Evaluating Transport Investments With National Economic Models: Australian Experience With ORANI

Working Paper

This Working Paper is an intermediate output in a research project being conducted by the Bureau of Transport and Communications Economics (BTCE). The project team examines the adequacy of conventional methods for estimating economic benefits from transport and communications infrastructure investment.

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Evaluating transport investments with national economic models: Australian experience with ORANI

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FOREWORD

This working paper is an intermediate output in a research project being conducted by the Bureau of Transport and Communications Economics (BTCE). The project team is examining the adequacy of conventional methods for estimating economic benefits from transport and communications infrastructure investment. In a pilot case study for the project, the Bureau examined the regional development effects of two highway bypasses in rural New South Wales (BTCE 1994a). The study found that the improvement in the environments of the bypassed towns, due to the reduction in traffic, was stimulating local economic development—particularly in one of the towns which had become more attractive to tourists. The study further found that this stimulus has a net benefit to society which was not valued in the original benefit–cost analysis of the bypasses. However, the evidence was insufficient to conclude that the original benefit–cost analysis had underestimated economic benefits, since evidence was lacking on the accuracy of its traffic projections and other key assumptions.

This paper examines the potential of the ORANI model of the Australian economy for evaluating transport infrastructure investments. In particular, it considers whether applications of the model imply larger benefits from transport infrastructure investments than are captured in benefit–cost analyses. The more basic question of what an ideal national economic model would reveal about benefit–cost analyses will be addressed in the final report for the BTCE project, scheduled for release in the second half of 1995. The report will also consider evidence from case studies, and from econometric studies of the productivity effects of public infrastructure.

David Luskin prepared this paper after helpful discussions with colleagues, particularly Mike Cronin. Discussions were also held with people outside the Bureau, whose assistance is gratefully acknowledged, but whose views are not necessarily reflected by the contents of this paper. Particularly generous with

their time were Mark Horridge and Robert McDougall, both of the Centre of Policy Studies, and John Cox, a transport consultant based in Melbourne. Also consulted were John Fallon and John Zeitch, of Swan Consultants, Peter Dixon and Brian Parmenter, of the Centre of Policy Studies, and John Madden of the Centre for Regional Economic Analysis.

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ABSTRACT

Recent use of the ORANI model of the Australian economy has reinforced thinking that investments in transport infrastructure have larger economic benefits than are measured in benefit–cost analyses. This paper shows this inference to be based on errors in interpretation of the ORANI model. ORANI and its dynamic offshoot, the MONASH model, can serve to analyse the distributional effects of transport investments, but do not lend themselves to summary measures of benefit to society. Moreover, some shortcomings of the model for analysing distributional effects, particularly at the State and regional level, emerge from our review.

INTRODUCTION

Do evaluations of transport infrastructure investments take too narrow an economic perspective? This question has concerned governments in Australia, where most of the transport infrastructure is publicly provided. Investments in these assets can have far–reaching effects on sectors of the economy —for example, urban road improvements might stimulate employment in distant rural regions. Evaluations of investments mention these broader effects far more often than they estimate them. Normally, they focus on the market for the infrastructure service being evaluated and, sometimes, on closely related markets. For road projects, which attract most of the public investment in transport infrastructure, a typical evaluation is a benefit–cost analysis (BCA) which predicts the savings in road user costs. It may also predict the effects on traffic volumes and the associated benefits. (People take advantage of better roads by increasing their use of them.) Infrequently do evaluations of road projects predict the economic effects outside the road sector, such as those pertaining to industries, occupations and regional economies.

Broadening the economic focus of transport infrastructure evaluations has pros and cons. Estimates of the broader effects can shed light on the net benefit of the investment to society, and on how benefits and costs are distributed. However, many such effects are very hard to estimate. Attempts can involve costly modelling exercises which, in the end, are highly speculative. Thus, transport planners need to think carefully about which effects really matter for policy purposes, and which are amenable to estimation. Currently, AUSTROADS and other transport organisations in Australia are thinking about the need for estimating macroeconomic effects. They want to know whether effects on real GDP, the balance of trade, or other macroeconomic indicators would provide a much better picture of benefits and costs than do conventional evaluations, and whether estimates of these effects can be trusted.

In Australia, studies using national economic models to analyse transport infrastructure investments have turned mainly to the ORANI model. In addition to distinguishing a large number of industries, ORANI has the attraction of being well documented and transparent. The original model, described in Dixon et al. (1982), forms the core of the many versions that have evolved.

Allen Consulting (1993) used ORANI to analyse the macroeconomic effects of road investments, in its study for the Australian Automobile Association. It found that the overall benefit from road investments, as indicated by the increase in real GDP, was between 50 to 80 per cent larger than the overall benefit in more conventional evaluations (depending on the type of road investment modelled). This finding has encouraged the widespread belief that benefit–cost analyses of road investments typically underestimate benefits (see Cox 1994).

The proposed Very Fast Train (VFT) between Melbourne and Sydney occasioned another ORANI–based study (CREA 1990), which examined the implications for the State and national economies. The study measured national net benefit by changes in consumption rather than real GDP. Other differences from the Allen study, apart from the choice of welfare measure, stand out. The CREA study investigated the cost of investment more comprehensively. However, unlike the Allen study, it did not compare its indication of national benefit to benefit measures from more conventional evaluations.

This paper critically examines what the ORANI findings reveal about the benefits and costs of transport infrastructure investments. Whether the findings for real GDP, real consumption, or some other macroeconomic variable indicate the net benefit of the investments is a central question. The findings for States and industries are also critiqued.

Claims that conventional evaluations mismeasure the economic benefits of transport infrastructure investments have emanated from econometric analyses and case studies, as well as from applications of ORANI. The Bureau is reviewing all these sources of evidence in its current research project on the economic benefits of transport and communications infrastructure investment. The project team is also looking at how transport and communications infrastructure investments affect employment levels. For a recent progress report, see BTCE 1994a.

THE CREA STUDY OF THE VERY FAST TRAIN

The CREA prepared its study for VFT Joint Venture Partners, which had approached the Commonwealth government for a tax break on its intended investment.

Evaluations of infrastructure investments sometimes predict that the construction activity will stimulate the economy, and record the resulting increase in national income as a benefit (see for example Buffington et al. 1992). The expectation is that construction will put unemployed labour and capital back to work, both directly in the construction sector and indirectly through input linkages with other sectors. Whether such a stimulus operates is open to question, particularly for construction undertaken when the economy is well out of recession. Moreover, estimates of the increase in national income, supposing it exists, usually come from highly optimistic input–output analyses. Such analyses ignore resource constraints on the economy's ability to expand, including the upward pressures on wages that result from a tightening of the labour market. These constraints operate in at least parts of the economy even during recession.

In comparison, the CREA study modelled the costs of the VFT conservatively. It assumed that construction and operation of the VFT would have no effect on aggregate employment and it abstracted from unemployed capital.

If construction of the VFT cannot draw on unemployed resources, it must displace other investment or consumption. The CREA study allowed displacement to occur during either the construction or operating phase. In two scenarios, construction is accompanied by restraint in consumption expenditure —either by households alone or in combination with equal per cent restraint by government. Hence, national saving increases.

Another scenario defers crowding out until the operating phase by assuming financing from overseas. Considering debt financing may make this scenario easier to grasp. In this case, the trade balance moves toward deficit during the construction phase as foreign loans flows in, and back toward surplus during the operating phase as foreigners are repaid. It is important to realise that the move toward trade surplus does not represent a benefit of the VFT but the burden of financing its construction. During the operating phase, Australians would export more and import less to repay foreign loans; and this would limit their ability to invest and consume. The move toward trade surplus ensures that the current account deficit is unaffected by the VFT during the operating phase, which is an implicit assumption in the CREA study.

Operation of the VFT would benefit users of the service and, with some luck, would produce a surplus for investors. The CREA study used ORANI to analyse the flow–on effects of the gross operating surplus. The benefit to users of the VFT was estimated outside the ORANI framework through more conventional tools of benefit–cost analysis (the 'consumer surplus' approach).

Evidence on the VFT's net benefit to Australia

The study measured the VFT's net benefit to Australia as a present value sum of changes in aggregate consumption. The measure combined: the sacrifices in consumption needed for constructing the VFT; the gains in consumption resulting from the VFT's gross operating surplus (which increases national income); and the benefit to users of the VFT service net of what they pay (referred to as the gain in consumer surplus). For illustration, the study considered a blend of the financing scenarios described above and assumed a gross operating surplus corresponding to a 7 per cent rate of return. Assuming as well that the VFT would operate forever, the study estimated a net benefit equivalent to a once–off increase in consumption (public and private) of 2.8 per cent.

The assumption of an infinite project life clearly biased the calculation of net benefit in the VFT's favour. A previous critique of the CREA study noted that a project life of 40 years have been more realistic (CIE 1990). The present discussion puts aside the concerns of the earlier critique to focus on other questions about the CREA study.

A key question is how the study's estimate of net benefit, derived from complicated ORANI simulations, compares to the result of a simpler and more conventional calculation. This comparison, which the study did not attempt, can be drawn from the reported findings. A more conventional measure of net benefit would be the present value sum of gross operating surplus and the net benefit to users, minus construction costs.[1] Such a measure would count the gross operating surplus itself as a benefit rather than the change in real consumption which it induces, and likewise for construction costs. Under the study's illustrative assumptions, this conventional measure of net benefit turns out to be about 25 per cent larger than the study's own consumption–based measure. Thus, unlike the Allen study of road investments, the CREA study creates no impression that conventional evaluations would underestimate benefits. Any other inferences from the above comparison would be unwarranted, in light of the problems with the CREA's analysis. Certainly, one should not infer that a conventional evaluation would *overestimate* the VFT's net benefit.

One problem with the CREA's analysis is the lack of dynamics in the ORANI model. ORANI cannot estimate the effects of some change to the economy, like the VFT investment, year by year. The CREA study reached ORANI's dynamic limits by distinguishing between construction and operating phases, and implicitly assuming that the effects of the VFT remain constant within each phase (in percentage terms). In reality, some within–phase variation should occur, if only because responses to a new infrastructure service develop

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[1] For this to measure the net benefit to society, the figures for gross operating surplus and benefit to users should ideally be adjusted for fuel taxes. The CREA study does not report whether such adjustments have been made.

gradually. A greater concern, however, is that ORANI lacks the structure to ensure consistency in outcomes between the construction and operating phases. In two of the CREA's modelling scenarios, investment in the VFT crowds out other investment during the construction phase. Logically, this implies that less non–VFT capital will be accumulated by the time of the operating phase. The absence of this dynamic linkage from the ORANI model could have biased the findings of the CREA study.

Another problem is the focus on consumption in measuring net benefit. On the surface, the focus seems natural. The level of consumption, one might argue, is the economic outcome that directly shapes our well–being. It might also appear that taking a present value of consumption, as the CREA study does, allows for shifting of benefits and costs over time. If an infrastructure investment yields an increase in income which the current generation does not consume, then savings increase and some future generation can consume more. Equally, if we do not reduce our consumption to cover investment costs, then we are saving less and reducing the consumption opportunities of posterity. But what if some benefit or cost gets passed on indefinitely to posterity, never showing up as a change in consumption? The consumption–based welfare indicator would show no change, yet the cost or benefit would remain real. Benefits and costs which are 'unconsumed' can feature in ORANI–based scenarios, and apparently do in the CREA study. (See box 1 for further discussion of this point, and a hypothetical illustration.)

Evidence of the VFT's effects on States and Industries

Residents of each State pay taxes to the Commonwealth government, which returns some of its revenues to the State governments through grants. If the VFT project had gone ahead with tax relief from the Commonwealth government, all States would have been contributing to the cost of a transport service operating only in New South Wales and Victoria (and possibly through the ACT). The fairness of such an arrangement depends, in part, on the effects of the VFT on the various State economies.

The State-level findings in the CREA study combine the predictable with the surprising. Predictably, they indicate a stimulus to the economies of New South Wales and Victoria during the VFT's construction. If aggregate employment is unaffected, as the CREA study assumes, the employment which these States gain from construction activity must displace employment elsewhere. The study predicts that the VFT construction activity would reduce employment and production in each of the non–VFT States. While the directions of effects may seem obvious, the numbers which the CREA study places on them could not have been deduced without formal modelling.

Box 1: Hypothetical illustration - the tale of the white elephant

A public investment in economic infrastructure turns out to be a total 'white elephant', generating no returns. Financing is through overseas borrowing. The government never pays off the principal but services the interest through further overseas borrowing. Hence, the overseas debt created by the project grows continually at the rate of interest. The white elephant notwithstanding, the economy is growing rapidly, and at a rate which exceeds the rate of interest. Hence, the overseas debt created by the project, while continually burgeoning, actually declines over time relative to GDP. Hence, there is no blow–out in the debt to GDP ratio to send financial markets into shock. Moreover, because the costs of the project are never paid off, no consumption restraint is ever imposed on Australians. Yet the continuing overseas debt means that the white elephant has reduced the net assets and consumption opportunities of each generation. This is a real cost, regardless of whether a generation chooses to actually reduce its consumption or to suffer guilt from saddling future generations with debt.

The framework for the CREA study allows consumption to respond to a change in national income, unlike in the above tale. In the scenario of overseas funding for the VFT, repayments to foreigners during the operating phase constrain consumption. But the predicted decline in consumption is less than the repayments, suggesting that some of the construction cost never translates to reduced consumption.

The surprises in the State–level findings are the predicted contractionary effects on the economies of New South Wales and Victoria during the VFT's operation. The study explains that the VFT service would be less labour–intensive than other transport services in New South Wales and Victoria from which it diverts business. The consequent reduction in demand for transport workers is said to have negative multiplier effects on those States' economies. This result illustrates the value of economic models for identifying effects of infrastructure investments which are not so obvious. Yet it also illustrates the potential of economic models to overly simplify.

One of the major simplifications in the CREA's analysis is the omission of effects on business location decisions. Producers in many industries can serve customers far from their establishments, and will compare production costs in different States when deciding where to locate. The VFT would have reduced production costs in New South Wales and Victoria relative to other States, since it would have partly catered to business transport (passenger and freight). However, the ORANI model does not link location decisions to State differences in production costs. The linkage would be most important for industries which derive much of their business from out–of–State. For these 'national' industries, which cover most of mining, agriculture and manufacturing, ORANI normally takes the inter–State distribution of production as fixed. (Changes can be imposed, but this requires information from outside the model.) In the model, the production of national industries in each State form the economic base for the 'local' industries. The latter serve intra–State customers almost exclusively and include most of the service industries.

ORANI also abstracts from people's preferences for living in different States. The VFT would increase the lifestyle appeal of New South Wales and Victoria, which, by itself, would attract population and employment. The improved cost competitiveness of these States relative to other States would have similar effects. Both considerations call into question the CREA's finding that operation of the VFT would cause economic contraction in the States served.

The findings for industries throw further light on those for States. Start with the scenario where the VFT is foreign–financed, and recall that the inflow of foreign funds pushes the trade balance toward deficit during the construction phase. In the ORANI simulation, the deterioration in the trade balance is effected through an increase in the real exchange rate, which causes imports to increase and exports to decline. Among the non–VFT States, Western Australia and Queensland are particularly dependent on export–oriented industries. Hence, these are the States for which VFT construction activity is predicted to have the most adverse economic effects. Other financing scenarios present different industry and State–level patterns. In the case where the VFT is financed out of national savings (reduced consumption), the export–oriented industries are no longer squeezed to the same extent as in the case of foreign financing, and Western Australia and Queensland fare no worse during the construction phase than the other non–VFT States.

The sensitivity of findings to the financing assumptions makes it important to understand the macroeconomic sense in which the CREA study refers to financing. The study is concerned with the way in which Australia as a whole ultimately finances the VFT's construction, and this may differ from the way in which the construction is directly financed. For example, foreign loans may directly finance the VFT's construction, but if they displace an equal amount of foreign loans for other investments, net foreign lending remains unchanged. In that case, the VFT is not foreign–financed in the macroeconomic sense.

The sensitivity of findings is a concern because the likely method of macroeconomic financing is not obvious. The CREA study presents alternative

TABLE 1 MEASURES OF BENEFIT FROM ROAD IMPROVEMENTS : INPUTS AND OUTPUTS FROM ORANI SIMULATIONS

	Inputs			Outputs	
Road group	*Gross average BCR*[a]	*Adjusted average BCR*[a]	*Adjusted benefit (% of GDP)*	*Increase in real GDP (%)*	*Welfare multiplier*[c]
Rural roads					
National	2.1	1.9	0.050	0.075	1.5
Arterial	2.0	1.8	0.048	0.073	1.5
Local	1.0	0.9	0.023	0.037	1.6
Urban roads					
Freeways	4.8	3.9	0.103	0.160	1.6
Arterial	6.0	5.0	0.131	0.210	1.6
Local	1.0	0.8	0.020	0.033	1.7

a. Benefit–cost ratio.

b. Net of time benefits for personal travel.

c. Welfare multiplier = $\frac{\text{increase in real GDP}}{\text{adjusted benefit}}$.

Source Allen Consulting (1993)

financing scenarios without indicating that one is more likely than another. People interested in how the VFT would affect their State or industries would be dissatisfied with such ambiguity.

ORANI ANALYSIS OF ROAD INVESTMENTS (THE ALLEN STUDY)

The Allen study used information from economic evaluations of road investments as input to the ORANI model. The information came mainly from a sample of 122 evaluations of roads that were under construction or soon to be built. The average benefit–cost ratios among the sampled evaluations came out considerably higher for major urban roads than for major rural roads (table 1). Local roads were thinly represented in the sample of evaluations, and were assigned a benefit–cost ratio of 1.0 based on less recent information (BTE 1984).

As further preparation for the ORANI analysis, the Allen study estimated the distribution of benefits between categories (table 2). Benefits from savings in personal travel time were estimated to comprise between 9 and 22 per cent of total benefits, with the share being largest for local and urban roads. These benefits were then excluded from the ORANI analysis. For urban roads, savings in business travel time appear to provide the biggest pay off, contributing much more than accident reduction benefits or savings in vehicle operating costs. For rural roads, the distribution is more even, with savings in vehicle operating costs contributing the most.

TABLE 2 DISTRIBUTION OF ROAD INVESTMENT BENEFITS BY BENEFIT CATEGORY

(per cent of total benefit)

Road group	*Vehicle operating benefits*	*Travel time benefits*		*Accident benefits*
		Personal	*Business*	
Rural roads				
National	37	9	27	27
Arterial	37	9	27	27
Local	43	14	26	17
Urban roads				
Freeway	16	19	49	16
Arterial	21	17	41	21
Local	23	22	43	12

Source Allen Consulting (1993). The Allen study reports the per cent distribution among the benefits excluding personal travel time benefits. The latter, as a per cent of total benefits, can be calculated from other estimates presented in the Allen study. Hence, the distribution among all benefits can also be calculated, though rounding off was required for the figures to sum to 100.

The inputs to the ORANI simulations should be viewed cautiously. Evaluations of road investments contain many conjectural elements such as the future traffic levels and the value of travel time. Moreover, the State road authorities, which oversee most of the evaluations, may be inclined toward pro–spending assumptions. This paper does not tackle the enormous task of attempting to verify the inputs to the ORANI simulations. Instead, it examines the Allen study's use of the ORANI model, and whether it adds much to the information already obtained from the economic evaluations. [2]

The Allen study used the ORANI model to estimate the long–run effects of road investments, once the economy has adjusted to the resulting road improvements. Unlike the study of the VFT, it did not model the construction phase.

The core simulations of the Allen study channelled the labour market pressures from road investments toward changes in wage rates rather than employment. The simulations allowed the productivity gains from road improvements to flow through to higher wages, and for wages also to be affected by road investment costs. The adjustments in wage rates were assumed to 'clear the labour market'–meaning, apparently, that they would neutralise any effects on

[2] One feature of the benefit distribution that has been queried for this paper is that time benefits accrue mainly on business rather than personal travel. On the surface, this does not seem to accord with personal travel accounting for most of the traffic on Australian roads (about three–fourths, as reported by Cox 1994). However, the same reduction in travel time (say, 30 minutes) is usually valued more highly for business than for personal trips, judging by what people seem to be willing to pay to shorten their trips. The Allen study set this differential at a ratio of three to one, consistent with standard practice.

unemployment–related indicators. With unemployment unaffected, the model predicts minor changes in aggregate employment.[3]

For each road category in table 1, the Allen study considered a hypothetical $1 billion increase in the 1990–91 level of investment. The resulting savings in road use costs were estimated from the information in tables 1 and 2; additional information was used to apportion these benefits to the household sector and the many industries in ORANI.

The effects of road investment costs were simulated separately from the effects of road improvements. In combining the results of these simulations, the Allen study emphasised the effects on real GDP:

> "The GDP results can be taken as an indication of the net benefits of each road investment because the simulations account for both the benefits and costs of each road investment."

Elsewhere, the study describes the estimated gain in real GDP as the 'final net benefit to the economy' and the cost savings that were input to the ORANI model as the 'initial benefit'. The consultants who conducted the ORANI modelling have informed the BTCE that they did not mean to suggest that the benefits of road investments can be better measured by real GDP effects than by the estimates of cost savings from the benefit-cost analyses. However, the frequent focus on real GDP effects in discussions of government policy would have made this a natural interpretation for readers of the Allen study. The following assessment of the study's ORANI analysis argues that, on the contrary, the estimates of real GDP gains reveal less about net benefits than do the results of the benefit cost-analyses. The findings on how better roads affect the economy are discussed first, before turning to the findings on road investment costs.

Economic Effects of Road Improvements

The Allen study found that road improvements generate increases in real GDP which exceed the benefit estimates from the project evaluations. The pattern

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[3] The study reports very slight effects on aggregate employment in its core simulations. It does not indicate whether employment is measured in persons or person–hours. In the version of ORANI used for the Allen study, aggregate employment in persons usually moves in an opposite direction from average hours per worker. (The version contains labour supply relationships in which increases in real wages have two opposing effects on total labour supply: they attract people into the labour force; and they induce people who were already employed to supply fewer hours. If, as seems likely, the Allen study was referring to employment in persons, its findings for per cent impacts on aggregate employment imply even smaller effects on employment of person–hours.)

appears in table 1, which uses the results from the core simulations. For urban arterials, the estimates indicate that the road improvements due to an additional $1 billion investment would eventually increase real GDP by 0.21 per cent–that is, once the economy has adjusted, real GDP in each year would be an estimated 0.21 per cent higher than if the road improvements had not occurred. Compared to the benefits input to the simulation for urban arterials, this increase in real GDP is about 60 per cent larger. In other words, there is an apparent 'welfare multiplier' of 1.6, when real GDP serves as the welfare measure. For the other road categories in table 1, the apparent welfare multiplier ranges between 1.5 and 1.7. The Allen study noted the range in these ratios without drawing out a welfare interpretation. Even so, these results have fed speculation that evaluations of road investments typically estimate only a portion of the economic benefits. (See Cox 1994 and AURDR 1994).

The picture changes when real GDP is replaced by aggregate real consumption, which has some currency as a welfare measure in ORANI applications (CREA 1990; Dixon et al. 1992; CIE 1994). The welfare multipliers fall below one, superficially suggesting overestimation of benefits in most evaluations of road projects (table 3). However, part of any increase in national income resulting from road improvements will go toward saving rather than consumption. For this reason, the increases in real consumption may underestimate benefits, and the welfare multipliers based on them may be pessimistic. (See box 1 and accompanying discussion.)

The predicted increases in real GDP are also poor measures of benefit. Since real GDP measures only market output of goods and services, it cannot meaningfully reflect nonmarket benefits. In addition, the ORANI simulations

TABLE 3 WELFARE MULTIPLIERS BASED ON ALLEN STUDY FINDINGS

	Welfare measure		
	Real GDP	*Adjusted measure*	*Real consumption*
Rural roads			
National	1.5	1.2	0.7
Arterial	1.5	1.2	0.8
Local	1.6	1.2	0.9
Urban roads			
Freeways	1.6	1.3	0.7
Arterial	1.6	1.3	0.8
Local	1.7	1.3	0.8

Source Allen Consulting (1993).

indicate that road improvements give rise to certain costs which are not measured by the increase in real GDP. These are the costs of lower prices for Australian exports and of the investments which road improvements induce. Each of these problems are now discussed.

Costs of induced investments

The Allen study's analysis indicates that better roads would stimulate investment in most industries. The resulting accumulation of non–road capital contributes in the analysis to the long–run gains in real GDP (table 4). But the costs of raising and maintaining the additional non–road capital are not recognised. (These are not to be confused with the costs of the roads themselves, which the study did attempt to model.) Many other ORANI analyses have likewise predicted an increase in investment stemming from some improvement to the economy (apart from better roads), and have likewise omitted investment costs. Cronin (1984) called attention to this problem, which stems in large part from the lack of dynamics in ORANI. Horridge (1985) developed a quasi–dynamic extension which features in some versions of the

TABLE 4 ESTIMATED EFFECTS OF ROAD IMPROVEMENTS RESULTING FROM A $1 BILLION INVESTMENT

(per cent change)

	Real GDP	*Capital stock (non–road)*	*Export prices*
Rural roads			
National	0.075	0.058	-0.021
Arterial	0.073	0.059	-0.018
Local	0.037	0.035	-0.007
Urban roads			
Freeways	0.160	0.132	-0.041
Arterial	0.210	0.170	-0.049
Local	0.033	0.029	-0.007

Source Allen Consulting (1993).

model, apparently including the version used for the Allen study (MR–ORANI). The extension recognises that investment in Australia is partly funded by foreigners, who receive their share of the returns and, conversely, that Australians earn returns from overseas investments. It deducts from GDP the net flow of investment returns to overseas, to arrive at GNP. The extension does not rigorously model the net flow of investment returns, being only a band–aid solution to ORANI's lack of dynamics. Even so, reporting findings for real GNP would have brought the Allen study closer to measuring benefits of road improvements to Australians. At least the cost of foreign–funding for the extra non–road capital would have been recognised. But the costs met from domestic savings–the costs of immediately refraining from consumption to invest more–would still have been omitted.

Adjusting the real GDP results to allow for induced investment costs removes much of the impression of a welfare multiplier. The cost of investing in Australia depends on the rates of return to investments in other countries, given that investment funds can cross borders. In the ORANI model, the mobility of funds ensures that rates of return in Australia are competitive over the long run with those overseas. Put another way, the model assumes that over the long run the returns to Australian investments match their opportunity costs. On this logic, one might subtract the returns to the induced investment from the predicted increase in real GDP, to more properly measure the benefit to Australians from road improvements. A minor wrinkle in this recommendation is that ORANI subsumes the returns to working capital (inventories) within a category of miscellaneous production costs. Returns to fixed capital are much larger, however, and are separately identified. When the recommended adjustment is made for investment in fixed capital alone, the apparent welfare multipliers are much smaller than before. They now indicate benefits which are between 20 and 30 per cent larger than the benefits measured in the conventional economic evaluations.[4]

Lower prices for Australian exports

That road improvements would reduce the prices for Australian exports can be easily explained. Better roads reduce production costs in Australian industries; if producers in each industry compete vigorously, they will pass on some of the cost reductions to customers. ORANI assumes that industries are perfectly competitive, so road improvements are predicted to reduce export prices (table 4).

The adverse effect on export prices calls for another adjustment to tease out the welfare implications of the Allen study's findings. Real GDP measures national

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[4] Forsyth (1992) made a similar adjustment to the real GDP findings from an ORANI analysis conducted by the Industry Commission. The analysis had modelled a broad package of microeconomic reforms predicted to raise real GDP in the long run by 6.5 per cent. Forsyth deducted from the real GDP gains the costs of the induced increases in the economy's capital stock, measuring the opportunity cost of capital at a 7 per cent rate of return. He also deducted the costs of the induced increase in aggregate employment, valuing labour at about the average wage rate after–tax. This represented the value of foregone leisure time. The present analysis has not made a deduction for foregone leisure costs since the core simulations of the Allen study predicted a negligible increase in aggregate employment. In the Industry Commission's findings also, the aggregate capital stock increases by a much larger percentage than does aggregate employment. Forsyth's calculations indicate that the adjusted net benefit measure is about 70 per cent of the predicted increase in real GDP.

output at constant prices. So the predicted increases in real GDP do not reflect the cost to Australians of lower prices for their exports. The adjustment called for is to weight real GDP by a relative price measure: the ratio of the GDP price index, which measures the prices for Australian products, to an index of the prices for what Australians purchase. Exports are only purchased by foreigners, so a decline in export prices would reduce the relative price measure. The Allen study provides insufficient information for making the proposed adjustment. ORANI simulations conducted for the BTCE suggest that the adjustment would reduce the study's estimate of benefit only slightly. However, as discussed later in this paper, it would have a larger effect under alternative assumptions about export demand.

Nonmarket benefits

Some benefits from road investments cannot be measured by changes in the market economy. Savings in personal travel time improve the quality of life, even without any effects on incomes, prices, and other aspects of the market economy. The Allen study excluded savings in personal travel time from its analysis with ORANI, which only represents the market economy, but included other nonmarket benefits.

Some benefits, while clearly reflected by market outcomes, belong in the nonmarket category, since they are essentially productivity improvements in nonmarket production. For personal road travel, people sometimes rely on market producers, like bus and taxi operators, but often they produce their own transport with inputs of their own time, fuel, vehicle capital and so on. Improvements in vehicle operating efficiency for this self–provided travel are nonmarket benefits, as are many of the benefits from accident reduction.

By representing nonmarket benefits as productivity improvements in market production, the Allen study introduced some errors into its ORANI analysis. Focusing on nonmarket provision of personal road transport, consider what happens if fuel economy improves (due to better roads). In all likelihood, employment declines in petrol supplying industries. If aggregate employment is unaffected–a common assumption in ORANI simulations–employment must increase in some other industries. The direction of the change in real GDP will depend on the relative capital intensiveness of the industries gaining and losing employment. If the losing industries are the more capital intensive, the economy's total stock of capital could decline. With aggregate employment unchanged and a reduced capital stock, real GDP would probably decline as well. However, even in this scenario, society would benefit from the improved fuel economy. Real GDP would be smaller, but society would have made fewer sacrifices to accumulate capital. In a welfare calculation, these effects would roughly balance. The benefit from improved fuel economy for personal travel is that people can stretch their incomes further.

The Allen study overrides the possibility of negative real GDP effects by representing all benefits as market benefits. Cost savings for personal road travel enter the ORANI analysis as productivity improvements for market provision of road passenger services. This is fine for personal road travel which actually relies on market providers (buses, taxis and the like), but not for that which is self–provided. By allocating all costs savings for personal road travel to the market sector, the Allen study overestimates their effect on real GDP (which measures national output of market goods and services).

Similar caveats apply to the modelling of accident reduction benefits. Some of these benefits can be measured by productivity improvements in the market economy. Less accident damage to business property means lower depreciation. Workers escaping injury have more days at work and are more productive. Other benefits cannot be measured by market productivity improvements, and certainly not by the effect on real GDP. Avoiding accidents doesn't just maintain our earning capacity, it spares us pain and suffering. It also permits us to spend less on medical care and more on things that we enjoy. The Allen study represented all benefits from accident reductions as productivity improvements to either the health care industry or the mechanical repairs industry. While making for impressive real GDP results, the modelling again confuses market and nonmarket benefits. Fewer accidents do not mean that our doctors have become more productive, simply that we need them less.

Economic Effects of the Costs of Road Investments

Public investments in roads entail costs in the resources used for construction and maintenance. Labour employed on road construction, for example, would be diverted from employment elsewhere in the economy, or from uses of time outside the workplace ('leisure')—either way, it has an opportunity cost. Additional costs can arise from the financing of the investments through taxes. The taxes are not costs to society by themselves, being merely transfers of income from taxpayers to the government. The costs they impose arise through their disincentive effects. An income tax, for example, may discourage saving and work effort. The cost to Australian society of an additional dollar of income tax revenue has not been conclusively quantified, though estimates range up to 40 cents (Dept. of Finance 1991). For the United States, the estimates range between 21 and 46 cents, according to studies surveyed by Jorgenson and Yun (1990).

The Allen study simulated with ORANI an increase in income taxes to cover the costs of the hypothetical investments. Construction costs of $1 billion were amortised over 35 years (the estimated technical life of road) and added to maintenance costs. The sum represents the cost of the road investment to government, or the increase in annual taxes which was modelled. The same

ORANI simulation imposed an increase in government purchases from the non–residential construction sector, to represent the resource costs of the road maintenance. In combination, the increases in government purchases and income taxes were predicted to reduce real GDP. The Allen study added this negative effect to the positive real GDP effect from the benefit simulations, to provide an indication of the net benefit from each road investment.

Since taxes are not resource costs in themselves, it is unclear from the Allen study how the resource costs of construction were modelled. Allen Consultants have explained to the BTCE that they were only concerned with effects on the economy after the road investments are in place. However, the resource costs of road construction can affect the economy well after this happens. If the construction phase were modelled as in the above-discussed VFT study (CREA 1990), the economy would have to 'pay' for road construction by foregoing other domestic expenditure or by foreign borrowing. If expenditure on other investment were sacrificed, future levels of national output would be reduced. Similarly, foreign funding would have effects beyond the construction phase, since it would give foreigners a greater claim on future national output. Only if the economy pays for road construction through simultaneous restraint in consumption spending might the effects of the resource costs be seen as mainly confined to the construction phase. The modelling approach in the Allen study might be consistent with the latter scenario, though the study does not provide enough information to establish this. On this interpretation, the effects of the resource costs of construction have not been modelled.

The modelling does, on the other hand, allow for the resource costs of road maintenance after construction. The benefits of such maintenance would be reflected in the Allen study's benefit simulations that have already been discussed. The cost simulation allows for the effects of government expenditures on road maintenance, excluding these benefits. Government expenditures on road maintenance imposes a cost on society by diverting resources from other production activities. However, this diversion of resources would not necessarily reduce total national output, as measured by real GDP, and could well increase it if road maintenance were capital-intensive. (Recall the ambiguous real GDP effects in the above discussion of nonmarket benefits.) Using real GDP effects as an indication of road maintenance costs is thus inadvisable. If the resources allocated to road maintenance are mainly diverted from, say, private consumption, a more reasonable indication might be the effect on real private consumption. One might well wonder, though: why not simply measure the cost of road maintenance from data on government expenditures, rather than from a national economic model?

National economic models have a more natural role to play in estimating the costs of income taxes. Unlike government expenditures on road maintenance, tax revenues are no indication of cost to society. In principle, a national economic model could estimate this cost, and the associated disincentive effects on labour supply, investment and savings. The Allen study's ORANI analysis does not, however, appear to have captured the disincentive to save. It assumes that households save a fixed proportion of their income, whereas higher income taxes reduce the incentive to save by reducing the private rate of return. Moreover, no ORANI variable looks suitable for measuring the efficiency cost of income taxes. Real GDP is not the right variable for this purpose any more than it was the right variable for measuring the benefits from better roads. If a rise in income taxes induces us to save less, growth in national income declines. But more immediately, the reduction in saving means that we consume a larger portion of our income, leaving us better off. This immediate gain would not show up in ORANI estimates of effects on national income or real GDP. Measuring the net cost of income taxes requires something that ORANI does not offer - a quantitative, if stylised, description of people's preferences between present consumption and future income. In simplified terms, this means a description of people's preferences between their present and future consumption.[5]

The above considerations call into question the Allen study's use of the ORANI model to compare the efficiency of income taxes and fuel taxes as a means of funding road investments. The study finds that a revenue-neutral shift from income to fuel taxes would reduce real GDP. It goes on to say:

> "This result was expected as the demand for fuel is more price elastic than is the supply of labour. Shifting the tax base to the factor which is more price responsive would create greater inefficiencies for a given tax take.'

The posited difference in price-responsiveness sounds plausible: changes in after-tax wage rates appear to have only weak effects on aggregate labour supply, as ORANI assumes (see Luskin 1991). But what about the effects of income taxes on saving and investment? These effects contribute substantially to some estimates of the efficiency costs of income taxes. In some estimates for the US, an extra dollar of tax revenue creates about twice as large an efficiency cost when levied on capital income rather than on labour income (Jorgenson and Yun 1990). The household saving ratio was fixed in the Allen study's

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[5] Modellers sometimes resort to the fiction of an single infinitely-lived consumer. Endowed with perfect foresight, the consumer chooses a time-profile of consumption subject to an intertemporal budget constraint. Inter-generational and inter-personal concerns do not arise in this paradigm. Only the consumer's preferences regarding own consumption at different stages of life matter. This is the approach taken in Jorgenson and Yun (1990). Adaptations of ORANI for analysing investment projects like the VFT have sometimes computed a discounted present value of real consumption (CREA 1990). As a description of consumer preferences, the discounted present value lacks realism and cannot be reconciled with any plausible specification of consumer demand.

analysis, and the lack of mention of effects of income taxes on investment is surprising. In any event, real GDP effects are poor measures of efficiency costs, for the reasons discussed above and because of the environmental implications of fuel consumption.

Assessment

The Allen study, through its ORANI analysis, has inadvertently encouraged a criticism of benefit–cost analysis which the findings do not substantiate. The study's interpretation of the real GDP findings might give the impression that benefit–cost analyses of road investments tend to underestimate benefits. As we have seen, the impression is at least partly an illusion (and perhaps nothing more). Road improvements can create costs by reducing export prices and by inducing investment in non–road capital. The predicted increase in real GDP reflects neither of these costs, while including the returns from the induced investment. In addition, the predicted increase in real GDP stems partly from the mismodelling of nonmarket benefits as improvements in market productivity.

Moreover, it is not apparent which features of the ORANI model would pick up significant benefits missing from benefit–cost analysis. In theory, a national economic model might capture generated traffic benefits omitted from other evaluations of road investments. It might identify cost savings when producers substitute road transport for other inputs, such as inventory and warehousing capital. However, the ORANI model generally does not allow substitution of material or service inputs, like road transport, for other inputs. The Allen study used a version of the model which allows substitution between road and other modes of freight transport. But like most applications of ORANI, it took a computational shortcut which would have eliminated any cost savings from input substitution responses. (The shortcut is to linearise the equations of the model). Benefits from reduced unemployment would be minimal in the Allen study's core simulations, where aggregate employment changes little. In alternative ORANI simulations, the study assumed that road investments would have no effects on real wages and predicted more significant increases in aggregate employment. If the assumption of no real wage response in the long run is extreme, as the Allen study acknowledges, so would be the assumption that workers entering employment do not value the time they lose for nonwork pursuits. Just as the costs of induced investment need to be deducted from the real GDP results, so do the opportunity costs of the extra time people spend working. From a welfare perspective, the real GDP findings from the alternative simulations hold little interest.

Additional sensitivity analysis would have enhanced the Allen study's use of the ORANI model, since many of the parameter estimates in the model are fairly conjectural. The export demand elasticities have been a particular bone of contention. ORANI makes the demand for major export commodities quite price–sensitive, by setting most of the elasticities at about 10 or more (in absolute value). Cronin (1984), among others, has suggested that lower values would be more realistic. Since the question is unsettled, it can warrant sensitivity analysis in applications of ORANI. It appears likely that in the Allen study, using smaller export demand elasticities would have reduced the increases in real GDP and made for larger declines in export prices. Implied welfare gains, as far as they can be measured within ORANI, would probably have been smaller.

The implied welfare gains would also be smaller if the resource costs of road construction were netted out. The real GDP findings in the Allen study do not appear to reflect these costs, as discussed above.

In the end, the best measures of net benefit in the Allen study are to be found outside the ORANI model. The benefit–cost ratios from other evaluations, which served as inputs to the ORANI analysis, tell an interesting story in themselves. The evidence that benefit–cost ratios are particularly high for major urban roads has stimulated much-needed debate on the allocation of road funds (Cox 1994).

If the ORANI findings do not provide a satisfactory measure of net benefit, do they advance the evaluation of road investments in other ways?

The macroeconomic findings remain of interest even after the removal of strained welfare interpretations. Particularly striking is the finding that some road investments, by stimulating economic activity, generate sufficient tax revenue to cover investment costs. However, as the Allen study observes, the generated tax revenue would accrue mainly to the Commonwealth government, and thus may not by sufficient to reimburse State governments for their investment costs.

The finding that road investments would eventually improve the trade balance has some political relevance. However, the finding measures only the long–run effect on the trade balance, after the economy has adjusted to having better roads in place. More immediately, road investments could well worsen the trade balance. The investments themselves, plus the non–road investments which they induce, would require funding which domestic saving might not cover. The portion of the funding obtained from abroad would aggravate the trade imbalance for a while. Moreover, the main concern about external balance in the Australian economy is the current account deficit, of which the balance of trade deficit forms only a small part. The major part is the net outflow from Australia of returns to capital (debt payments and repatriated profits). Any foreign funding (direct or indirect) for the road investments, or for the non-road investments they induce, would eventually add to this outflow. Hence, in long-run terms, road investments might improve the trade balance, while aggravating the current account deficit. The Allen study does not discuss the effects of road investments on the current account deficit, and one should not infer from the findings a negative effect, as the Road Transport Forum (1995) has done.

The industry–level findings also have some policy relevance. Someone concerned with greenhouse gas emissions, say, could want to know how road investments affect the demand for transport services. Industry associations take stances on government road spending and other transport policies (see for example Barnard and Kelso 1994), and want to know the effects of the policies on their members. The Allen study discusses its findings for freight transport industries–road, rail, air and water–but not for other industries. A supporting study by Fallon (1993) presents the findings for all ORANI industries without discussing them.

Another contribution of the Allen study's ORANI analysis is to remind us that costs, not only benefits, can be omitted from evaluations of public investments in transport infrastructure. Indeed, while the analysis does not pinpoint any omitted benefits, it does identify a cost omitted from traditional evaluations of Australian road investments—the reduction in prices for Australian exports. Evaluations also frequently fail to value environmental costs, which may include reductions in productivity (say, the productivity of office workers exposed to traffic noise).[6]

Last mentioned, but not least, is the likely contribution of the Allen study to future use of national economic models for evaluating infrastructure investments. Blemishes can be found in any economic modelling exercise and identifying them, as has been done in this paper, can clarify directions for future research.

WHERE TO FROM HERE?

The ORANI model is not well suited to estimating the net benefit from transport infrastructure investments. The lack of dynamics is a major impediment to such analysis, as the above discussion indicates.

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[6] Investments in transport infrastructure can also have environmental benefits. For example, construction of an urban freeway might actually improve air quality by reducing congestion. (For a given volume of traffic, noxious emissions are greater under start-stop driving conditions.) BTCE (1994b) discusses the environmental benefits from highway bypasses and how such benefits are magnified through regional development effects.

The new MONASH model builds on ORANI by adding dynamics and making other improvements, but does not offer any summary measure of welfare. It appears to be intended mainly for forecasting and for analysing distributional effects of government policy changes (and other shocks to the economy). Dixon and Parmenter (1994), two of the architects of MONASH and ORANI, recently evaluated the performance of the broad class of models to which their models belong, known as computable general equilibrium (CGE) models. While recording many achievements of CGE models, they count the analysis of welfare effects as one of the failures. The causes they mention are the lack of dynamics and the difficulties in modelling imperfect competition. To these, other causes might be added. It is hard enough to model household preferences among commodities they consume in a given year. Deriving a measure of societal welfare involves that plus more daunting tasks. How does one model the value people place on public consumption expenditure (say on parks and museums)? In addition, how does one model people's preferences for consumption in different years? Many (probably most) CGE models do not tackle these questions.

Models of the national economy which are not of the CGE type would do no better at measuring welfare effects. The distinction between CGE and other models is, in fact, a blurred one. What are considered CGE models attempt to maintain theoretical rigour in representing producer and consumer behaviour. Other models, sometimes called 'econometric', maintain a looser connection to theory and, it is claimed, a closer connection to patterns of observed behaviour. Such models, because they are not wedded to a theory of optimising behaviour, would be even less suited than CGE models for estimating net welfare effects.

In short, it is uncertain whether, in practice, national economic models can outperform conventional tools for measuring the net benefit of transport infrastructure investments. At this stage, models of the Australian economy would better serve to analyse the distributional effects of such investments.

Regional effects command particular attention in debates over transport policies, but the treatment of them in ORANI only scrapes the surface (as we saw from the VFT analysis). The MONASH model will distinguish 56 regions rather than just the six States which are in ORANI. Otherwise, its treatment of regional effects will have the same shortcomings as ORANI's. The BTCE is following with interest the development at the Centre of Policy Studies of a full-fledged spatial model of the Australian economy. A research project being conducted for VICROADS is using the current version of this model to estimate the effects of a ring road around Melbourne.

The BTCE is also monitoring, and playing an advisory role in a research project being funded by AUSTROADS. The project is examining the effects of road investments using two models of the national economy belonging to Access Economics, one of the project consultants.

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ABBREVIATIONS

ARRB	Australian Road Research Board
AURDR	Australian Urban and Regional Development Review
BTCE	Bureau of Transport and Communications Economics
BTE	Bureau of Transport Economics
CIE	Centre for International Economics
CREA	Centre for Regional Economic Analysis

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ABBREVIATIONS

BTCE	Bureau of Transport and Communications Economics
BCA	benefit-cost analysis
VFT	Very Fast Train
CREA	Centre for Regional Economic Analysis
GDP	gross domestic product
CIE	Centre for International Economics
ACT	Australian Capital Territory
BCR	benefit-cost ratio
AURDR	Australian Urban and Regional Development Review
GNP	gross national product
CGE	computable general equilibrium