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A Review of Cost-Benefit Analysis for Freight Projects

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Abstract

Cost-Benefit Analysis is most often used to evaluate the net impact of a project to the community. The project can be evaluated from the public perspective in an empirical manner using Cost-Benefit Analysis. Measuring net impacts of a freight project can be a complex task, as it can impact the whole freight network including numerous modes of transport. However, the literature review highlighted that there are a number of inconsistencies and disagreements between academic studies of freight project evaluations. This paper reviews the Cost-Benefit Analyses of a number of land freight projects, in order to investigate how freight projects are evaluated in practice. It has a particular focus on the types of benefits that have been quantified in the analysis and the data that has been used to quantify those benefits. The review found that there are significant inconsistencies between case studies with regard to the types of benefits that have been captured in the analysis. It also found that the treatment of some impacts, particularly those impacts to freight companies, need further investigation. Moreover, the availability of rail freight data compared to road freight data is significantly lacking. For the purpose of conducting Cost-Benefit Analysis of freight projects consistently between freight projects, a standardised methodology and clear guidance need to be established and provided. Additionally, this review can serve as a useful reference list for practitioners for the purpose of conducting Cost-Benefit Analysis of freight projects.

1. Introduction

Cost-Benefit Analysis (CBA) is the most commonly used project evaluation tool of government funded or sponsored projects. The CBA quantifies the net impact of a project from the perspective of the host government and the community. Measuring net impacts of a freight project can be complex, because the project can impact the whole freight network and numerous modes of transport. Moreover, there has been a lack of detailed guidance with regard to the CBA methodology for freight projects. The aim of this paper is to provide a review of the CBA methodologies used to conduct the analyses of six major land freight projects, including four Australian and two international cases. It focuses on the benefits identified and the sources used to quantify those benefits. It then identifies the gaps in the available data and CBA methodologies. This paper also provides a summary of sources that have been used previously, which can be of use to CBA practitioners.

The paper first provides a review of academic literature and Australian manuals and guidelines. It then provides an overview of the case studies. The impacts, and the sources that have been used to quantify those impacts, are summarised. The gaps of data and guidance are finally discussed.

2. Background

Governments are typically responsible in selecting public investment, where the economic benefits of a decision outweigh the economic costs. For the purpose of evaluating and measuring the net impact to the community, CBA is most often used as the preferred project evaluation tool (Wee & Rietveld, 2014). CBA is well-established in academic literature (Boardman, Greenberg, Vining, & Weimer, 2014; De Rus, 2010), and measures and monetises project impacts (Rogers & Duffy, 2012; Wee & Rietveld, 2014). The fundamental difference between CBA and financial analysis is that the former focuses on the impacts to the community. For instance, monetised travel time impacts and travel distance impacts, which are not captured in financial analysis, are considered in CBA of a transport project. Broad perspectives including the host government, facility users and non-users can be included in CBA (Decorla-Souza, Lee, Timothy, & Mayer, 2013).

3. Literature Review

A review of academic literature and guidelines was undertaken to identify freight related cost benefit analysis studies. The scope of CBA is generally limited to the economic impacts to the community. The analysis becomes more complex when the scope includes the economic impacts to the whole of a state or country (Australian Transport and Infrastructure Council, 2016c). The Australian Transport and Infrastructure Council currently advises that the wider economic impacts should be only be included in sensitivity analysis (Australian Transport and Infrastructure Council, 2016b).

As Transport for New South Wales (2013) highlights, before conducting CBA, all relevant impacts need to be determined. For example, Table 1 summarises potential impacts of when a new rail freight facility is provided to an existing rail network. It presumes that road facilities exist within the same freight network. The potential impacts are shown as examples and are not limited to those listed in the table.

Table 1: Impacts of a new freight rail project

Impact	Impacted facility	Outcome
Freight throughput	Existing rail facilities	Potentially decreased through diverting some train movements to a new rail facility
	Existing freight road network	Decreased through diverting some freight movements to a new rail facility
	The whole freight network	Can be impacted due to the changes in freight costs to freight operating firms
Vehicle hours travelled	Existing rail facilities	Potentially decreased due to less congestion through diverting some train movements to a new rail facility
	Existing freight road network	Potentially decreased due to less congestion through diverting some freight movements to a new rail facility
Vehicle kilometres travelled	Trains on the new rail facility	Potentially improved
Crash rate	Existing freight network both rail and road	Potentially reduced due to less congestion through diverting some freight movements to a new rail facility
Reliability and waiting time of passenger rail services	Existing passenger rail services that share the network with freight trains	Potentially reduced due to less congestion through diverting some freight movements to a new rail facility
Vehicle operating costs	Trains on the new rail facility	Potentially decreased by improving rail operations and designs

Tseng, Rietveld and Verhoef (2012) claim that not capturing changes to reliability can significantly affect the CBA outcome. There are various opinions in the literature with regard to whether to include the reliability as a wider economic benefit. Moreover, the methodology for the estimation of reliability conflicts between scholars (Transport for New South Wales, 2013).

Other impacts, such as additional employment and competitiveness with international markets, tend to be included as wider economic benefits (Australian Transport and Infrastructure Council, 2016b; Dobes & Leung, 2015; Legaspi, Hensher, & Wang, 2015). Vadali, Kruse, Kuhn and Goodchild (2017) further discuss wider economic benefit estimations.

Protopapas, Warner and Morgan (2012), in their review of freight projects in America, claim that better definitions and greater standardisation in CBA, as well as clear and available documentation of data sources, assumptions and forecasts for a variety of input parameters are needed. Although the CBA methodology of major road projects is well-established and well-documented in Australia (Australian Transport and Infrastructure Council, 2016a, 2016c; Tsolakis, Preski, & Patrick, 2009), the CBA methodology of freight projects (in particular rail) is seldom explained in the Australian guidelines (Australian Transport and Infrastructure Council, 2016c; Transport for New South Wales, 2013).

This issue is highlighted in table 2, where the differences in the types of costs that have been included as environmental and external costs of a freight project are summarised. Table 2 also contains the Australian Transport Council's recommended types of environmental and external costs that should be included in CBA.

Table 2: Types of costs included as external costs in various academic literature and Australian guidelines

Author	Type of costs included
Forkenbrock (1999)	Accidents, emissions, noise, and unrecovered costs associated with the provision, operation and maintenance of public facilities
Jakob, Craig and Fisher (2006)	Accidents, air pollution and climate change
Janic (2007)	Air pollution, congestion, noise and traffic accidents
Janic (2008)	Noise, energy consumption, air pollution, traffic accidents and congestion
Ricci and Black (2005)	Impacts to upstream and downstream, electricity production, congestion, noise, global warming, accidents and air pollution
Sahin, Yilmaz, Ust, Guneri and Gulsun (2009)	Accidents, emissions and noise
Australian Transport Council (2006a)	Air pollution, greenhouse gas/climate change, noise, water, nature and landscape, and urban separation

The lack of guidance in the impacts that should be captured as environmental and external costs in CBA leads to inconsistencies, misleading analysis outcomes and double counting. For instance, capturing both the impacts to climate change and air pollution costs may lead to double counting.

4. Case Studies

Six cases are studied in this paper. The following provides a background of each case study.

4.1 Dedicated Freight Rail Corridor

The Dedicated Freight Rail Corridor (DFRC) is a proposed new freight rail corridor that provides a direct connection to the Port of Brisbane from the existing freight rail network in Brisbane, Australia (Ernst & Young, 2014). It includes an extension of Fisherman Islands Rail Line for 37 kilometres and upgrades of the Interstate Standard Gauge Rail Line and the Queensland Rail Western Line (Ernst & Young, 2014).

4.2 Melbourne-Brisbane Inland Rail

The Melbourne to Brisbane Inland Rail (MBIR) project is a proposed 1,700-kilometre-long freight rail corridor between Melbourne and Brisbane, Australia (Australian Rail Track Corporation, 2017). The new rail route will be up to ten hours faster than the existing rail network (Australian Rail Track Corporation, 2017).

4.3 Northern Sydney Freight Corridor Program

The Northern Sydney Freight Corridor Program (NSFCP) is an initiative to improve the capacity and reliability of the freight network between Strathfield and Broadmeadow, Australia (Transport for New South Wales, 2017). NSFCP consists of multiple projects that improve the section of rail network, which include a provision of third rail track between Epping and Thornleigh, Australia (Transport for New South Wales, 2017).

4.4 Southern Freight Rail Corridor Study

The Southern Freight Rail Corridor Study (SFRCS) is a proposed 55-kilometre freight rail corridor between Rosewood and Kagaru, Australia (Queensland Department of Transport and Main Roads, 2010). SFRCS will serve as a link between the proposed MBIR and the existing south-east Queensland Rail freight network (Queensland Department of Transport and Main Roads, 2017).

4.5 Global Rail Baltica Project

The Global Rail Baltica Project (GRBP) is a 870 kilometre freight and passenger railway in the Baltic states, which consists of Estonia, Latvia and Lithuania (Rail Baltica, 2017). GRBP also includes provisions of freight intermodal facilities in Muuga in Estonia, Salaspils in Latvia, and Kaunas and Vilnius in Lithuania (Ernst & Young, 2017).

4.6 Western Virginia Intermodal Facility

The Western Virginia Intermodal Facility (WVIF) is proposed to be located southwest of Roanoke, Virginia in U.S (AECOM, 2015). Roanoke is located where three existing freight corridors meet and captures the areas that are away from the existing intermodal facilities (AECOM, 2015).

5. Identifications of Benefits

5.1 Benefits Identified in Cases

Table 3, 4, 5 and 6 summarise the types of benefits that have been incorporated in the CBA of the case studies. Although there are differences in the scope of the work, there is a significant variation in terms of the types of benefits that have been accounted for. For instance, although MBIR and DFRC are similar in nature, there is a large variation between the benefits that have been included between the two cases.

Table 3: Types of benefits of the new facility included in previous freight CBA

Type of benefits included	Reduced environmental and external costs unit price	Reduced crash rate	Reduced vehicle operating cost unit price	Reduced freight travel time	Induced freight volume	Freight availability and reliability
DFRC (Ernst & Young, 2014)	Yes	Yes	Yes			
MBIR (Australian Rail Track Corporation, 2010)	Yes	Yes	Yes	Yes	Yes	
NSFCP (Deloitte, 2011)		Yes	Yes	Yes		Yes
SFRCS (Queensland Department of Transport and Main Roads, 2010)				Yes		
GRBP (Ernst & Young, 2017)	Yes	Yes	Yes	Yes		
WVIF (AECOM, 2015)	Yes	Yes	Yes			

Table 4: Types of benefits to other rail facilities included in previous freight CBA

Type of benefits included	Delaying constructions to replace the existing rail facilities	Improved reliability of passenger services	Reduced maintenance costs	Reduced travel time
DFRC (Ernst & Young, 2014)	Yes			
MBIR (Australian Rail Track Corporation, 2010)		Yes	Yes	
NSFCP (Deloitte, 2011)				
SFRCS (Queensland Department of Transport and Main Roads, 2010)				
GRBP (Ernst & Young, 2017)				Yes
WVIF (AECOM, 2015)				

Table 5: Types of benefits to other road facilities included in previous freight CBA

Type of benefits included	Reduced road congestion	Reduced maintenance costs	Reduced crash rate	Reduced environmental impacts	Reduced travel time
DFRC (Ernst & Young, 2014)	Yes	Yes			
MBIR (Australian Rail Track Corporation, 2010)	Yes	Yes			
NSFCP (Deloitte, 2011)	Yes		Yes		
SFRCS (Queensland Department of Transport and Main Roads, 2010)		Yes		Yes	
GRBP (Ernst & Young, 2017)					Yes
WVIF (AECOM, 2015)	Yes	Yes			

Table 6: Types of other benefits included in previous freight CBA

Type of benefits included	Increased track access revenues	Impacts of modal shifts from private vehicles - reduced operating and maintenance costs
DFRC (Ernst & Young, 2014)		
MBIR (Australian Rail Track Corporation, 2010)		
NSFCP (Deloitte, 2011)	Yes	
SFRCS (Queensland Department of Transport and Main Roads, 2010)	Yes	
GRBP (Ernst & Young, 2017)		Yes
WVIF (AECOM, 2015)		

5.2 Benefits Due to Variations in Transport Cost Unit Prices

The majority of the impacts captured in CBA for freight projects are derived from the differences in transport unit prices between road and rail facilities. The transport unit prices are well-documented in Australian guidelines including Austroads (Tan, Lloyd, & Evans, 2012) and the Australian Transport Assessment and Planning Guidelines (Australian Transport and Infrastructure Council, 2016a). However, the transport unit prices of rail are not as well-documented. Australian Transport Assessment and Planning Guidelines (Australian Transport Council, 2006a, 2006b) provide a number of rail related costs, such as track maintenance cost, locomotive capital cost and rolling stock capital cost, and unit prices of environmental and external costs. Other rail related parameters are however not provided, including the key terminal and pick up delivery costs, which are an important component of the total cost of rail.

5.3 Avoided Rehabilitation Costs and Delayed Constructions

One case has included the delayed construction benefits in the CBA. Careful consideration need to be given when counting avoided costs of construction of existing facilities. For instance, if an existing facility does not need to be replaced within the analysis horizon, because some traffic is expected to divert to a new facility, the avoided cost of the construction may be accounted in the CBA. However, the scope of CBA needs to be clearly defined at the beginning of the analysis and the accounted impacts need to stay within the defined scope. In other words, once the avoided cost has been captured in CBA of a project, it should not be counted again in CBA of any other projects. Inconsistencies in terms of the scope of CBA can lead to justifying otherwise economically unviable projects.

5.4 Impacts to Freight Companies

Chi et al. (2017) claim that when conducting CBA to measure the net impact to the community, the impacts to the private sector need to be given a careful thought whether they should be accounted in the analysis. Similarly to the previous study in CBA of toll roads (Chi et al., 2017), further study is needed to investigate whether to include the impacts to the freight companies in CBA. The impacts to the private sector may need to be excluded from the CBA, for the purpose of evaluating a project from the public perspective. Similarly, transfer payments between public and private agencies need to be accurately determined and excluded in CBA, in order to avoid the overestimation of benefits.

For instance, the impacts to maintenance requirements due to changes in traffic demand in existing road and rail facilities need to be carefully considered, when a private road or rail operator is responsible for the maintenance. Additionally, the host government and public are usually not responsible for freight operating costs. This then raises a question as to whether to include the impacts to the freight operation costs.

5.5 Road Decongestion Benefits

Reduced road congestion can result from mode shifts between road and rail and/or improvement in road and rail interactions, such as removals of level crossings. Reductions in road congestion impact the road demand, and therefore, it would also impact traffic volumes and travel times along the surrounding road network. These changes can be captured in the traffic demand forecast. In the cases, the road decongestion benefits have been measured by assuming that the vehicle kilometres travelled is reduced due to the decongestion, and by applying the unit price of the decongestion benefit to the vehicle kilometres travelled saving. When the traffic forecast was conducted appropriately and the changes due to decongestion have been accounted for the traffic forecast, accounting the decongestion again using the congestion cost may lead to double counting. This needs to be investigated further.

5.6 Impacts to the Freight Network as a Whole

It was highlighted in MBIR that the proposed rail does not reach the Port of Brisbane and a new freight intermodal facility is needed for the goods to be transported by heavy vehicles on roads. At the current state, the goods are transported by heavy vehicles on roads in Brisbane, however when the project induces more heavy vehicles, this could lead to more frequent road maintenances and a number of negative impacts to the road surroundings. This raises the importance of freight road traffic forecasts. The negative impacts due to the induced heavy vehicle movements along the missing link between MBIR and the Port of Brisbane need to be captured. Whether this may or may not be significant in a large-scale project, it is important to evaluate a project from the network point of view.

6. Quantifying Benefits

Table 7, 8 and 9 summarise the sources that have been used in the cases, in order to conduct CBA. This table is not intended as a list of parameters each source contains. It rather highlights the sources and parameters that have been referenced in the cases and variability of the range of variables included in each analysis. Overall, the availability of required data is significantly lacking. This is particularly evident in Australian cases, as the data that was used for MBIR (Australian Rail Track Corporation, 2010) was also used in DFRC (Ernst & Young, 2014) and NSFCP (Deloitte, 2011), despite some differences in the characteristics of the projects. The availability of data for rail projects is extremely limited compared to the availability of data for road projects.

Table 7: Sources used for quantifications of benefits for rail related impacts

Source used	Case	Environmental and external costs unit price	Crash rate	Maintenance costs	Vehicle operating costs	Crash cost
ATRC[1] (2010)	**DFRC, NSFCP**	Yes	Yes	Yes	Yes	
ATC[2] (2006a)	**NSFCP**	Yes				
BTE[3] (2000)	**MBIR**					
ERA[4] (2013)	**GRBP**		Yes			
Korzhenevych et al. (2014)	**GRBP**	Yes				Yes
Tan, Lloyd, & Evans (2012)	**DFRC, NSFCP**					
TfNSW (2013)	**NSFCP**					
U.S. Dept of Transportation (2000)	**WVIF**					

Table 8: Sources used for quantifications of benefits for road related impacts

Source used	Case	Environmental and external costs unit price	Congestion cost	Value of time	Vehicle operating costs	Crash cost
ATRC (2010)	**DFRC, NSFCP**					
ATC (2006a)	**NSFCP**	Yes				
BTE (2000)	**MBIR**					
ERA (2013)	**GRBP**					
Korzhenevych et al. (2014)	**GRBP**		Yes			
Tan, Lloyd, & Evans (2012)	**DFRC, NSFCP**	Yes	Yes	Yes	Yes	Yes
TfNSW (2013)	**NSFCP**					
U.S. Dept of Transportation (2000)	**WVIF**	Yes	Yes			Yes

[1] Australian Rail Track Corporation
[2] Australian Transport Council
[3] Bureau of Transport Economics
[4] European Rail Agency

Table 9: Sources used for quantifications of benefits for other impacts

Source used	Case	Value of freight time	Proportion of business peak hours	Pavement costs
ATRC (2010)	**DFRC, NSFCP**			
ATC (2006a)	**NSFCP**			
BTE (2000)	**MBIR**	Yes		
ERA (2013)	**GRBP**			
Korzhenevych et al. (2014)	**GRBP**			
Tan, Lloyd, & Evans (2012)	**DFRC, NSFCP**			
TfNSW (2013)	**NSFCP**	Yes	Yes	
U.S. Dept of Transportation (2000)	**WVIF**			Yes

7. Conclusions

This paper provided a review of CBA that have been conducted previously for existing land freight projects, with a particular focus on the types of the benefits that have been accounted and the sources of data that have been referenced in the CBA. Four Australian case studies and two international cases were reviewed. The gaps and limitations of data and guidance for the purpose of conducting CBA for freight projects were identified.

There are a number of inconsistencies between various scholars with regard to the CBA methodology for freight projects and the types of benefits that should be accounted in the CBA. For instance, opinions differ between scholars whether reliability should be accounted in CBA and how the reliability should be estimated.

The current guidelines lack comprehensive guidance on the CBA methodology for freight projects. The scope of the analysis, the types of impacts that should be captured in CBA, and the impacts that should be captured as part of wider economic benefits need to be clearly defined to maintain consistency among analyses. Lack of guidance can also lead to double counting some impacts. Specifically, guidelines need to provide a list of impacts of the new facility and the existing surrounding facilities that should be accounted, guidance in terms of the impacts that should be captured in traffic forecasts, such as changes of freight operating costs and freight traffic demand, the types of impacts that need to be captured when modal shift is expected, and various transport cost unit prices for rail. The types of impacts that need to be accounted in CBA for freight projects can depend on the nature of the project and can differ between projects. The units of transport costs of rail and road are also often different. The analysis approach of freight CBA may need to be developed separately to the road CBA.

The review of freight project cases revealed inconsistencies between cases with regard to the types of benefits that have been accounted in each CBA. This can be the result of the lack of guidance in the CBA methodology. Moreover, further investigations into the treatment of impacts to freight companies are required, in order to properly reflect the net impacts of the freight project to the community. The inconsistencies of the CBA can lead to justifying economically unviable projects. It also suggests that the analysis methodology highly relies on the analyst’s judgements, which can cause misrepresentations and bias in the analysis.

The number of case studies that were reviewed in this paper was limited. This is due to the lack of publicly available CBAs of freight projects. The majority of freight projects in Australia are mine related projects, which are generally assessed on the basis of their financial viabilities. Their impacts to the community are therefore not generally assessed for the purpose of evaluations. This suggests the lack of studies and experiences in CBA of freight projects in Australia. At the same time, this also suggests the lack of guidance can be due to the lack of its need.

This paper provided an overview of how freight projects have previously been evaluated using CBA and the gaps of data and guidance that need to be filled. These gaps suggest wide range of further studies required, including development of transport cost unit prices for rail projects that can be used in the analysis, clearly defining the types of benefits that should be considered in the analysis, and more standardised methodology of measuring the impacts.

Additionally, the list of sources that was provided in this paper can be extremely useful for CBA practitioners. Although this paper is not intended to serve as a guideline, it provides a list of references that can be useful for the purpose of conducting CBA for freight, road and rail projects.

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