BTE Publication Summary

A Road Construction Price Index



Occasional Paper

This paper describes a method of measuring price changes at the national level in the road and bridge construction and maintenance industry. The paper gives the results of application of such methodology to measure the price changes for roadworks from 1963-64 to 1977-78 in the form of a price index. This index is a refinement and update of the price index developed by the author for the former Commonwealth Bureau of Roads.





BUREAU OF TRANSPORT ECONOMICS

A ROAD CONSTRUCTION PRICE INDEX

R.H. BURKE

AUSTRALIAN GOVERNMENT PUBLISHING SERVICE

CANBERRA 1978

 \odot

Commonwealth of Australia

Printed by Canberra Reprographic Printers, 119 Wollongong Street, Fyshwick, Canberra, A.C.T. 2609

FOREWORD

The Bureau of Transport Economics provides economic, technical and financial advice to the Commonwealth Government on matters relating to transport. Currently the Bureau is preparing a report on an economic analyis of road construction and maintenance needs in Australia for the period to 1982-83.

To analyse past expenditures on road works in Australia it is necessary to measure such expenditures in constant prices. No specific nath hal road price index is available from official sources to convert current price expenditures to constant prices. The former Commonwealth Bureau of Roads developed methods of measuring such price changes and incorporated the results in the various reports presented to the Commonwealth Government.

This paper describes the refinement and update of the road price index of the former Bureau of Roads. It also incorporates a measure of total productivity of the non-farm sector of Australia which is used in the compilation of the revised road price index.

The paper is made public for several reasons viz:-

- it provides a nation-wide measure of price changes of investment in roads, which will be both useful in analysing past expenditure patterns on roads and which can usefully be compared with other indexes officially published and relating to various other categories of investment;
- the estimate of the total productivity of non-farm economic activity;
- the estimates of capital stock made from 1963-64 which incorporate estimates of capital expenditure on building and construction from 1924-25 at constant prices; and
- the possibility that the results of this research will be useful in general economic analyses as well as in the transport and roads sectors.

T. M. HOGG ACTING DEPUTY DIRECTOR

OCTOBER, 1978.

CONTENTS

	Page
FOREWORD	iii
PREFACE	ix
CHAPTER 1 - INTRODUCTION	1
CHAPTER 2 - METHODOLOGY	3
CHAPTER 3 - THE ECONOMIC SERIES USED IN THE ROAD CONSTRUCTION PRICE INDEX	
Wages, Salaries and Supplements	6
Depreciation	7
Income Tax	7
Other Surplus	8
Commodity Taxes	11
Payroll Tax	12
Local Government Rates	13
Sales to Final Buyers	13
Complementary Imports	14
Competing Imports	15
Import Duty	15
CHAPTER 4 - PRODUCTIVITY	
Definition	16
The Measurement of Productivity	16
Product	17
Labour	18
Capital	19
Share of Capital in Total Rewards	24
Estimates of Productivity 1963-64 to 1977-78	25
CHAPTER 5 - ESTIMATES OF ROAD CONSTRUCTION PRICE CHANGES	27

TABLES

		Page
2.1	Proportions of the Component Costs of the Road Construction Industry for 1968-69	5
3.1	Wages, Salaries and Supplements Index	· 6
3.2	Index of Depreciation Costs	7
3.3	Index of Enterprise Tax Rates	8
3.4	Surplus comprising Indirect Charges and Profit	9
3.5	Capital Stock in Current Prices	10
3.6	Return on Capital and a Price Index of the Cost of Capital	11
3.7	Fuel Tax Index	12
3.8	Payroll Tax Index	12
3.9	Local Government Rates Index	13
3.10	Consumer Price Index	14
3.11	Import Price Index of Mineral Oils and Lubricants	14
3.12	Import Price Index of Competing Imports	15
4.1	Non-farm Product at 1968-69 Prices	18
4.2	Non-farm Employment	18
4.3	Capital Expenditure on Building and Construction in 1968-69 Prices	21

vii

TABLES

		Page
4.4	Capital Stock from Building and Construction in 1968-69 Prices	22
4.5	Capital Investment in Plant and Equipment 1968-69 Prices	23
4.6	Capital Stock - Plant and Equipment 1968-69 Prices	23
4.7	Total Capital Stock 1968-69 Prices	24
4.8	Share of Capital in Total Rewards	24
4.9	Non-farm Productivity Measures	26
5.1	Road Construction Price Index	28
5.2	Comparative Price Indexes	30

PREFACE

This paper describes a method of measuring price changes at the national level in the road and bridge construction and maintenance industry. The paper gives the results of application of such methodology to measure the price changes for roadworks from 1963-64 to 1977-78 in the form of a price index. This index is a refinement and update of the price index developed by the author for the former Commonwealth Bureau of Roads. ⁽¹⁾

In the course of applying the method it was necessary to develop a number of economic series which are not published by official sources. Two of the more important of these indicators are a measure of capital stock at constant prices and an index of total non-farm productivity for Australia. This latter index embodies a measure of productivity changes attributable to both capital and labour.

Significant benefit was received from discussions with Mr. A.S. Atkins, Centre for Environmental Studies, University of Melbourne, Mr. B.D. Haig, Research School of Social Sciences, Australian National University, Mr. T. M. Hogg, Bureau of Transport Economics and Mr. S. Stevens, Victorian Premier's Department and their assistance in this regard is gratefully acknowledged.

The paper is divided into four parts. Chapter 1 discusses the scope of the index in general terms and the various measures currently available for measuring price changes. Chapter 2 describes the overall methodology employed in constructing the price index. The estimation procedures used in providing data as input required by the price index are set out in Chapter 3. Chapter 4 describes the method of obtaining a measure of the total productivity of non-farm activity in the Australian economy. The last chapter details the results of application of the data estimates to the road construction price index method and discusses briefly the impact and importance of changes in prices of road works.

(1)	Commonwealth Bureau of Roads :	Cos	t In	dexe	s A	Applica	able_	to	Road	Construction
	Associated Bureau Paper 23									
	:	Rep	ort	on Re	oad	ls in A	Austi	ral:	ia 197	<u>75</u> ,
	Appendix 7, Melbourne December	197	5.							

CHAPTER 1 - INTRODUCTION

There is no official national price index of road and bridge construction and maintenance activity in Australia. The Australian Statistician publishes an implicit price index⁽¹⁾ of public gross capital expenditure which includes expenditure on road works. Such an index is not satisfactory as a measure of changes in prices of roadworks as the road activities comprise only about 20 per cent of total public gross capital expenditure and changes in this index do not necessarily reflect changes in prices for the road industry.

An implicit price index can be derived from estimates of public authority gross fixed capital expenditure on building and construction (excluding dwellings) at constant and current prices as published by the Australian Statistician.⁽²⁾ This index is also not completely satisfactory as road activities comprise less than 35 per cent of such capital expenditure and it is believed that the non-road building and construction prices do not move concomitantly with roadworks prices.

The road and bridge construction and maintenance industry (road construction industry) comprises those activities relating to roads and bridges which are the responsibility of state and territory road authorities and local government authorities. A number of state road authorities have estimated indexes which reflect price changes. These indexes usually relate to actual work undertaken by the state road authorities and exclude both contract work and local government road activity - they are used primarily as a management tool. The activities of road authorities are not necessarily representative of the total road construction industry for the state. Furthermore, the price index methodology adopted by each of the states varies and since all attempts at measuring price changes in the form of a price index have defects, the state price indexes when aggregated could produce unacceptable levels of inaccuracy of price changes.

(2) Ibid.

Australian Bureau of Statistics : <u>Australian National Accounts</u>, <u>National Income and Expenditure 1976-77</u>, Canberra, February, 1978.

The Commonwealth is a major contributor in the funding of roads in Australia. In assessing Australia's needs for roads and the level of Commonwealth grants it is necessary to have some measure of the real output of past road construction activity. It is for these reasons that a national road construction price index was developed by the former Commonwealth Bureau of Roads. The coverage of the resultant index included the road activities of all state road authorities and local government authorities. This paper describes the refinement of that earlier methodology of the former Bureau of Roads and updates the road construction price index to 1977-78.

CHAPTER 2 - METHODOLOGY

The output of the road construction industry is not a marketed product and it is generally heterogeneous, both spatially and temporally. Consequently there are difficulties in measuring price changes in road construction by output methods. An alternative to the conventional method of measuring price changes of marketed goods and services is to estimate the overall price changes of the output at resource cost valuation by measuring changes in the prices of inputs of goods and services, suitably weighted. This method generally ignores the productivity changes which occur in the activity over time. Changing the weightings of the component inputs through time only partially overcomes this problem as it ignores the changes in the quantity of final product relative to the inputs.

In this paper an input approach is used to develop a price index for the road construction industry. Adjustment is made for changes in productivity by use of a productivity index.

The Australian Statistician has produced Australian national account inputoutput tables for 1968-69.⁽¹⁾ These tables disaggregate the Australian economy into 109 industries and describe the transactions or flows of goods and services between the 109 industries and the destination of goods and services to final consumption, capital accumulation and export. In addition the tables set out the labour costs, surplus, indirect taxes and imports (collectively termed primary inputs) required in the production of goods and services for each of the industries.

The classification of industries included in the tables does not separately identify the road construction industry - such activity is included under the 'other building and construction' industry. This last industry has been disaggregated by the author into the road construction industry together with a number of other industries which are relevant to the work of the Bureau of Transport Economics, and it is envisaged this method of disaggregation will be reported on by the author in a future publication of the Bureau in 1979.

 Australian Bureau of Statistics <u>Australian National Accounts</u> - <u>Input</u> -<u>Output Tables 1968/69</u> Canberra 1978. The modified input-output transactions table is then transformed into a direct coefficients table and direct and indirect coefficients tables.⁽¹⁾ By multiplying the column vector for the road construction industry of the direct and indirect coefficients table by each of the primary input row vectors of the direct coefficients table, the direct and indirect proportions of primary inputs in the road construction industry are estimated.

This procedure can be interpreted in the following way. The direct coefficients give estimates of the proportions of materials and the primary inputs of labour, surplus, etc. used by the road construction industry. The materials component is converted to primary inputs by the above calculation so that estimates are obtained of the labour, surplus etc. required to produce the goods and services used by the road construction industry.

The surplus proportion is divided into its component parts of depreciation, enterprise income tax, interest charges and other surplus (covering distributed and undistributed profits) from an analysis of the enterprise income and outlay accounts incorporated in the Australian national accounts. The indirect taxes component of the inputs into the road construction industry are divided into payroll tax and local government taxes determined by calculating the ratio of payroll tax payments relative to wages salaries and supplements paid in 1968-69 and from that is calculated the proportion of total costs for 1968-69 of payroll tax - the difference between the payroll tax proportion and total indirect taxes is the local government taxes. Table 2.1 sets out the details of the proportions of the various components of the road construction industry for 1968-69.

 This procedure is described in Commonwealth Bureau of Roads <u>Report on</u> <u>Roads in Australia 1975</u>, Appendix 1, Attachment 2, 1975, Melbourne.

4

Component	Proportion
Wages, salaries and supplements	62.3
Depreciation	5.7
Income Tax	6.0
Other Surplus	12.2
Commodity Taxes	2.8
Payroll Tax	0.9
Local Government Taxes	2.1
Sales by Final Buyers	0.2
Complementary Imports	2.9
Competing Imports	4.6
Duty on Competing Imports	0.3
TOTAL	100.0

 TABLE 2.1 - PROPORTIONS OF THE COMPONENT COSTS OF THE ROAD CONSTRUCTION

 INDUSTRY FOR 1968-69

Source : Derived by author from various National Accounts bulletins published by the Australian Bureau of Statistics.

The road construction price index is calculated by the weighted sum of the price indexes for the above components. The weights are the base year proportions given in Table 2.1. This series is adjusted for changes in productivity by use of a total productivity index for non-farm production in the Australian economy. This adjustment is appropriate to the indirect inputs in the road construction industry as these cover a wide spectrum of goods and services produced in the Australian economy. No specific productivity measure is available for the value added by the road construction industry so it is assumed that the productivity of the road construction industry is similar to that experienced throughout the non-farm sector. The reason for the base year being 1968-69 is that the proportions are primarily estimated from the 1968-69 input-output tables - these being the latest available from the Australian Bureau of Statistics.

5

CHAPTER 3 - THE ECONOMIC SERIES USED IN THE ROAD CONSTRUCTION PRICE INDEX

This chapter describes the procedures of estimation of indexes for the components of the road construction price index listed in Table 2.1.

Wages, Salaries and Supplements

Previous work by the Commonwealth Bureau of Roads treated this component in two parts viz. that which was related directly to the road construction industry and secondly that relating to the wages and salaries consumed in the production of goods and services used by the road construction industry. However, it is considered that the difference between the series is insignificant and a separate series for the two components is not warranted. Consequently an index relating to average weekly earnings is used for measuring both direct and indirect costs of wages, salaries and supplements used by the road construction industry. This information is derived from official sources.⁽¹⁾ Table 3.1 sets out the index of wages, salaries and supplements.

Year ended 30 June	Index	Year ended 30 June	Index
1964	73.3	1971	120.5
1965	78.8	1972	132.7
1966	82.4	1973	144.6
1967	87.9	1974	168.0
1968	93.0	1975	210.7
1969	100.0	1976	240.9
1970	108.4	1977	270.9
		1978	298.3 p

TABLE 3.1 - WAGES, SALARIES AND SUPPLEMENTS INDEX

p - provisional

(1) Australian Bureau of Statistics, <u>Wage Rates and Earnings</u>, various Bulletins, Canberra, A.C.T.

Depreciation

The cost of depreciation of capital equipment is derived from an index which assumes that all capital equipment is evenly written off in eight years. This is a little higher than that allowed for taxation purposes but it is considered closer to common practice in business. As such, each year has a component of the capital costs incurred in each of the past eight years. The changes in prices of capital equipment are derived from the implicit price index of 'all other' components of gross fixed capital expenditure in the Australian national accounts. ⁽¹⁾ The index is set out in Table 3.2.

Year ended 30 June	Index	Year ended 30 June	Index
1964	92.3	1971	105.6
1965	93.7	1972	109.9
1966	95.0	1973	114.4
1967	96.5	1974	119.7
1968	98.1	1975	128.4
1969	100.0	1976	140.0
1970	102.4	1977	154.3
		1978	171.2

TABLE 3.2 - INDEX OF DEPRECIATION COSTS

Income Tax

The index relating to enterprise income tax is estimated by compiling an index which measures the changes in enterprise income tax payable relative to total disbursements. Such information is obtained from corporate trading enterprises and financial enterprises income and outlay accounts as published in the Australian national accounts.⁽²⁾ Details of changes in the cost of income tax are set out in Table 3.3

- Australian Bureau of Statistics : <u>Australian National Accounts</u> : Income <u>Expenditure</u>, various bulletins, Canberra, A.C.T.
- (2) Australian Bureau of Statistics, <u>Australian National Accounts</u>: Income and Expenditure, various bulletins, Canberra, A.C.T.

Year ended 30 June	Index	Year ended 30 June	Index
1964	100.0	1971	103.4
1965	98.7	197 2	99.9
1966	95.6	1973	110.6
1967	95.2	1974	110.3
1968	100.1	1975	102.9
1969	100.0	1976	96.3
1970	107.9	1977	86.5
		1978 p	86.5

TABLE 3.3 - INDEX OF ENTERPRISE INCOME TAX RATES

p - provisional

Other Surplus

Other surplus comprises interest charges, distributed and undistributed profit of contractors in the road construction industry and of industries supplying materials and services to the road construction industry. This component is treated in the economic sense as a cost of production in that it is regarded as a payment for services rendered by one of the factors of production i.e. use of capital. It is in this sense the surplus is regarded as a cost of production in the road construction industry and can identically be related to capital employed to derive a cost of capital.

No official index is available to measure changes in the cost of capital. Therefore an estimate has been calculated by relating interest and profit of enterprises both incorporated and unincorporated to capital stock. The capital stock comprises machinery and equipment, that which is derived from building and construction and inventories.

Details of the series of interest and profit are obtained from official sources in the estimates of national accounts relating to corporate trading enterprises, financial enterprises and unincorporated enterprises.⁽¹⁾ This information is set out in Table 3.4.

Australian Bureau of Statistics, <u>National Accounts : Income and Expenditure</u>, various bulletins, Canberra, A.C.T.

Year ended 30 June	Amount	Year ended 30 June	Amount
<u></u>	\$ million		\$ million
1964	3686	1971	5719
1965	3948	1 97 2	6353
1966	3884	1973	7487
1967	4481	1974	79 9 5
1968	4403 .	1975	7724
1969	5252	1976	10118
1970	5471	1977	13275
		1978	13005

TABLE 3.4 - SURPLUS COMPRISING INTEREST CHARGES AND PROFIT

Capital stock estimates at constant prices for both machinery and equipment and that derived from building and construction are described in Chapter 4 of this paper. As it is necessary to relate the surplus to the current value of the capital stock the constant price series of the two types of capital stock are converted to current prices for each year by using the respective price deflators. In addition to the above capital stock, the value of closing stock inventories must be included to obtain a value of total capital stock. Official sources supply details of changes in stock inventories⁽¹⁾ and from work associated with research on medium term economic forecasting⁽²⁾ a series of stock inventories is calculated. Details of capital stock are set out in Table 3.5.

The surplus for each year as listed in Table 3.4 divided by the total capital stock of each year as set out in Table 3.5 gives an estimate on the return on capital in Australia, or in other terms the cost of capital. By dividing the series by the 1968-69 return on capital a price index of cost of capital is obtained with a base of 1968-69 equals 100. This information is set out in Table 3.6

- (1) Australian Bureau of Statistics <u>National Accounts</u> : Income and Expenditure, various bulletins, Canberra A.C.T.
- (2) B.D. Haig, <u>A Model for Medium Term Economic Forecasting</u> Occastional Paper 14 Bureau of Transport Economics, 1978, Canberra A.C.T.

9

Year ended 30 June	Building and Construction	Plant and Equipment	Stock Inventories	Total
	\$ million	\$ million		
1964	25534	7534	2850	35918
1965	28554	8602	3410	40566
1966	31319	9601	3523	44443
1967	34745	10549	3883	49177
1968	38227	11516	4023	53766
1969	42239	12654	4744	59637
1970	47111	13889	5198	66198
1971	53300	15476	5696	74472
1972	60166	17254	5725	83145
1973	69217	18032	5344	9 2593
1974	84807	20048	6661	111516
1975	110468	24864	7591	142923
1976	136873	29126	7624	173623
1977	155307	33854	8697	197858
1978	169328 p	39105 p	8472 p	216905 p

TABLE 3.5 - CAPITAL STOCK AT CURRENT PRICES

p - provisional

Year ended 30 June	Return on ⁽¹⁾ Capital	Price Index of Cost of Capital
	per cent	
1964	10.3	116.5
1965	9.7	110.4
1966	8.7	99.2
1967	9.1	103.4
1968	8.2	93.0
196 9	8.8	100.0
1970	8.3	93.8
1971	7.7	87.2
1972	7.6	86.7
1973	8.1	91.8
1974	7.2	81.4
1975	5.4	61.3
1976	5.8	66.2
1977	6.7	72.2
1978	6.0	68.1

TABLE 3.6 - RETURN ON CAPITAL AND A PRICE INDEX OF THE COST OF CAPITAL

(1) Ratio of surplus (interest and profit) to capital stock.

Commodity Taxes

The commodity tax component consists primarily of fuel tax (sales taxes apply to final demand items and play a very small part in interindustry transactions). An index has been calculated which reflects the changes in the petrol and diesel fuel import and excise duty rates. Details of this index are set out in Table 3.7.

TABLE 3.7 - FUEL TAX INDEX

Year ended 30 June	Index	Year ended 30 June	Index
1964	79.7	1971	121.5
1965	79.7	1 97 2	138.8
1966	79.7	1973	140.8
1967	98.3	1974	176.5
1968	100.0	1975	181.5
1969	100.0	1 97 6	181.5
1970	100.0	1977	181.5
		1978	189.5

Payroll Tax

Payroll tax is directly related to wage and salaries as it is levied as a proportion of wages and salaries. To determine the changes in costs of this component it is necessary to incorporate the changes in the proportional rates of the levy. Therefore the index relating to this component is the average weekly earning index adjusted for the changing proportional rate. The adjustment of the rate is calculated from the changes in the proportion of payroll tax to wages and salaries paid.⁽¹⁾ Table 3.8 sets out details of the changes in payroll tax index form.

Year ended 30 June	Index	Year ended 30 June	Index
1964	76.3	1971	113.1
1965	81.5	1972	177.8
1966	85.2	1973	200.7
1967	88.5	1974	280.1
1968	91.7	1975	410.0
1969	100.0	1976	476.9
1970	108.4	1977	534.5
		1978	588.5

TABLE 3.8 - PAYROLL TAX INDEX

(1) Australian Bureau of Statistics, <u>Public Authority Finance</u>, various bulletins, Canberra, A.C.T.

Local Government Rates

The index which reflects the changes in costs due to local government taxes is measured by the consumer price index component relating to local government rates.⁽¹⁾ Details of this index are set out in Table 3.9.

Year ended 30 June	Index	Year ended 30 June	Index
1964	71.6	1971	115.3
1965	73.8	1972	126.6
1966	80.8	1973	137.0
1967	85.8	1974	148.7
1968	93.1	1975	170.8
1969	100.0	1976	221.8
1970	106.5	1977	263.5
		1978	290.4

TABLE 3.9 - LOCAL GOVERNMENT RATES INDEX

Sales to Final Buyers

This component relates to the mark-up associated with the sale of second hand goods and the consumer price index for all products is considered the appropriate measure of this item. Table 3.10 sets out the series of the consumer price index adjusted to 1968/69 equals 100.⁽¹⁾

 Australian Bureau of Statistics, <u>Labour Report</u>, various bulletins, Canberra, A.C.T.
 Australian Bureau of Statistics, <u>Consumer Price Index</u>, various bulletins, Canberra, A.C.T.

Index	Year ended 30 June	Index
87.3	1971	108.1
89.9	1972	115.5
92.5	1973	122.5
94.3	1974	138.3
97.5	197 5	161.3
100.0	1976	182.4
103.2	1977	207.5
	1 9 78	227.3
	Index 87.3 89.9 92.5 94.3 97.5 100.0 103.2	IndexYear ended 30 June87.3197189.9197292.5197394.3197497.51975100.01976103.219771978

TABLE 3.10 - CONSUMER PRICE INDEX

Complementary Imports

The main item of complementary imports used by the road construction industry is crude mineral oil. The Reserve Bank produced an index relating to the changes in import prices of mineral oils and lubricants.⁽¹⁾ This index has been adjusted so that 1968/69 equals 100 and is used to measure the changes in prices of complementary imports. Details of this series are set out in Table 3.11.

Year ended 30 June	Index	Year ended 30 June	Index
1964	110.1	1971	99.9
1965	109.0	1972	118.6
1966	108.6	1973	125.2
1967	103.3	1974	290.2
1968	100.6	1975	589.5
1969	100.0	1976	690.3
1970	99.0	1977	760.6
		1978	825.0

TABLE 3.11 - IMPORT PRICE INDEX OF MINERAL OILS AND LUBRICANTS

(1) Reserve Bank, <u>Statistical Supplement</u>, various bulletins, Sydney, New South Wales.

Competing Imports

This item relates primarily to imports other than mineral crude oil. The Reserve Bank has produced an import index reflecting changes in prices of such imports over recent years. In earlier years the overall import price index of the Reserve Bank is adjusted for the mineral oil price changes using the published weighting and import price index for imported mineral oils and lubricants. Table 3.12 sets out the results of the price changes of competing imports.

Year ended 30 June	Index	Year ended 30 June	Index
1964	93.6	1971	108.2
1965	95. 4	1972	114.2
1966	97.8	1973	112.2
1967	99.3	1974	121.9
1968	98.4	1975	154.9
1969	100.0	1976	174.0
1 97 0	104.4	1977	202.6

TABLE 3.12 - IMPORT PRICE INDEX OF COMPETING IMPORTS

Import Duty

The import duties are usually of an <u>ad valorem</u> type and consequently the costs of this tax are related to the price changes of imports. The price index relating to competing imports as set out in Table 3.12 is used for measuring changes in the cost of this component.

Definition

In economic terms a productive process in a given industry or for a given product can be expressed as a relationship between output and inputs of labour, materials and capital, (known as the factors of production) or alternatively as the relationship between product (the value added by the process of production) and inputs of labour and capital (materials and services are omitted as they are the result of economic activities of other industries). It is the latter concept which is used in the succeeding analysis. Productivity is accordingly measured by the savings in inputs at constant prices of capital and labour relative to a given product (value added) at constant prices.

There has been a common practice of measuring productivity in terms of changes in output with respect to labour inputs. In general, the method used has been erroneous as it also incorporates the changes in intensity of capital utilization, and the results have been interpreted as being wholly attributable to changes in productivity of labour. It is the purpose of the above definition to measure productivity completely and at the same time identifying the contributions of the component factors of labour and capital.

The Measurement of Productivity

The measurement of productivity is based on the production function. The production function is a technical relation between the quantities of various factors of production (inputs) and the amount of output which they yield when combined together. The production function used in the analysis follows that adopted by Deakin and Seward⁽¹⁾ whose formulation is based on the Cobb-Douglas production function. By differentiating with respect to time the logarithmic transform of the function, the production function is expressed in exponential rates of growth per annum.

 B.M. Deakin and T. Seward, <u>Productivity in Transport</u>, C.U.P., 1969, Cambridge. $\Delta Y = (1-\alpha) \Delta L + \alpha \Delta K + \Delta ATOKE$

where Y = product

~ = the share of capital in total rewards

K = capital stock

L = 1abour

ATOKE = applied technical and organizational knowledge and external factors

 Δ = exponential rate of growth

The equation is transformed to give a measure of total productivity AATOKE

 $\triangle ATOKE = \triangle (Y/L) - \propto \triangle (K/L).$

The following paragraphs detail the information required to measure productivity of non-farm production in Australia from 1963-64 onwards.

Product

The Australian Statistician has published product by industry at constant 1968-69 prices from 1962-63 to 1973-74⁽¹⁾. Subsequent to that period, data is published in 1973-74 prices⁽²⁾ for farm and non-farm product. The latter information is converted to 1968-69 prices by converting the major components of Gross National Expenditure in 1973-74 prices to 1968-69 prices adding exports at 1968-69 prices and subtracting imports and farm product at 1968-69 prices. This gives an estimate of the continuation of the non-farm product as published in the earlier series. Table 4.1 sets out this information.

 Australian Bureau of Statistics, <u>Australian National Accounts, Gross</u> <u>Product by Industry at Current and Constant Prices 1962-63 to 1973-74</u>, 1975, Canberra, A.C.T.

(2) Australian Bureau of Statistics, <u>Australian National Accounts: National Income Expenditure 1976/77</u>, 1978 Canberra A.C.T.

17

Year ended 30 June	Value	Year ended 30 June	Value
	<pre>\$ million</pre>		\$ million
1964	18342	1971	27735
1965	19628	1972	28763
1966	20376	1973	30206
1967	21366	1974	32311
1968	22788	1975	32732
1969	24615	1976	33475
1970	26423	1977	34873
		1978	35492

TABLE 4.1 - NON-FARM PRODUCT AT 1968-69 PRICES

Labour

Labour is measured by the number of employed, self employed or proprietors who undertake work for reward. The agricultural (or farm) work force is excluded. The information is obtained from official sources $^{(1)}$ and is set out in Table 4.2.

TABLE 4.2 - NON-FARM EMPLOYMENT

Year ended 30 June	Number	Year ended 30 June	Number
	thousands		thousands
1964	4029	1971	4957
1965	4119	1972	5011
1966	4258	1973	5153
1967	4397	1974	5327
1968	4515	1975	5347
1969	4643	1976	5421
1970	4805	1977	5477
	· .	1978	5510

(1) Australian Bureau of Statistics, <u>The Labour Force</u>, 1977, 1978, Canberra, A.C.T.

Capital

There are no official estimates of the value of the nation's accumulated capital stock and to obtain such estimates it is necessary to accumulate net capital expenditure for a past period. There are two major categories of capital stock viz. machinery and equipment and that which is derived from building and construction. It is assumed that the economic life of the latter is 40 years and that of the former is eight years. Further it is assumed that the capital is consumed evenly throughout its economic life.

To obtain data on the capital stock derived from building and construction for the period 1963-64 onwards it is necessary to obtain capital expenditure on building and construction back to 1924-25. The main source of information from 1924-25 to 1940-41 are the estimations made by Keating.⁽¹⁾ Subsequent to 1947-48 official estimates have been made of capital expenditure on building and construction.⁽²⁾ Little information is available for the intervening years.

Keating estimated the expenditure in current prices and 1910-11 prices on electricity, water and sewerage, building, roads and other. He also estimated the workforce involved on gas construction activity and an estimate has been made on gas construction activity. The summation of these expenditures gives an estimate of expenditure at current and 1910-11 prices on building and construction capital expenditure from 1924-5 to 1940-41.

Since 1959-60 the Australian Statistician has published information on gross fixed capital expenditure at current and at either 1966-67 prices or 1973-74 prices disaggregated into public and pricate, and dwellings, other building and construction and other capital equipment. For the period 1947-48 to 1959-60 the Statistician published the series of capital expenditure on private dwellings at current and constant prices, and separate details of private capital expenditure on other building and construction, and other capital equipment. To obtain the private capital expenditure on building and construction at constant prices the implicit price inexes relating to dwellings are applied to the private building and construction current expenditure.

M. Keating, <u>The Australian Workforce 1919-11 to 1960-61</u>, Department of Economic History, The Australian National University, Canberra, 1973.

⁽²⁾ Australia Bureau of Statistics <u>Australian National Accounts National</u> : <u>Income and Expenditure</u>, various bulletins, Canberra, A.C.T.

Capital expenditure by public authorities in national accounting terms is not directly available for this period in either current and constant prices from official sources. However capital expenditure by public authority activity in current prices is available.

From the nature of the activity an estimate of the buildings and construction expenditure is obtained e.g. capital expenditure on land settlement is regarded as being totally building and construction. This is coverted to constant prices by the implicit price index derived from published data on total authority fixed capital expenditure. The expenditure at the various constant prices are linked together to give a series from 1947-48 to the present at 1968-69 prices.

The capital expenditure on building and construction between 1940-41 and 1947-48 is estimated by extrapolation backwards of the ratio of output in 1968-69 prices per person employed in building construction and this in turn is linked to the series 1924-25 to 1940-41. Such a procedure is prone to give a biased result of capital expenditure in the early years. However, the error from such a bias in the measurement of capital stock as described in the following paragraphs would be small. Details of the capital expenditure on building and construction are set out in Table 4.3.

The net capital stock derived from building and construction is estimated from the foregoing series using the perpetual inventory approach and assuming that capital stock is consumed at a rate of $2\frac{I_2}{2}$ per cent per annum. Table 4.4 sets out the resultant capital stock of building and construction.

Year ended 30 June	Expenditure	Year ended 30 June	Expenditure
	\$ million	·····	\$ million
1925	603	1952	1723
1926	569	1953	1662
1927	. 634	1954	1639
1928	660	1955	1722
1929	626	1956	1783
1930	461	1957	1845
1931	307	1958	1919
1932	246	1959	2059
1933	296	1960	2420
1934	362	1961	2559
1935	466	1962	2542
1936	511	1963	2730
1937	551	1964	3002
1938	591	1965	3282
1939	587	1966	3477
1940	563	1967	3504
1941	468	1968	3752
1942	371	1969	4084
1943	365	1970	4309
1944	357	1971	4493
1945	378	1972	4675
1946	490	1973	4655
1947	767	1974	4705
1948	940	1975	4560
1949	1030	1976	4563
1950	1220	1977	4633
1951	1467	1978	4600 p

TABLE 4.3 - CAPITAL EXPENDITURE ON BUILDING AND CONSTRUCTION IN 1968-69 PRICES

p - provisional

Year ended 30 June	Value	Year ended 30 June	Value
	\$ million		\$ million
1964	30289	1971	48018
1965	32485	1972	51031
1966	34799	1973	53907
1967	37081	1974	56727
1968	39532	1975	5 9 296
1969	42239	1976	61766
1970	45082	1977	64203
		1978	65504 p

TABLE 4.4 - CAPITAL STOCK FROM BUILDING AND CONSTRUCTION 1968-69 PRICES

p - provisional

The remaining capital investment comprises plant and equipment for which information is available from official sources.⁽¹⁾ The data on capital investment on plant is available at constant prices from 1959-60. Prior to this year private investment in capital expenditure other than dwellings is available at both current and constant prices. The public sector investment is available only for current expenditure. The implicit price index derived from the private sector other investment is used to convert the current price capital investment of plant and equipment to constant prices. The whole series is then converted to 1968-69 prices and details are set out in Table 4.5.

The capital stock of plant and equipment is estimated from the foregoing series using the perpetual inventory approach and by assuming capital expenditure is consumed at a rate of $12\frac{1}{2}$ per cent per annum. Table 4.6 sets out the capital stock of plant and equipment.

⁽¹⁾ Australian Bureau of Statistics, <u>Australian National Accounts: Income</u> and <u>Expenditure</u> various bulletins, Canberra, A.C.T.

Table 4.7 details the total capital stock for Australia from 1963-64. The capital stock for the purposes of productivity measures excludes inventory stock because the latter does not have a direct effect on the productive process.

Year ended 30 June	Value	Year ended 30 June	Value
<u></u>	\$ million		\$ million
1957	1543	1968	3005
1958	1637	1969	3169
1959	1656	1970	3270
1960	1790	1971	3417
1961	1878	1972	3430
1962	1917	1973	3326
1963	2055	1974	3738
1964	2271	[,] 1975	3704
1965	2656	1976	3749
1966	2807	1977	3876
1967	2891	1978	3920 p

TABLE 4.5 - CAPITAL INVESTMENT IN PLANT AND EQUIPMENT 1968-69 PRICES

p - provisional

TABLE 4.6 - CAPITAL STOCK PLANT AND EQUIPMENT 1968-69 PRICES

Year ended 30 June	Value Year ended 30 June		Value
	\$ million		\$ million
1964	8600	1971	13980
1965	9611	1972	14475
1966	10436	1973	14720
1967	11199	1974	15292
1968	11921	1975	15717
1969	12654	1976	16083
1970	13329	1977	16482
		1978	17000 p

p - provisional

Year ended 30 June	Value	Year ended 30 June	Value
	\$ million		\$ million
1964	38889	1971	61998
1965	42096	1972	65506
1966	45235	1973	68627
1967	48280	1974	72019
1968	51453	1975	75013
1969	54893	1976	77849
1970	58411	1977	80685
		1978	82678

TABLE 4.7 - TOTAL CAPITAL STOCK 1968-69 PRICES

Share of Capital in Total Rewards

The procedure adopted in measuring the share of capital in total factor rewards is to obtain the wages and salaries paid less that paid in the agricultural sector and relate this to the total non-farm product and subtract the ratio from unity for each year. Details of these estimates are set out in Table 4.8.

TABLE	4.8	_	SHARE	\mathbf{OF}	CAPITAL	IN	TOTAL	FACTOR	REWARDS
			-						

Year ended 30 June	Share	Year ended 30 June	Share
1964	0.4516	1971	0.4362
1965	0.4488	1972	0.4339
1966	0.4436	1973	0.4370
1967	0.4416	1974	0.4178
1968	0.4478	1975	0.3919
1969	0.4507	1976	0.4119
1970	0.4510	1977	0.4264
		1978	0.4299

ESTIMATES OF PRODUCTIVITY 1963-64 TO 1977-78

By substitution of the estimates of capital stock, labour and the share of capital in total factor rewards in the equation outlined at the beginning of this chapter, percentage productivity changes and an index of non-farm productivity are estimated e.g. productivity for 1964-65 is calculated as follows:-

Capital stock		
1963-64, K _{t-1} , \$ million	8	38889
1964-65, K, \$ million	=	42096
Non-farm product		
1963-64, Y _{t-1} , \$ million	=	18342
1964-65, Y, \$ million	=	19628
Labour units (Non-farm)		
1963-64, L _{t-1} , thousands	=	4029
1964-65, L, thousands	=	4119
Capital per unit of labour		
1963-64, K_{t-1}/L_{t-1}	=	9652
1964-65, K_t/L_t	=	10220
Product per unit of labour		
$1963-64$, Y_{t-1}/L_{t-1}	=	4552
1964-65, Y_t/L_t	=	4765
Exponential growth rate of capital per		
unit of labour, 1964-65, ln $(K_t L_{t-1}/K_{t-1}L_t), \Delta^{K}/L$	=	0.0572
Exponential growth rate of product per		
unit of labour, 1964-65, ln $(Y_t_{t-1}/Y_{t-1}L)$, Δ^Y/L	=	0.0457
Share of capital in total rewards 1964-65, α	=	0.4488
Exponential growth rate in productivity 1964-65, $\Delta^{Y}/L = \alpha \Delta^{K}/L$	=	0.0367
Percentage productivity change in 1964-65 over 1963-64	=	3.74

Table 4.9 sets out the results of these procedures from 1963-64 to 1977-78.

Year ended 30 June	Percentage Productivity Changes	Productivity Index
1964	n.a.	87.4
1965	3.74	90.7
1966	3.76	94.1
1967	2.66	96.6
1968	2.04	98.5
1969	1.47	100.0
1970	1.14	101.1
1971	2.12	103.3
1972	3.36	106.7
1973	0.95	107.8
1974	0.08	107.8
1975	3.40	111.5
1976	2.00	113.7
1977	1.25	115.2
1978	1.13	116.7

TABLE	4.	9	-	MEASURES	\mathbf{OF}	CHANGES	IN	NON-FARM	PRODUCTIVITY

26

.

CHAPTER 5 - ESTIMATES OF ROAD CONSTRUCTION PRICE CHANGES

In Chapter 2 the methodology of measuring price changes in road works is set out. Chapters 3 and 4 describe the derivation of data to calculate a road construction price index. The results are set out in Table 5.1.

In the base year 1968-69 the direct and indirect labour costs constituted 64 per cent of the total costs of road works. As a result changes in the cost of labour have a significant impact on the cost of roads.

The indirect cost of complementary imports, which are primarily crude mineral oils used in the production of bitumen products, is an item which has had an important bearing on the increased costs of roads even though their proportion of costs in 1968-69 was only three per cent. This has arisen because of the massive increase in the price of imported crude mineral oils - the price in 1977-78 being over eight times higher than in 1968-69.

Payroll tax has risen nearly six times higher than that which it was in 1968-69. This can be attributed to two factors - the increase in salaries and wages, and the increase in the percentage rate of tax on the payroll. However, the component of costs due to this item is small (in 1968-69 amounting to less than one per cent of total costs) and does not have a large impact on the overall costs of roads. This is due to the fact that local governments (with exception of local governments in Victoria) and Commonwealth constructing authorities do not pay payroll tax on road construction works. This item could be of some significance in costs for those authorities not exempt from payroll tax such as the state road authorities.

All other changes in component costs moved at a lower rate than salaries and wages and had a dampening effect on total cost rises.

The 'sub-total' column describes the changes in costs if there were no productivity changes in either the road construction industry or any of the supplying industries to the road construction industry. It is unrealistic to assume no changes in productivity either in a specific industry or in the economy as a whole over a period of years. It is for this reason that the 'sub-total' column is deflated by a productivity index. The index as

27

TABLE	5.1	-	ROAD	CONSTRU	ICTION	PRICE	INDEX

Year Ended 30 June	Wages Salaries and Supple- ments	Deprec iation	Enterpríse Income Tax	Oth er Surplus	Commodity Taxes	Payroll Taxes	Local Govern- ment Rates	Sales by Final Buyers	Comple- mentary Imports	Competing Imports	Import Duty	Sub-total	Product ivity Index	Road Constr- uction Price Index	Year Ended 30 June
Weight- ing	62.29	5.68	6.02	12.27	2.83	0.90	2.06	0.15	2.89	4.63	0.28	100.0	-	-	-
1964	73.3	92.3	100.0	116.5	79.7	76.3	71.6	87.3	110.1	93.6	93.6	83.5	87.4	95.6	1964
1965	78.8	93.7	98.7	110.4	79.7	81.5	73.8	89.9	109.0	95.4	95.4	86.4	90.7	95.2	1965
1966	82.4	95.0	95.6	99.2	79.7	85.2	80.8	92.5	108.6	97.8	97.8	87.4	94.1	92.9	1966
1967	87.9	96.5	95.2	103.4	98.3	88.5	85.8	94.3	103.3	99.3	99.3	92.0	96.6	95.3	1967 -
1968	93.0	98.1	100.1	93.0	100.0	91.7	93.1	97.5	100.6	98.4	98.4	94.4	98.5	95.9	1968
1969	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	1969
1970	108.4	102.4	107.9	93.8	100.0	108.4	106.5	103.2	99.9	104.4	104.4	105.5	101.1	104.4	1 970
1971	120.5	105.6	103.4	87.2	121.5	113.1	115.3	108.1	99.9	108.2	108.2	113.2	103.3	109.6	1971
1972	132.7	109.9	99.9	86.7	138.8	177.8	126.6	115.5	118.6	114.2	114.2	. 122.9	106.7	115.2	1972
1973	144.6	114.4	110.6	91.8	140.8	200.7	137.0	122.5	125.2	112.2	112.2	107.8	107,8	122.8	1973
1974	168.0	119.7	110.3	81.4	176.5	280.1	148.7	138.3	290.2	121.9	121.9	153.2	107.8	142.1	1974
1975	210.7	128.4	102.9	61.3	181.5	410.0	170.8	161.3	589.5	154.9	154.9	189.5	111.5	169.9	1975
1976	240.9	140.0	96.3	66.2	181.5	476.9	221.8	182.4	690.3	174.0	174.0	214.7	113.7	188.8	1976
1977	270.9	154.3	86.5	76.2	181.5	534.5	263.5	207.5	760.6	202.6	202.6	239.7	115.2	208.1	1977
1978 p	298.3	171.2	86.5	68.1	189.5	588.5	290.4	227.3	825.0	228.0	228.0	261.1	116.7	223.8	1978

. –

4

p provisional.

.

calculated in Chapter 4 gives a reasonable approximation to the changes in productivity of the supplying industries as they cover a wide spectrum of the Australian economy either directly or indirectly. In the absence of a productivity index specifically for the road construction industry the above national non-farm productivity index is applied to the value added component of the road construction industry. The 'sub-total' column is deflated by the national non-farm productivity index to give an estimate of a national road construction price index.

The actual year by year measures of productivity changes are used rather than an averaged trend of productivity which would eliminate cyclical changes. The reason for adopting the former approach is that the use of the productivity index in the road construction price index requires measures of changes on an annual basis.

Of some interest is a comparison of price changes in a number of aggregate activities in the Australian economy with the road construction industry as measured by the road construction price index. Table 5.2 sets out these details.

The higher rises of the official indexes can in part be attributed to the method used by the Australian Bureau of Statistics. The latter in respect of construction other than dwellings capital expenditure both public and private, uses an input method which incorporates special purpose indexes of wages and material inputs⁽¹⁾. This method over a period of time will over-estimate price changes because it does not incorporate the effect of technological change and other productivity effects. Further, little cognisance appears to be taken of the changes in profitability in the construction work undertaken by the private sector which can have a significant effect on pricing.

 Australian Bureau of Statistics, <u>Australian National Accounts</u>, <u>Outline</u> of Principal Sources and Methods, 1978, Canberra, A.C.T.

29

The official price indexes relating to building and construction investment should <u>not be compared</u> with the road construction price index because the former are biased and overestimate the price changes that have occurred.

Year ended 30 June	Private Dwellings	Private Other Construction	Public Other Construction	Road Construction
1964	86.6	83.3	82.0	95.6
1965	89.0	87.4	86.3	95.2
1 96 6	91.7	88.9	88.5	92.9
1967	94.5	92.8	92.9	95.3
1968	97.3	95.4	95 . 9	95.9
1969	100.0	100.0	100.0	100.0
197 0	103.9	104.6	105.0	104.4
1971	109.0	111.3	112.0	109.6
1972	117.1	119.6	119.6	115.2
1973	127.1	127.8	129.2	122.8
1974	154.5	146.3	147.9	142.1
1975	188.6	185.2	185.1	169.9
1976	219.0	214.8	215.0	188.8
1977	246.0	241.5	240.3	208.1
1 97 8	260.9	256.1	n.a.	223.8

TABLE 5.2 ~ COMPARATIVE PRICE INDEXES

Source: Australian Bureau of Statistics, <u>Australian National Accounts</u>: National Income and Expenditure, various bulletins, Camberra A.C.T.

The road construction price index makes an allowance for the defects which exist in the official aggregate implicit price indexes. At the same time the road construction price index could be improved by estimations of a productivity index specifically relating to road construction.

It is considered that the road construction price index is a reasonably accurate measure of the changes in the levels of prices of road works because it specifically relates to roads and incorporates a measure for productivity changes which other indexes do not appear to include.