thirdly, it would be useful to revisit the productive road infrastructure capital stock estimates for the entire period and investigate the possibility of splitting it between highways and local roads. Finally, as there seems to be feedback effects between GDP, and capital and labour, further research on other approaches to handle such effects is needed.

5. References

Ashauer, D (1989) *Is public expenditure productive?* New England Economic Review, Jan/Feb, pp.3-22

Brian, B (2005) *Public Infrastructure and Economic Productivity: A Transportation-Focused Review*, Journal of the Transportation Research Board, No. 1932, pp. 54-60

Garcia-Mila, T and McGuire, T (1992) *The contribution of publicly provided inputs to states' economies,* Regional Science and Urban Economics, Vol. 22, pp. 229-241

Miller, R and Blair, P (2009) *Input-Output Analysis – Foundations and Extensions,* 2nd Edition, Cambridge

Munnell, A (1990) *How does public infrastructure affect regional economic performance?* New England Economic Review, Sept/Oct, pp.11-32

Organisation for Economic Co-operation and Development (2001), *Measuring productivity: Measurement of aggregate and industry-level productivity growth,* Paris, OECD

Preston, J and Holvad, T (2005) *Road Transport and Additional Benefits: A Review of the Empirical Evidence on the additional benefits of road investment,* Transport Study Unit, University of Oxford

Statistics New Zealand (SNZ) (2010a) *Industry Productivity Statistics 1978 – 2008*, Wellington

Statistics New Zealand (SNZ) (2010b) *Measuring Capital Stock in the New Zealand Economy*, Wellington

United Nations (UN) (1999) Handbook of Input-Output Table Compilation and Analysis, New York

United Nations (UN) (2008) System of National Accounts 2008, New York

6. Appendix

Table A1 Unit root tests

		In levels		In differences	
		ADF p-values	**PP p-values**	**ADF p-values**	**PP p-values**
Real GDP	Y	0.585	0.800	0.033	0.033
Road infrastructure productive stock	R	0.996	0.999	0.002	0.004
Other productive stock	K	0.218	0.318	0.004	0.146
Labour	L	0.343	0.790	0.064	0.052

Notes:

- The above table reports the p-values for the Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) tests under the null hypothesis of a unit root.
- The optimal lag length was selected based on Akaike information criterion (for the ADF test) and Newey-West using Barlett kennel (for the PP test).
- Unit root test results show the variables are stationary in differences.

Table A2 Johansen cointegration test

Null hypothesis	Alternative hypothesis	Test statistics	5% critical values
Trace statistics			
r = 0 *	≥1	85.539	47.856
r ≤ 1 *	≥2	32.232	29.797
r ≤ 2	≥3	11.224	15.495
r ≤ 3	≥4	0.808	3.841
Maximum eigenvalue statistics			
r = 0 *	≥1	53.307	27.584
r ≤ 1	≥2	21.008	21.132
r ≤ 2	≥3	10.416	14.265
r ≤ 3	≥4	0.808	3.841

Both the Trace statistics and the Maximum Eignevalue statistics reject the null hypothesis of no cointegration at the 5% significant level. The results suggest the existence of at least one cointegration vector.

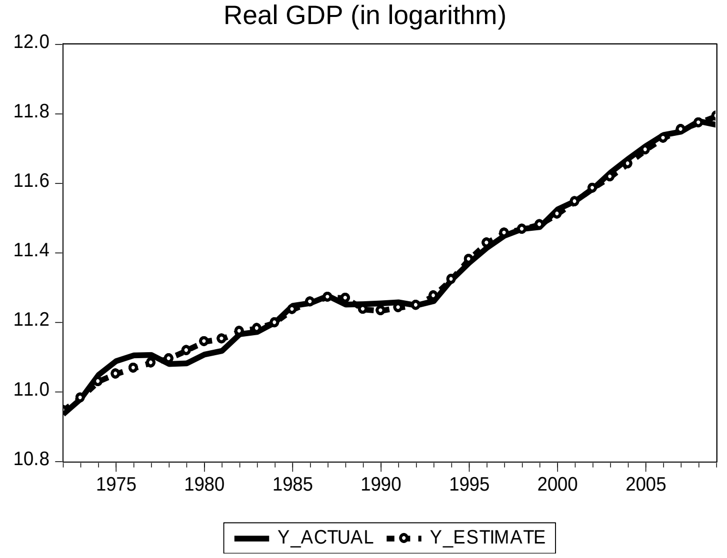
Table A3 Unit root tests on the cointegrating residuals

Specification		p-values	
Constant	**Trend**	**ADF**	**PP**
yes	yes	0.016	0.192
no	no	0.000	0.004
yes	no	0.003	0.054

Notes:

- The above table reports the p-values for the ADF and the PP tests on the residuals of the estimated cointegrating equation (7) under the null hypothesis of a unit root.
- The optimal lag length was selected based on Akaike information criterion and Newey-West using Barlett kennel.
- Unit root test results show the cointegrating equation is stationary.

Figure A1 Actual, fitted and residual plots for the cointegration (long run) equation



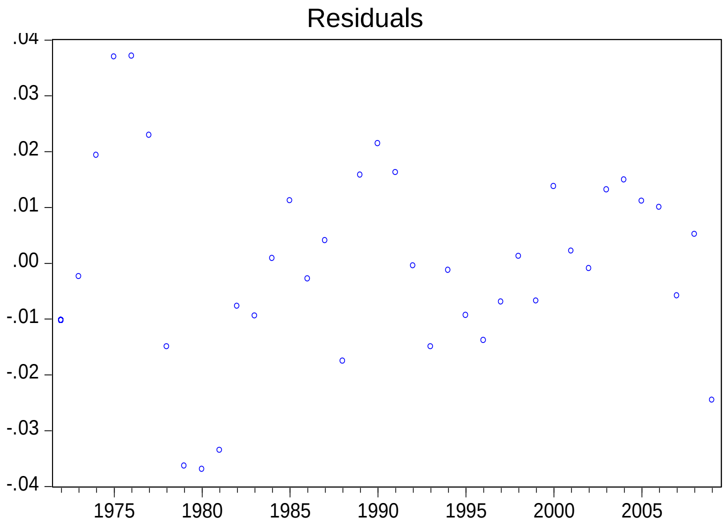


Figure A2 Actual and fitted values of the short run equation