Australian Transport Research Forum 2022 Proceedings
28-30 September, Adelaide, Australia
Publication Website http://www.atrf.info

Producer Surplus in Transport Economics

R J Nairn BE, BEc, FIEAust, LFITE, CPEng, EngExec
rjnairn@grapevine.com.au

Abstract

This paper discusses the World Bank's "Producer Surplus" method for evaluating the economic benefits of rural roads, which was first published in 1976. This methodology focuses on the economic production environment which the transport project serves instead of just looking at the vehicle operating costs, road maintenance, accidents, time savings and user benefit issues. It focuses on the mechanisms and constraints which assist or restrain the ability of transport price reductions in creating new economic productive activity.

1. Introduction

The World Bank's "Producer Surplus" concept, for evaluating the benefits of rural roads, was first published by Carnemark, Biderman and Bovet[1] in 1976.

The paper pointed out that the traditional methods of economic analyses of highway projects is unsuitable for rural roads with low levels of traffic and that the analysis should focus on the mechanisms by which transport cost savings are translated into increased agricultural production and income. This methodology requires the practitioner to investigate the economic production environment which the transport project is intended to serve instead of just looking at the vehicle operating costs, road maintenance, accidents, time savings and user benefit issues. It focuses on the mechanisms and constraints which assist or restrain the ability of transport price reductions in creating new economic productive activity.

The approach broadens the myopic focus of the transport economist away from road user interests to focus on the economic effects that the road is intended to induce in the surrounding area it serves – the degree to which it, and any complementary investments, produces economic activity.

With this approach it is necessary to investigate the rural economy in some depth. Instead of just focusing the analysis on the quantification of road user savings, it is necessary to examine four critical points:-

- **Distribution of Benefits**. To whom do the transport cost savings accrue (producers, truckers, traders or consumers)?
- **Producer Response**. How will producers respond to the lower transport costs (higher farm-gate prices, lower input costs, and improved services)?; and
- **Non-Transport Costs and Constraints**. Do other costs or constraints exist which may prevent the producer from responding to this incentive?
- **Induced Export**. Is any part of the additional induced production for export or import replacement?

Transport improvements trigger induced land-use development which may have its own economic value (not attributable to the transport project) and it may or may not improve the

1 WORLD BANK (1976). Technical working paper No. 241. International Bank for Reconstruction and Development, Washington.

economic results of the transport project which induces it. Nevertheless, there is little doubt that transport projects improve the productivity of nearby industries. The "Producer Surplus" concept focuses directly on induced industrial production, not by attributing all of the benefits to the transport project, but by explaining how these benefits are distributed. In addition, when this leads to new exports, or import replacement, added benefits can accrue to the transport project.

2. The importance of Australia's rural export industry

Australia's rural industry consists largely of tourism, mineral extraction and agriculture (wool, sheep, cattle, wheat, wine and fruit). These industries account for over 60% of all our exports and are amongst the fastest growing export industries. Table 1 shows the proportion of Australia's export trade derived from these industries.

Table 1 - Australian exports

Produce	Year			Growth Rate
	2016	2017	2018	
Minerals	45.6%	48.3%	51.3%	20.9%
Agriculture	7.0%	7.0%	6.3%	7.7%
Tourism	4.0%	4.0%	4.1%	9.0%
Services	32.3%	31.0%	30.2%	11.8%
Other	11.0%	9.7%	8.1%	-2.0%
Total	100.0%	100.0%	100.0%	14.0%

Source: Department of Foreign Affairs and Trade

By comparison, in the financial year 2017–18 Australia's national GDP grew by 2.3%. Tourism directly employed 646,000 Australians making up 5.2% of Australia's workforce. 43 cents of every tourism dollar were spent in regional destinations[2]. Australia is the world's largest exporter of live sheep and fourth largest for live cattle, with the industry employing an estimated 10,000 people in regional Australia alone[3]. Australia is the world's third largest beef exporter, exporting a total of 1,385,000 metric tons in 2016. The beef industry is the largest agricultural sector in Australia and is dependent on the export market, as about 75% of beef produced is exported, mainly to the United States, Korea, and Japan. Over 70% of wheat and canola grown in Australia is exported.

Within Australia the rural produce is largely carried by road, for part of the journey, to market or processing plants, but rail transport accounts for some part of their journey as shown in Table 2.

Table 2 - Rural exports carried by mode

Produce	Rail	Road
Minerals	69.7%	30.3%
Agriculture	37.2%	62.8%
Growth Rate	16.5%	24.1%

Source: Estimates from CARTS models of Queensland, NSW and Western Australia only

[22] Tourism Australia statistics
[3] Maina Wambugu, Daniel . "The World's Largest Exporters of Beef." World Atlas, Dec. 10, 2018,

Many of these roads, at least in the first part of their journey, are not paved and carry very low daily volumes, as low as say 40 vehicles per day. They are often closed by flooding, are dusty and stray cattle or kangaroos are a constant hazard. Very long road trains are a hazard to other traffic and they are usually in areas of eco-tourist attraction.

Cattle trucks bogged by flooding

A cattle feed lot

A long road train

A very long coal train

3. The Methodology

The transport of general freight and supplies, to and from rural or urban destinations, benefits through transport improvements. The direction of freight movements are usually simulated in the modeling but it is useful to be able to check these, where possible, by freight surveys, which can be used to determine, not only the volume of different types of freight in each direction, but also the pavement axle-loading stress. Unfortunately this form of data is seldom available in Australia so simulation is necessary. A typical freight survey is illustrated in Table 3 for a Bangladesh survey. This also gives direct guidance if field surveys of rural industries are needed.

Table 3 - A freight movement survey at a rural intersection in Bangladesh (tonnes/annum)

Type	to South	to East	from South	from East
Food-grains	194,000	207,000	19,400	177,000
Jute	-	4,000	-	3,900
Fertilizer	-	11,600	19,600	52,000
Cement	4,000	42,000	137,500	235,000
Coal	3,900	-	-	-
Stone/gravel	8,000	50,400	8,000	42,400
Petroleum	11,600	193,000	20,000	66,000
Steel	7,800	9,300	19,000	138,500
Other	11,800	80,400	75,600	382,500

Source: Western Bangladesh Rural Roads Study – World Bank

Transport improvements can reduce the transport costs for freight carriers through:-

- a reduction in delays and delivery times, or reduced breakages to goods; or
- reduced vehicle maintenance due to the road improvements; or

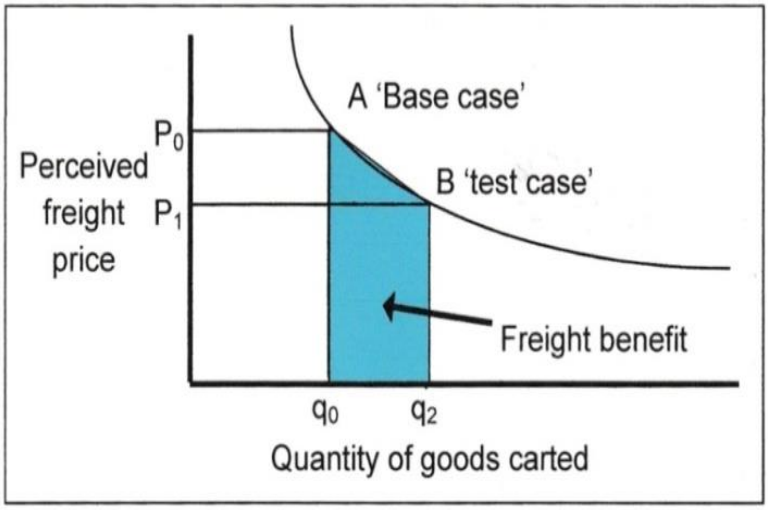
- the ability to gain greater vehicle fleet utilisation through reduced travel times or down-time or increased back-loading; or
- Increased reliability for freight scheduling and delivery.

These cost reductions and service improvements may be partly or wholly passed on to producers and consumers in the form of lower freight prices and, if this is so, this can result in induced higher rates of general production and consumption for these goods.

The economic evaluation of freight movement relies on exactly the same principles and procedures as the economics of personal travel. One relates to the movement of people to participate in economically desirable activities, the other to the movement of goods for consumption.

Graphically the computation of benefits is familiar and illustrated in Figure 1.

Figure 1 - Freight movement benefits



The production or consumption of general goods is price elastic and, insofar as their market price can be reduced, because the freight cost is reduced by transport improvements, a benefit is attributable to road or transport system improvements. It is computed as follows:-

Freight benefit = $1/2*(q_2-q_0)*(p_1+p_0)$

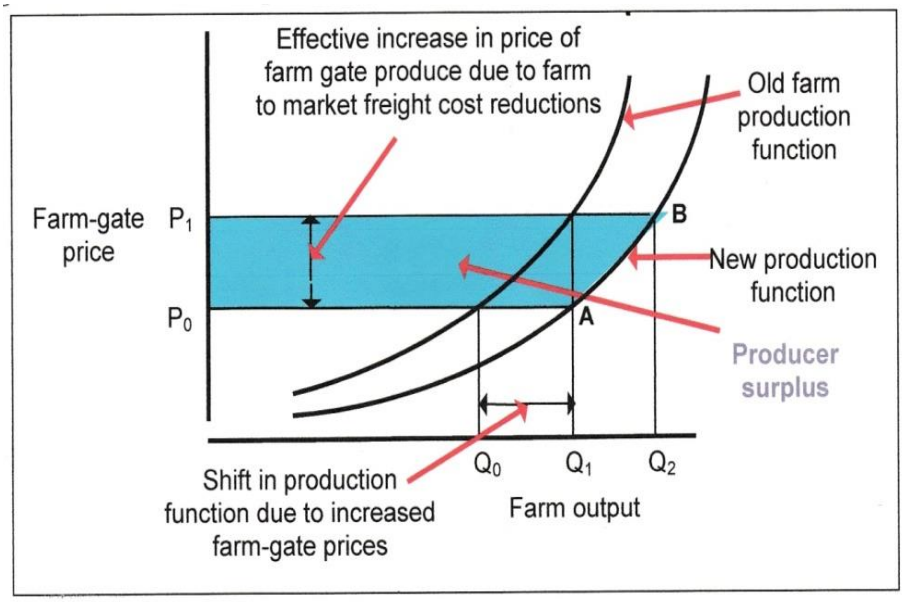
This benefit accrues either to the freight carrier or it may be passed on to the freight producer or consumer in the form of lower freight prices.

As far as this economic benefit is concerned, it does not matter who gains this benefit. However, if the price reduction is fully or partially passed on to either the producer or consumer, it is capable of inducing additional production and consumption. If it produces induced exports, or import replacement consumption, it can justifiably increase the project's benefit stream.

The method acknowledges that freight price reductions can have two effects. Farm inputs, such as fertilizers, are effectively cheaper at the farm-gate if freight prices are reduced and passed on, and this can also lead to a shift in the production function so that more farm output is produced.

In addition, if the farm-to-market freight cost is reduced and passed on, this is equivalent to an increased profit for the farm output, which in turn can induce increased production. The method of valuing the producer is set out in Figure 2.

Figure 2 - Producer surplus benefit



The area $p_1.p_0.A.B$ is the producer surplus benefit attributable to the road or freight service improvement. The benefit can also be computed as follows:-

Rural Industry Benefit = $0.5 * (Q_1 + Q_2) * (P_1 – P_0)$

Where: Q_1 = Increased level of production valued at the old price,
Q_2 = Increased level of production, and
P_1-P_0 = Transport price improvement.

A similar benefit is also available if fertilizer and other farm inputs are carried by road transport, and a further increase in production occurs due to savings in input prices.

Induced industrial output would normally not be included as an economic benefit attributable to the transport improvement as it is assumed it displaces output elsewhere in the economy. This is appropriate for the domestic economy, but induced exports do not displace domestic production and their net value at Port (after added production costs) should be attributed as a benefit to the transport project.

Similarly if it induces import replacement consumption, this adds to the gross value of the Australian economy, and this benefit should be attributed to the transport project.

Estimating the value of induced exports involves an assessment of export price elasticity. The price elasticity for various industries is usually available in Australia.

For instance, the price elasticity of demand for Australian beef exports to markets other than the United States, Canada, Japan and the European Community was estimated[4] to be -1.27. That is a 10% reduction in freight price, estimated at 10% of the ex-port production cost, if fully passed on as exports, should result in a 1.27% increase in export demand.

[4] Freebairn and Gruen (1977)

In practice the elasticity of the production function is usually taken to be the export price elasticity (because this is usually easily estimated in developing countries) although this should relate to the total market elasticity not just exports.

If the price elasticity cannot be estimated, then computing the shift in the export production function typically involves case study investigations into a sample of farms (or industries). These studies may also be necessary to assess the added production costs if export benefits are to be included.

Care needs to be taken to ensure that travel benefits, freight benefits and producer benefits do not overlap where all three types are included in the one evaluation. It is also important to review the marketing chain to assess the degree to which potential freight cost savings, including delays and other time-related costs, are translated into industry price reductions. This is specific for each industry or crop.

Modeling the logistic freight chain often involves two-stage assignment processes in either direction in the modeling – farm-abattoir-market or farm-silo-port. These may involve different modes – farm-silo by truck then silo-port by rail.

The method is suitable for all forms of urban or rural industrial impacts, not just the rural agricultural setting, although it is difficult to apply in urban areas because of the complexity of freight movements in cities. It is most relevant where the promotion of export trade is part of the transport projects' objective. Modeling freight in multimodal rural networks is more complex and involves many assumptions bur can be achieved.[5]

4. A Case Study

This case study[6] relates to a number of potential improvements to unpaved roads in western Queensland, where the rural economy is primarily based on cattle and tourism.

The road improvements will induce traffic growth on the road sections in addition to the growth that would normally occur due to gradual increases in the population and wealth of the residents of the towns in the area. This added growth will mainly be due to domestic and international tourists attracted to western Queensland but will also include growth in the cattle industry and additional growth in traffic and freight from the towns as they grow faster to service this tourism industry. Table 4 shows the forecast traffic with/without the road improvements for each road.

Table 4 Daily traffic forecasts with and without the road improvements – Vehicles per day

Road Section	2004		2014		2034	
	Without	With	Without	With	Without	With
Windora to Birdsville	40	50	65	105	100	180
Windora to Bedourie	35	40	60	90	110	165
Birdsville to Bedourie	40	50	70	95	120	170
Bedourie to Boulia	50	60	75	100	145	195
Cunnamulla to Quilpie	45	55	80	95	130	155

Source: Scott Wilson Nairn's CARTS[7] model

[5] R J Nairn, "Rural Freight Modeling", ATRF 2022

[6] Scott Wilson Nairn Pty. Ltd. (2004). "Outback Queensland Development Roads Feasibility Study' for Barcoo and Diamantina Shires.

Table 5 lists the implied annual traffic growth rates on each road section with and without the road improvements. The traffic growth rates were initially based on, and are less than, the current growth in tourism expenditure in Bedourie (7.6%) or for Western Queensland as a whole (7.5%). Bedourie fuel sales rose at 8.7%.

Discussions with local cattle graziers and tourism industry proprietors, particularly about their need, willingness and capacity to grow, confirmed these growth rates.

Table 5 Implied annual traffic growth rates

Road Section	Without Improvements		With Improvements	
	2004-14	2014-34	2004-14	2014-34
Windora to Birdsville	5.0%	2.2%	7.7%	2.7%
Windora to Bedourie	5.5%	3.1%	8.4%	3.1%
Birdsville to Bedourie	5.7%	2.7%	6.6%	3.0%
Bedourie to Boulia	4.1%	3.4%	5.2%	3.4%
Cunnamulla to Quilpie	5.9%	2.5%	6.6%	2.5%

The economic evaluation results for these road improvements are shown in Table 6.

Table 6 - Economic results for alternative Western Queensland road improvements

Cost or Benefit	Windora Birdsville	Windora Bedourie	Birdsville Bedourie	Bedourie to Boulia	Cunnamulla to Quilpie
Capital Cost	$31,316	$29,628	$14,639	$10,819	$17,278
Resource Savings					
Maintenance	$5,037	$5,462	$311	$751	-$320
Accidents	$1,178	$1,350	$2,328	$588	$937
Veh Op Cost	$845	$1,049	$173	$206	-$9,072
Time	$4,267	$4,145	$2,895	$2,179	$3,728
Total Savings	$11,327	$12,006	$5,707	$3,724	-$4,727
Industry Benefits					
Tourism	$54,294	$40,904	$33,709	$24,049	$38,531
Freight Industry	$8,414	$6,887	$5,333	$3,811	$6,094
Beef Industry	$12,636	$12,983	$8,041	$7,034	$9,190
Total Benefits	$86,671	$72,780	$52,790	$38,618	$49,088
Net Benefits	**$55,355**	**$43,152**	**$38,151**	**$27,799**	**$31,810**
BCR	**2.77**	**2.46**	**3.61**	**3.57**	**2.84**

Source: CARTS model. The values are discounted @ 9% in $'000.

Induced export benefits were not included in Table 6. It is estimated that these benefits would amount to approximately $17 million extra.

Produce from the cattle industry was carried by the graziers themselves (or by associated companies) and was assessed to be fully passed on. Fuel and general supplies were carried by only a few carriers. The results show that, despite the very low traffic volumes, improvements to each road are economically viable.

[7] Scott Wilson Nairn Pty. Ltd. "CARTS Program description and User manual" 1992

The distribution of the benefits is shown in Table 7.

Table 7 - Distribution of benefits between beneficiaries

Beneficiary	Windora Birdsville	Windora Bedourie	Birdsville Bedourie	Bedourie to Boulia	Cunnamulla to Quilpie
% Government	7.2%	9.4%	5.0%	3.5%	1.3%
% Road User	37.2%	35.2%	37.7%	37.3%	28.4%
% Tourism Industry	31.3%	28.1%	31.9%	31.1%	39.2%
% Freight Industry	9.7%	9.5%	10.1%	9.9%	12.4%
% Cattle Industry	14.6%	17.8%	15.2%	18.2%	18.7%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Source: Scott Wilson Nairn's CARTS model. Export benefits are not included.

The beneficiaries are accounted as follows - Government gets savings in road maintenance, road users and tourists get travel time, vehicle operating cost and accident savings, the freight industry get freight benefits which are not passed on and the cattle Industry, in this instance get the freight benefits that are passed on. These benefits are derived within the CARTS model.

5 Will the price reductions be passed on?

Either freight companies benefit from their reduced costs or they pass it on fully or partially. The degree to which the benefits are passed on to producers and consumers depends on the answer to two main questions:-

- To what extent are the freight companies in a competitive trading environment?
- How many producers or consumers carry their freight themselves?

In many areas the freight industry is highly competitive and cost reductions translate into price reductions in the short term, however freight is largely an unrestricted market and this needs to be investigated in each application.

Usually road freight carriers face considerable competition, if only from rail, but perhaps not in far rural areas. Many producers (farmers and graziers particularly) carry their own goods at least part of the way to market and many retail outlets carry their input goods in their own trucks.

Where this is so then reduced freight costs translate directly into input price reductions with benefit to either the producer or consumer.

6. Will the rural producers actually react?

If the benefits are passed on to producers, will it induce greater production? Will consumption grow due to reduced prices?

To address these questions, a survey of the businesses, that import or export freight, was conducted in one rural town (Griffith) in New South Wales.

These businesses comprise about 36% of all employment in the town. The type of industry that imports or exports freight and the direction of their freight are shown in Table 8.

Table 8 - Freight producing industries in a rural town

Freight Producing Industry Type	% Freight Movement		% of all Employment
	Inwards	Outwards	
Agricultural Products	75%	55%	25%
Retail/Wholesale	7%	5%	9%
Manufacturing/Other	18%	40%	2%
Total	100%	100%	36%

Source: "Griffith Freight Survey" R J Nairn & Partners Pty Ltd

Much of their lost opportunities are due to damage and delay caused by poor road conditions or rail schedules. The above freight producing businesses reported[8], when interviewed, that their annual losses, due to freight damage or delay, totals about 2% of their annual turnover amounting to about $9.0 Million in total.

One firm, which had installed cushioned suspension on their vehicles, nevertheless incurred substantial damage to their produce (eggs) due to road roughness, amounting to about $2.0 Million each year, more than sufficient to afford to pave the entire road from Griffith to the Hume Highway with a smoother "hotmix" surface.

In total the freight users estimated that, if freight cost, delays and damage could be reduced by 20%, they would expand their business turnover by about 3% more than their current market plans.

If this freight cost reduction were achieved and as the freight component of the annual turnover of these businesses is about 6% of their turnover, this means that the value of increased business turnover would exceed the loss of freight revenue by a factor of about 2.5.

It is clear from this survey in Griffith that a part of any freight cost reductions, if passed on, would create added economic output. Our current economic evaluation methods have not been properly addressing these kinds of economic opportunities to improve rural industry.

The World Bank producer surplus methodology invites this form of survey to properly validate the economic impact of transport projects.

7. Why bother with this?

The reader may well ask "Why bother with this?"

- It is a lot more work; and
- If there are no induced exports then the total economic benefit streams remain the same whatever their distribution so there is nothing incorrect about ignoring this whole "Producer Surplus" approach.

There are four main reasons for adopting this approach:-

- It may **create induced exports** (or import replacement consumption) which is a benefit that should be attributed to the transport project;
- It helps us to **better understand** the real problems facing producers and the freight companies and the opportunities we have to improve their businesses;

[8] "Griffith Freight Survey" R J Nairn & Partners Pty Ltd

- It **provides credibility** to the forecasts because their potential growth is understood much better as it is based on a real understanding of rural industry;
- It **improves the political acceptability** of the economic results because it provides other stake-holders with direct credible information about the nature and distribution of the benefit stream; and
- **It provides the direct link between transport price reductions and the resulting regional and national economic impacts**. This is important if we are to eventually progress to building a macro-economic model of the transport industry.

8. A national macro-economic model of transport

Transport Benefit-Cost analysis has always been constrained by arbitrary rules such as 'no multiplier effects allowed' or 'no employment benefits allowed'. It assumes that nothing will change except the immediate effects on the road and on travellers.

In consequence it has remained, at best, only a partial analysis of the national economy when what is needed is an approach which, like the macro-economic models used by the Federal Treasury, give guidance on current economic realities, including the impact of the transport improvement programme on:-

- Employment rates,
- Inflation rates,
- The balance in overseas payments,
- Interest rates,
- Social equity,
- Controlled, environmentally sustainable growth, and
- Private sector involvement, risk and responsibility.

Instead of the project investment, the key trigger for these models should be the travel and freight price reductions. These triggers feed into the input-output tables to establish the above current economic indicators within these macro-economic models.

These models have reached a position of total pre-eminence in credibility and influence with budget strategists - an influence which has not been rivaled nor tapped to any extent by the transport industry in Australia. Possibly as a consequence, the real value of finance available for transport improvements has not kept pace with the need.

While similar models have been constructed and used in Australia[9] they have not fully coped with the potential long-term benefit steam from transport projects.

Linking benefit/cost analysis techniques to long-term, multi-regional general equilibrium models of the National economy can be achieved. State-wide or nation-wide models such as CARTS, which combine multi-modal traffic assignment with this economic approach, can provide the freight price changes which trigger the macro-economic models. These macro-economic models need to be a built within a long-term framework because the short run influence of investments in road building and other transport improvements would produce very incomplete and misleading results – the costs are seen immediately but the benefits accrue over a much longer period.

[9] Australian Transport Assessment and Planning Guidelines August 2021 T4 Computable general equilibrium models in transport appraisal.

There needs to be a greater realization that investment, in roads and other infrastructure, rather than expenditure on short-term welfare issues leads to economic stability and sustainable growth, minimizing the boom-bust cycle.

One of the current impediments to achieving this aim is that Australia's input-output tables are not disaggregated into sufficient geographic divisions to make the dependent models worthwhile and, in addition, the current input-output macro-economic data sets are short-term. If these issues could be overcome, then the value of the transport industry, and all infrastructure investment, could be seen by economists and politicians in its true economic perspective[10]. Modeling the impact of freight price reductions is the key trigger for these models.

9. Conclusion

Economists are often accused of being in an "ivory tower" obsessed with theory rather than real on-the-ground experience. The "Producer Surplus" approach requires that they seek reality on the ground.

Many rural roads carry little traffic and thus are neglected. However, the traffic they carry is usually composed of a high proportion of freight movements with export content, and road improvements can make a significant difference to their industry. When their potential improvement attracts economic evaluation interest, they usually return convincing economic returns.

If they induce expansion in export industries then added benefits can be attributed to the project's economic returns. Their future implementation is politically assisted by the knowledge of their distributed benefit to local industry, which is credibly provided by this approach.

The methodology has been used extensively in Australia and in many overseas countries for the evaluation of rural roads. Nation-wide models have been built incorporating this approach in such countries as Bangladesh or Papua New Guinea although they are often built as State-wide models, as in Australia, China or the Philippines.

The method provides the essential trigger to any future transport industry macro-economic model, which, hopefully, will elevate transport economic evaluation techniques to provide a fully comprehensive input into national economic policy guidance.

References

WORLD BANK (1976). Technical working paper No. 241. International Bank for Reconstruction and Development, Washington.

Freebairn, J.W. and Gruen, F.H. (1977). "Marketing Australian beef and export diversification schemes", Australian Journal of Agricultural Economics 21 (1), 26-39.

Maina Wambugu, Daniel (Dec. 10, 2018). "The World's Largest Exporters of Beef." WorldAtlas.

[10] 'Linking micro- and macro-economic assessment of transport programs' R J Nairn ATRF 2000

R J Nairn, “Rural freight modeling”, ATRF 2022

Scott Wilson Nairn Pty. Ltd. (1992). “CARTS Program description and User manual”

Scott Wilson Nairn Pty. Ltd. (2004). “Outback Queensland Development Roads Feasibility Study’ for Barcoo and Diamantina Shires.

R J Nairn & Partners Pty Ltd (1998) “Griffith Freight Survey”

R J Nairn (2000) ‘Linking micro- and macro-economic assessment of transport programs’ ATRF 2000.

Infrastructure and Transport Ministers, ‘Australian Transport Assessment and Planning Guidelines August 2021 T4 Computable general equilibrium models in transport appraisal’.