International Transport Forum

# Estimating Wider Economic Impacts in Transport Project Prioritisation using Ex-Post Analysis

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# ITF Discussion Papers

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*Transport project prioritisation and selection processes require consideration of many aspects of costs, intended benefits and other impacts. Economic analysis methods can measure many of those factors, though the analysis methods must be specified in ways that meet the information needs of decision-makers. This paper examines how benefit-cost analysis, economic impact analysis and multi-criteria analysis approaches have evolved and been applied to address the specific form of governmental decision processes that exist in the U.S. and some other countries. It discusses how "ex-post" case studies and associated statistical studies of have been promoted and utilised to both inform and refine "ex-ante" evaluation methods. It concludes by discussing the advantages, limitations and trade-offs involved in the use of this approach for transport project decision-making.*

## Introduction

Decisions regarding transport projects, programs and policies are made at several stages – including planning, prioritising, funding and implementation. These decisions are best made when they are informed by complete and accurate information regarding requirements and consequences of following through on those decisions. Various forms of economic impact and benefit cost analysis are frequently applied to inform these decisions, though the specific approaches have varied across countries and governments over time. Overall, there has been a common progression (evolution) towards more complete and accurate information, and efforts to better align analysis methods with decision needs.

This paper examines one aspect of this evolution, which pertains to the definition, measurement and use of non-user impact measures in transport decision making. It further focuses on non-user economic impacts and their wider economic development consequences. It discusses how and why the definition and measurement of these effects differ among (national and state or regional) governments, and specifically how "case-based evaluation" methods and "*ex-post* case studies" are being increasingly used in the US to inform decision-making.

Much of the paper focuses on the evolution of evaluation and decision processes in the US, with some parallel examples drawn from Canada and Australia. The presentation is intended to provide an instructive example of how these issues are being addressed in the context of a very specific federal system of government. There is no intent to suggest that the approaches discussed in this report are necessarily applicable to other forms of governmental decision-making. Rather, the discussion is intended to highlight a core issue – how can benefit-cost (efficiency) analysis exist alongside broader methods that consider distributional equity and strategic policy factors in decision making. These broader methods can include other forms of economic analysis, including economic development and financial impact evaluation methods.

The rest of this paper is organised into four parts.

- *Defining and measuring wider benefits.* First, this paper defines benefits, and identifies available methods to assess them. It considers the motivations and intended benefits of transport projects and how those goals can or should affect the evaluation (appraisal) process. It then reviews the evolution of economic evaluation methods over time to encompass benefit-cost analysis (BCA), economic impact analysis (EIA) and financial impact analysis (FIA) – and the intent of these methods to facilitate better accounting of goal achievement and impact effects.
- *Development of evidence-based analysis methods in the US.* Second, the paper reviews the development and growth of *ex-post* case study analysis, *ex-ante* multi-criteria analysis and evidence-based planning methods in the US. It discusses the motivation for these approaches, and specifically their ability to cover threshold effects, interaction effects, and distributional effects. It also examines the consequences of these approaches for decision-making at various planning stages.
- *Key findings from ex-post case study datasets.* Third, the paper critically examines the strengths and weaknesses of *ex-post* analysis and evidence based planning methods, and extracts key impact factors that need to be better considered in decision frameworks. This includes needs to recognise how the creation of new spatial, temporal and distributional linkages may affect technology adoption and activity patterns in ways far broader than efficiencies for existing transport system beneficiaries.
- *Implications for cost and benefit accounting and decision support systems.* Finally, the paper discusses how the study findings can be incorporated into cost, benefit and impact accounting systems, and how that information can be used to better communicate to public and private stakeholders and decision-makers.

## Defining and measuring wider economic benefits and impacts

### Benefit and impact definitions

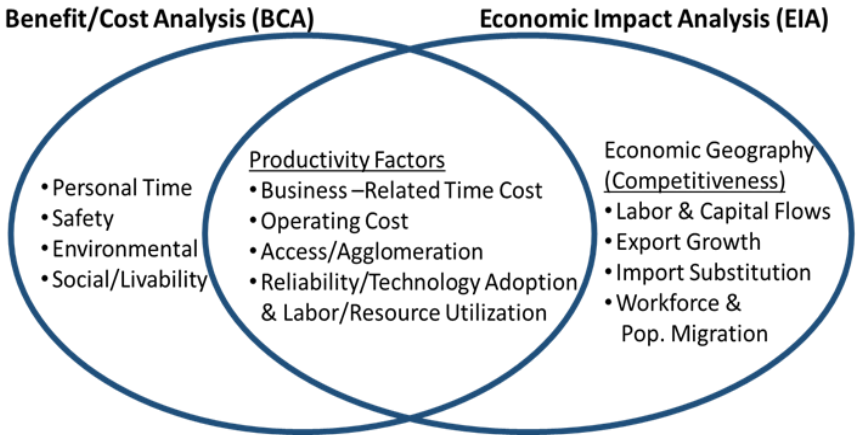
To understand the evolution of methods for evaluating wider economic impacts (and their use for prioritising and selecting projects), it is necessary to first establish the criteria used to define the concepts economic benefits and impacts. The definitions of these concepts, in turn, trace back to three separate lines of economic analysis that each reflect a different perspective and purpose in transport evaluation processes. The three lines of analysis are: BCA, EIA and FIA. Their inter-relationships, differences and uses have been discussed in a number of prior papers and reports (for instance, Thompson, 2008; Weisbrod et al, 2015). While they can complement each other and can be used together to inform decision-making, they also yield very different ways of viewing economic benefits and impacts.

The Venn diagram in Figure 1-A shows the overlap in coverage between BCA and EIA – as practiced in the US, Canada and sometimes also Australia. The core overlap area comprises business related money benefits, the left side comprises non-money benefits to society, and the right side comprises wider consequences for the development of a given region's economy. Elements considered in BCA are referred to as "benefits" and elements considered in EIA are referred to as "economic impacts." The latter are usually calculated using a regional economic simulation model.

The Venn diagram in Figure 1-B shows the overlap between welfare benefits and GDP impacts in UK Dept. for Transport documents. While it bears a superficial resemblance to the diagram above it, there are fundamental differences. Most critically, the second diagram focuses only on BCA measurement and it illustrates the distinction between elements of GDP that can be included as welfare gains in BCA and those that cannot be included as welfare gains. This second diagram takes a partial equilibrium perspective and hence does not attempt to represent the full range of GDP effects (associated with labour, capital and trade flows) that could be represented in a separate EIA study.

Figure 1. **Distinctions between BCA and EIA, welfare and GDP effects**

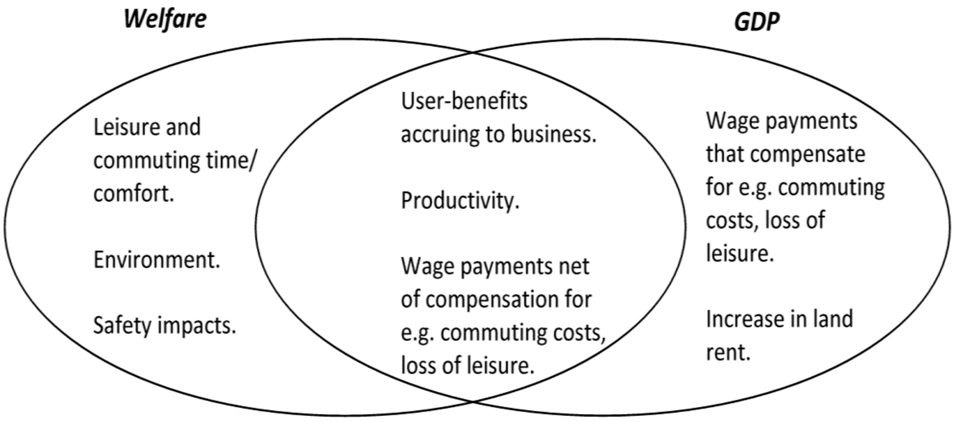
A. Coverage of BCA and EIA (US)




*Source:* Weisbrod, Mulley and Hensher, 2015.

Note: This also draws from earlier studies: see Wang, 2015; Weisbrod et al, 2015, 2006.

B. Coverage of welfare and GDP effects (UK)




*Source: Venables, Laird and Overman. 2014.*
*Note: This also draws from earlier studies: see Department for Transport (UK), 2005.*

As will be discussed, an underlying reason for the difference in these two approaches is that project prioritisation and selection decisions in the US are largely made at the state level. At that level of government, EIA is widely conducted and the full set of economic impact factors shown in Figure 1-A are widely considered as elements of a *strategic policy goal* for economic development. These impact elements are considered alongside user benefits in prioritisation and selection processes. This theme of differences in the context for measuring economic development impacts, and in how those measures are applied, is explored in more detail in the remainder of this paper.

*Note on terminology*: The title of this paper uses the phrase "wider economic impacts" to emphasise that it is examining the full set of economic development impact elements that are considered in EIA studies. In the US, these are referred to as "economic impacts" but there is a need to differentiate this broad category from use of the same phrase in the UK's transport guidance, where the term "economic impact" has now been assigned to the narrower category of what used to be called "wider economic benefits (WEB)." That latter concept (WEBs) is defined as the middle portion of Figure 1-B, excluding user benefits accruing to business.

**Criteria for evaluating proposed projects**

It is important at the outset to establish both the process and criteria used for *ex-ante* evaluation of proposed projects because they will dictate the kind of information that is needed. In the federal system of the US, central government does not have responsibility for prioritisation and selection decisions for surface transport projects. Rather, state departments of transport (DOTs) usually make those decisions with metropolitan planning organisations (MPOs) leading the process for urban areas. There is a formal process of steps that starts with a declaration of policy goals (guiding principles) and an evaluation of alternatives for long range vision plans that address the policy goals. There is then a screening and prioritisation of proposed projects that are consistent with the long range plan, which are then listed on a 5 or 6-year TIP (transportation improvement plan). Selected major projects go through an "alternatives analysis" that evaluates alternative project location and design options, and the selected plan is then moved forward for final funding and implementation decisions. (This process is described in ICF, 2009.) This progression of steps has a direct parallel in many other countries.

A recent study examined the formally stated goals of the long-range visions or plans of US State DOTs. It found that two-thirds of the states cited the same four key strategic goals for their residents: *safety, mobility/accessibility, environmental stewardship* and *economic development*. In other words, the ultimate outcomes desired by the long range transport vision plans were to improve the lives of people and their living/working environment. The efficiency of movement was far less frequently cited, meaning that it was most often seen as an intermediate consideration rather than as an ultimate outcome (Volpe, 2012).

The long range goals are important because they provide a basis for subsequent project planning, prioritisation, design and funding steps. At each step, there is a need for consideration of the costs as well as benefits or impacts of proposed alternatives, with benefit metrics defined in line with stated goals. While the decision processes at each of these steps is different, the methods used for evaluating alternative proposals (scenarios, schemes and projects) generally require three attributes:

- *Relevance:* To be relevant, an evaluation should consider project motivations and objectives, and assess the extent to which the project achieves those intended consequences as well possible unintended consequences. It should also consider the project “requirements” – money investment and non-money actions that need to occur in order for the project to go forward. Any misalignment of evaluation and objectives can represent a gap that undermines the usefulness of the evaluation for decision makers.
- *Practicality:* To be practical, an evaluation should be capable of discerning differences among competing projects in different settings. It should recognise cases where local project settings and contexts shift the upside and downside likelihood of impacts among alternatives. Anything less may fail to distinguish among competing projects that have similar passenger volumes and traveller savings but vastly different settings and contexts, and hence differences in the nature of their wider impacts. This distinction can be critical for prioritising and selecting projects within a given budget.
- *Accuracy:* To be accurate, an evaluation should discern needs and impacts relative to threshold factors concerning: (a) minimal acceptable conditions and (b) reasonable ranges for travel times and transport costs. Anything less may fail to distinguish projects that are addressing critical local needs and deficiencies, from other projects where needs are less severe. They may also fail to distinguish projects where impacts are too small or widely dispersed to have any real impact on behaviour or economic outcomes, from projects that have impacts sufficiently large and concentrated to have very observable and desired impacts.

Consideration of these three attributes, in combination with state-level decision-making, can help explain the relative use of benefit-cost analysis and multi-criteria analysis techniques in the US. They also help explain the interest in *ex-post* analysis and evidence-based planning. This paper examines these connections. It reviews the evolution of project evaluation methods in the US by considering how they have been evolving to better address the three criteria. We first look at the issue of *relevance*, in order to better understand how benefit evaluation methods are evolving to better account for project motivations. The *practicality* and *accuracy* issues are picked up later in this paper, insofar as *ex-post* case studies are helping to illuminate the needs and opportunities to improve on these matters.

## Historical background – role of wider benefits in investment objectives

The first matter is to establish the range of project motivations that may be *relevant* considerations in the definition of project benefits. It can useful to recognise to start with a wide view of how project motivations have been viewed, and how project goal achievement has been assessed over time.

Concern over project benefits and costs is not new. Processes of planning, funding and implementing transport projects, programs and policies have been going on for several thousand years – back to ancient times. This includes caravan services in ancient Mesopotamia, tourism cruises on the Nile in Egypt, passenger horse cart services in villages of ancient Greece, and land/sea intermodal trade centres across the Roman Empire (Casson, 1994, Bernstein, 2008). More recently (in the last four centuries), there have been major investments in canals and waterways, urban transport, intercity rail and highways, as well as air and marine ports. In each case, investment and implementation decisions had to be made with at least implicit or tacit consideration of the technological and financial viability of the project, as well as the existence of adequate benefit or payback for (public and private) investors.

In the examples cited above, the intended motivations of parties who built the transport facilities and initiated the transport services span a wide range. They include: enabling or strengthening national defence, new forms of trade among markets, access to jobs, access to recreation opportunities, adoption of new products and distribution technologies, shifts in urban land development patterns, time and cost savings, reliability, quality of life (liveability) and inward flows of investment and wealth, as well as reducing noise and air pollution, and improving health and safety. These goals encompass both direct benefits to users and wider effects on environments and economic development. In other words, interest in non-user benefits – now referred to as "wider" benefits – is longstanding and not just an attempt by countries with mature transport systems to justify projects that fail user benefit cost tests.

Formal consideration of *economic development* benefits in the US can be traced back to massive public sector investments in water (canal, dam and irrigation) projects in the 1800s. The Erie Canal (completed 1825) is considered a quintessential example of a transport infrastructure investment that was designed as a strategic investment intended to generate wider economic benefits. It had the direct effect of enabling larger canal barges to replace smaller horse-drawn carts as a means of transporting grain from the nation's interior to coastal population centres. As a result, the cost of wheat in New York City dropped twentyfold. The direct effect on cost savings was due to reduced travel time and transport cost per vehicle, and increased scale economies from larger vehicles (North, 1961).

However, the direct cost savings for pre-existing urban markets was dwarfed by a far larger secondary effect, which was to open up the broad Ohio River Valley to population and business growth that was previously not economically feasible or sustainable. The result was a large shift in investment and economic growth into the region, also enabling further increases in exports and national economic growth. It fostered development of new agricultural production technologies that could serve the broader markets. Thus, the Erie Canal had important direct effects on travel efficiency, but also wider secondary effects on productivity, technology adoption and spatial and economic sector growth patterns. These broader consequences are similar to economic development and growth effects that occurred in ancient times as new trade routes developed, and in later times as rail, highway and air routes developed.

A recent study looked at the motivations for US highway capacity projects in the last three decades, and found that these same motivations are still claimed today (EDR Group et al, 2012). Of particular note is the inclusion of factors representing connectivity and accessibility to markets as a factor enabling future economic development opportunities, as opposed to cost savings that affect existing travellers. These findings are presented in a more complete manner in a discussion of *ex-post* case studies later in this paper.

**Evolution of project evaluation (appraisal) methods**

There has been a significant evolution over time in the way that economic development impacts have been considered in the *ex-ante* evaluation of infrastructure projects in the US. Following the Erie Canal, claims of wider secondary benefits on regional economic development were used to justify a continuing set of publicly funded waterway and dam projects in the US over the next century. However, when the Great Depression hit in the 1930s, there was a clamouring for more accountability in public spending. The application of benefit-cost concepts was first required in the US in 1936, in a law that specified that federally funded water infrastructure projects should be undertaken if “the benefits to whomever they may accrue are in excess of the estimated costs” (US Flood Control Act of 1936, Section I). Initially, both direct savings to users and wider, secondary benefits that were induced by the project were counted (Hufschmidt, 2000).

By the 1960s, the field of welfare economics had become more developed. Consequently, narrower standards that focused on welfare economic principles were adopted and extended to transport investment. This perspective is reflected in the original US Red Book on road user benefits (AASHO, 1960, later updated several times with the latest being AASHTO, 2010). It is also reflected in UK applications dating back to the 1960s.

While those early guides ignored the wider, secondary effects, there have since been continuing efforts to make BCA more comprehensive by incorporating more explicit consideration of secondary environmental, economic and social benefits. By the 1990s, emission rates and unit valuation factors had been sufficiently established to enable environmental benefits to be included in transport BCA.

Efforts to also add wider economic development impacts emerged in the 1990s, driven by concerns among rural states that the traditional BCA methods favoured investment in speeding up high volume urban roads but did not provide a way to value rural market connectivity investments. The Wisconsin DOT case (Weisbrod and Beckwith, 1992) received significant attention as a first effort to take on this issue. The DOT wanted to justify a 293 km highway linking Green Bay to Minneapolis. The project was seen as capable of spurring regional economic growth in a northern region, particularly in economic sectors related to food product packaging and tourism, but it failed traditional BCA tests. The resulting study developed a benefit-cost ratio that substituted an estimate of GDP income growth (which accounted for enhanced market access) in place of the traditional business time and cost savings, enabling the project to pass the test and move forward. Indiana, Montana and other state DOTs followed by adopting revised BCA methods that used the same basic concept, but incorporated more sophisticated modelling of regional GDP impacts (Kaliski et al, 1999; Wornum, 2005). This same approach had also been applied in Scotland, in a study for the M74 motorway extension (Oscar Faber/TPA, 1993). Later, more refined approaches for incorporating GDP effects into BCA were developed in the UK (Dept. for Transport, 2005).

Subsequently, concerted efforts were made to extend BCA methods to include wider productivity effects. In the UK, these efforts focused largely incorporating urban agglomeration and labour force effects. In the US, there was more focus on freight logistics and supply chain connectivity effects that affected technology adoption as well as scale economies. (Shirley and Winston, 2004; ICF and HLB, 2004).

An even more important change occurring over the 2005–15 period has been a move by many State DOTs to adopt formal scoring systems based on "multi-criteria analysis" (MCA). That approach has been implemented in ways that make it possible to combine traditional user benefit measures with macroeconomic impacts and a wider set a strategic and social goal achievement measures. Typical MCA factors considered in State DOT prioritisation process are shown (for five example states) in Table 1. These factors generally fall into four categories: (1) travel-related benefits – which are typically estimated by transport models, (2) strategic goal related measures, (3) public policy (social goal) related measures, and (4) regional economic impacts – which are typically estimated with economic models. In most states, findings on user benefits and wider benefits became considered in a broader MCA scoring framework for prioritisation decisions.

Looking more closely at the set of strategic factors, it can be seen that many of them directly relate to supply chain or market accessibility, or connectivity to broader opportunities including major economic corridors, supply chains, international gateways and/or intermodal terminals. Reducing "bottlenecks" and increasing "reliability" are often also distinguished because they can affect supply chain productivity and technology adoption (related to loading and stocking inventory) – which are effects beyond what is counted in generalised congestion and reliability effects on travel time savings. Some states count these factors apart from user benefit and regional economic impact factors, though other states measure and apply them as inputs to a regional economic impact model.

The MCA calculations are carried out by staff of the State DOTs, who typically apply both travel demand and regional economic models to generate many of the factor metrics that then go into the scoring calculation. The weights assigned to individual factors vary from state to state, but in general they tend to be derived from a formal public input process, survey process or expert panel, and are then approved by the state legislature. The number of projects now being rated in these ways ranges from hundreds at a time (in the case of Kansas and Ohio) to several thousand at a time (in the case of North Carolina).

Since the state DOTs have fixed annual budgets for transport investment, they apply these scoring systems to both rank projects and select projects to be implemented. (However, subsequent steps of alternatives analysis and funding processes still depend to various degrees on consideration of BCA, financial analysis and funding program eligibility.) It is notable that the UK appraisal guidance also incorporates an "Appraisal Summary Table" (AST) that covers a similarly wide range of strategic policy factors that fall outside of BCA, and it provides a means for them to be considered in decision making as part of a larger "Business Case." (See last column of Table 1.) However, the AST does not incorporate that same kind of prescriptive measurement definitions and assigned weights that exist in the MCA scoring systems adopted by many US states.

At this juncture, the point to be drawn is that many of the US states have adopted MCA rating systems as a way to combine strategic economic development and social policy considerations alongside travel efficiency (user benefit) considerations in their transport infrastructure decision-making. While there are advantages and disadvantages of relying on MCA rating systems in this way, and there clearly are alternative ways of informing decision-making that are used in other countries, this paper does not pursue that topic. (Readers are referred to Worsely and Mackie, 2015, for a discussion of issues regarding the balancing of BCA with strategic and financial considerations in the UK context). Instead of pursuing that topic, this paper instead focuses on the observation that reliance on multi-criteria ratings and consideration of economic development impacts expands the number of transport project factors that need to be measured. That, in turn, increases the need for observational data and research regarding: (a) the measurement of accessibility, connectivity and related productivity factors, and (b) our understanding of how they lead to wider impacts on job and income creation. That has been a major impetus for *ex-post* case studies and decision processes that incorporate local factors, which are discussed later in this paper.

Table 1. **Multi-criteria rating factors used for prioritisation**
(UK Appraisal Table is also included for comparison)

| Rating Factor | CO | OH | NC | MO | WI | KS | UK |
|---|---|---|---|---|---|---|---|
| ***Traveller Benefit & Environment (quantitative)*** | | | | | | | |
| Efficiency: Travel time, cost, level of service | X | X | X | X | X | X | X |
| Safety (accident rate) | X | X | X | - | X | X | X |
| Pollution: emissions/greenhouse gases | X | X | - | X | X | - | X |
| ***Strategic (System Productivity) Benefit*** | | | | | | | |
| Intermodal facilities, access & interchange | (c) | X | *(a)* | X | *(a)* | *(a)* | X |
| Reduce localized congestion bottlenecks | X | X | X | X | X | X | *(b)* |
| Connectivity to key corridors, global gateways | - | - | *(a)* | X | X | *(a)* | - |
| Reliability of travel times | X | X | *(a)* | - | *(a)* | *(a)* | X |
| Truck freight route, supply chain impact | - | - | X | X | *(a)* | X | - |
| ***Social Goal Achievement (qualitative)*** | | | | | | | |
| Location: area revitalization / regeneration | - | X | - | X | - | - | X |
| Land use: supports cluster or in-fill development | X | X | - | X | - | - | X |
| Econ Policy: support target industry growth | X | - | - | X | - | - | - |
| Leveraging private investment | - | X | - | - | - | - | - |
| Local public Support | X | X | X | - | X | X | - |
| ***Macroeconomic Outcomes (modelled)*** | | | | | | | |
| Econ Productivity Calculation | X | *(a)* | *(a)* | - | *(a)* | *(a)* | X |
| Job Growth, reduced unemployment | X | X | X | - | X | - | - |
| Gross Regional Product | X | X | X | - | - | X | *(a)* |

*Notes:* X = explicitly included as an element of the rating system
(a) = implicitly allowed via calculation of additional productivity benefit in BCA or macroeconomic impact
(b) = included in travel efficiency benefit shown above
" - " = not part of formal rating system, but may still be considered through other elements of the decision process
CO=Colorado, OH=Ohio, NC=North Carolina, MO=Missouri, WI = Wisconsin, KS=Kansas, UK = WebTag Appraisal Table

*Source:* Weisbrod and Simmonds, 2011 with further update by the author.

**Why the move toward MCA in the US**

There appear to be several plausible explanations for the broad adoption of MCA-based ratings by the State DOTs in the US. The decision process of State DOTs focuses on selecting projects based on the use of prioritisation processes, which are applied to fixed capital investment budgets. The use of scoring systems for prioritisation enables the State DOTs to consider efficiency alongside many of the very same non-efficiency factors that they are required to consider in their environmental impact reports. This includes not only economic development and environmental impacts, but also equity and cumulative impacts on achievement of public policy goals (ICF, 2009).

Another likely reason for the movement to MCA-based ratings is that they provide a way for states to give priority to projects that are of strategic, long-term importance for providing sustainability and future economic development for states. Specifically, many of the states have long-range plans that recognise “strategic economic corridors,” emerging “technology clusters,” “labour market access” and “export gateways” and environmental sensitivity as issues deserving of special attention. The MCA ratings provide a means of giving weight to investments that support those goals and promote inward investment. Many states also make use of regional economic models to aid in evaluating the economic impacts of projects, and use the results to drive elements of their multi-criteria ratings.

In contrast, there tends to be greater reliance on formula-driven BCA appraisal processes in the UK and Scandinavian nations – where there are more centralised transport budgeting and selection processes. It can be postulated that this is a natural consequence of differences in the level of government that is responsible for decisions. After all, central governments typically face limitations on the ability to modify their decision processes to recognise regional differences in the values and priorities of residents. This makes it more logical for them to rely on BCA formulas that feature fixed elasticity and mark-up factors, and allow for local factors to be considered separately.

Further support for this interpretation about central governments comes from the experience of the US Dept. of Transportation (USDOT) and its “TIGER” program. Historically, the US DOT did not make project selection decisions. However, when Congress responded to the Great Recession by setting up a grant program to increase spending in the economy, US DOT established a process for judging applications. The resulting process relied on traditional BCA as the major screening criterion, with a separate and more qualitative process for considering local factors in a way that generally paralleled the UK process (US DOT, 2014).

## Development of evidence-based planning and analysis methods in the US

### Evolution of *ex-post* case studies of economic impacts

“Evidence-based” planning and prioritisation processes rely on evidence from previously observed cases, together with consideration of specific aspects of the proposed project, its setting, and local values. The prioritisation ratings of the State DOTs generally encompass these very types of considerations, and thus depend on having a base of supporting evidence concerning their importance and impact – which comes from *ex-post* analysis studies.

*Ex-post* analysis studies have been developed in the US for two main reasons: (1) to document how government programs have led to goal achievement, thus demonstrating the value of program funding for politicians, and (2) to draw lessons from past cases that enable local and state transport planning staff to make better planning and benefit estimation for future projects, and then communicate them more effectively to broader public audiences. Those two motivations created a focus on economic development outcomes rather than transport outcomes.

In 1991, the US General Accounting Office issued guidance on *ex-post* program evaluation of federally funded programs. It called for establishing economic impact metrics tied to program goals, use of *ex-post* comparison with matched pairs or statistical controls to account for exogenous changes over time, and suitable effort to attribute credit for observed changes (US GAO, 1991). This guidance was then used when the Appalachian Regional Commission (ARC) – a collaboration of 13 States and the federal government – funded case studies of the economic impacts of 300 local public works (roadway and water/sewer) projects. These projects were completed between 2000 and 2010 to support economic growth in economically depressed communities. The studies measured impacts on job and income growth. Over the 1990s, *ex-post* studies of local economic impact were also conducted by seven different State DOTs covering over 50 community bypass roads (Fitzroy and Weisbrod, 2014).

In 2001, US DOT issued a guidebook that set forth standards for documenting the actual *ex-post* economic effects of highway investments (EDR Group and Cambridge Systematics, 2001). It offered prototype designs for studies of the economic development impacts of highways at regional, corridor and local levels. In the next four years, US DOT sponsored a series of *ex-post* case studies of the economic impacts of major new rural highway projects around the country (e.g., FHWA, 2005).

In 2008, effort was started by the Strategic Highway Research Program, operating under the auspices of the Transportation Research Board, to assemble a national database of *ex-post* case studies concerning the economic development impacts of transport projects. With USD 2.5 million of funding, the TPICS (Transportation Project Impact Case Studies) database was developed covering highway and intermodal terminal case studies (www.tpics.us). Expansion of the system to cover public transport projects is also underway.

Cases in this database are required to include (a) project context and objectives, (b) both pre- and post-project economic measures, (c) inclusion of a counter-factual reference (such as surrounding area or state-wide average changes during the same time period), and (d) attribution of relative credit for observed changes that can be assigned to the transport project. Training materials were also developed for conducting new case studies and an analysis study was conducted to evaluate results of the first 100 case studies. The database has since continued to grow and it has been turned over AASHTO, the association of State DOTs, for further development. It is now being rebranded as the *EconWorks* Case Study database (https://planningtools.transportation.org/13/econworks.html).

Under the AASHTO umbrella, State DOTs are now making use of the *ex-post* database to assess (1) its usefulness for extracting planning process lessons and insights, (2) its transferability for identifying the range of likely impacts of proposed new projects in very early stage evaluation of proposed new projects, and (3) its applicability to further improve economic impact forecasting models and methods.

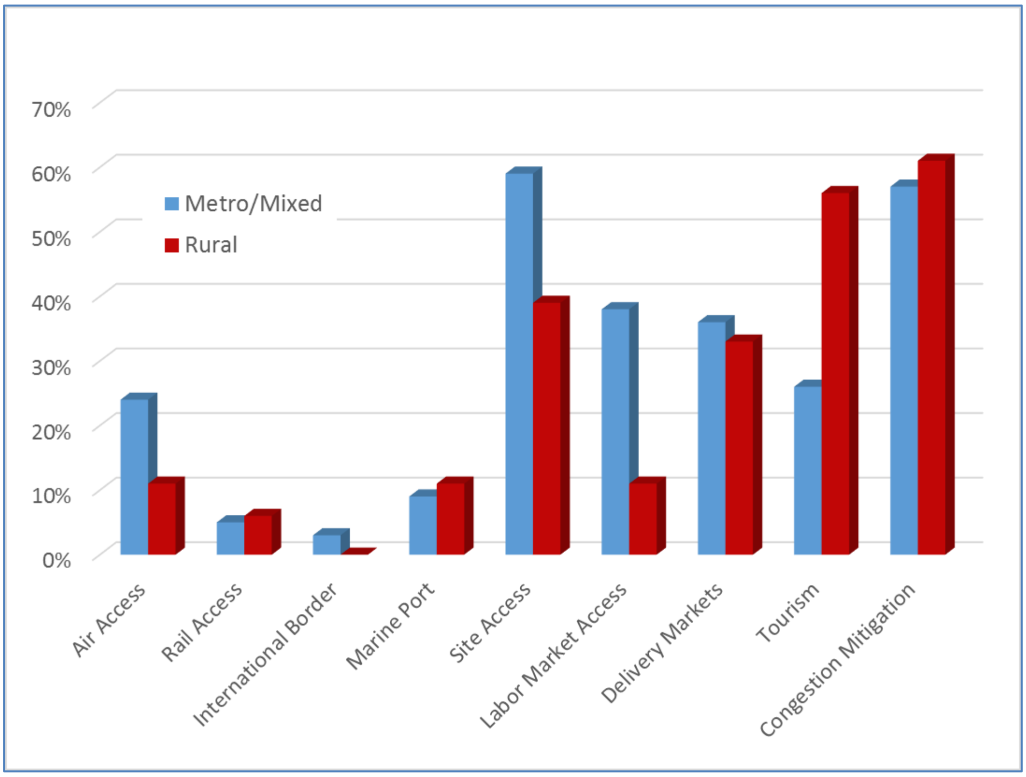
### Findings from *ex-post* case studies

The second of our three evaluation attributes is *practicality.* For evaluation or appraisal processes to be of practical use in project prioritisation and selection, they must be capable of discerning differences in potential impacts and benefits of competing alternatives that are due to variations in type of projects, type of settings and resulting classes of benefit. Such differences can indeed be observed from *ex-post* case studies. In general, the following types of findings have emerged concerning the incidence and rate of project impacts on inward investment, employment and income growth. The findings summarised below were all drawn from empirical analysis of the TPICS database (EDR Group, 2012), with some additional examples and illustrations drawn from other studies cited below.

- *Type of project* matters. Some projects are built to enable and generate wider economic development impacts, while others are constructed to address safety deficiencies, environmental concerns, functionally obsolete designs, or facility maintenance and rehabilitation. In general, only projects that are intended to enhance improve user costs, market access or locational connectivity can be expected to enable wider economic growth (in terms of jobs and income). There is no point in wasting resources to look for *ex-post* evidence of wider economic development impacts from the other types of transport projects, nor should they be expected in *ex-ante* benefit forecasts for those projects.

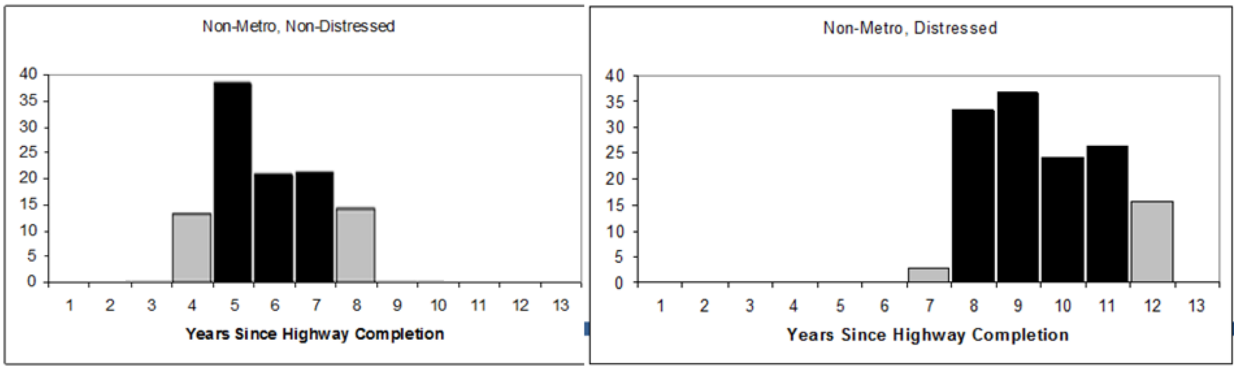
- *Benefits* are not necessarily just for existing travellers. Over half of all highway system capacity projects have a goal of enhancing future accessibility to labour and/or buyer/supplier markets, or connectivity to intermodal terminals. These projects are effectively supporting the growth of future economic activities (job and income growth opportunities) rather than just generating savings for current travel activities. For that reason, *ex-ante* appraisal of project benefits must recognise the role of expanding market access (as well improving intermodal connectivity and reliability) as factors enabling productivity and inward investment gains (Figure 2).
- *Time periods* of impact can vary substantially. Wider economic development impacts can take a decade or longer to occur. The pace of impact occurrence also depends on the local setting; it often takes longer in economically distressed areas (Figure 3). Yet it is in those areas that the impacts may be most desired and needed. *Ex-ante* prediction of agglomeration benefits and wider GDP impacts should recognise this delay aspect of impacts.

Figure 2. **Motivations for highway investments**




*Source:* Economic Development Research Group, 2012.

Figure 3. **Time lag in economic growth effects following highway investments**




*Note:* Study covered highway investments in the 13-state Appalachian region. The vertical scale represents standardised regression coefficient values. Black bars are statistically significant at 95% confidence; grey bars are significant at 90% confidence levels.

*Source:* Weisbrod and Comings, 2008, presented in pp. B-17 and B-18 of Cambridge Systematics et al, 2008.

- *Settings and local conditions* also affect observed economic development impacts. While only projects expected to have economic development impacts were studied, about 15% had no net impact or a small negative impact on the area economy. Lack of benefit was often related to a deficient business climate, as represented by a lack of supportive local regulation (zoning), utility infrastructure and financial support policies. This occurred more often in rural areas. Ideally, *ex-ante* forecasts of expected economic development impacts should also be capable of adjustment to allow for local support factors.

- *Concentration of beneficiaries* matters. It is particularly difficult to observe wider economic development impacts for projects that reduce bottlenecks (choke points). While their time and cost savings may be particularly distinct, their market access benefits will tend to be dispersed and diluted. For that reason, care should be taken in ascribing economic benefits associated with enhanced market access unless there is an identifiable business location area for which access is clearly expanded up by such improvements.

- *Incidence of local business cluster* effects can be observed and the conditions that enable them can be observed. Case studies have documented impacts of new highway and transit projects on several distinct types of clusters: (1) supply chain clusters that extend along highway corridors, (2) centralised logistics clusters that locate where major long distance routes intersect, (3) software and emerging technology clusters that locate at transit-served areas of major cities that have R&D universities, (4) industrial clusters that locate near major intermodal freight (air, rail) terminals, and (5) banking, finance and corporate headquarter clusters that locate in large markets with good international air services and usually good transit service. They share a common feature which is a dependence on both market scale and system connectivity factors. Examples are shown in Box 1 below. It is notable that these examples highlight the same specialised access, connectivity and reliability elements that were listed in Table 1 within the group of strategic, productivity-related rating factors.

Box 1. **Examples of clusters profiled in *ex-post* case studies**

An *automobile supply chain cluster* that developed along a 150 mile (200 km) stretch of I-65 and I-75 in rural Kentucky and Tennessee. The cluster's spatial boundaries and corridor location pattern reflect the limits of same day truck deliveries, "just in time" supply chain technology, and "lean production" processes. The rural location optimises access to multiple urban markets and minimises locally congested traffic sites. The spatially dispersed and largely rural siting of industries within the cluster reflects reliance on low labour cost areas (Rosenfeld, 2000; Vadali and Chandra, 2014).

A *centralised distribution warehousing cluster* located at two highway intersections along I-81 in the Scranton and Harrisburg areas of Pennsylvania. This highway developed as a north-south truck route that avoids the far more congested I-95 corridor. The two intersection sites provide east-west access for more reliable same day delivery from very large, centralised warehouses to simultaneously serve four large metro areas: Baltimore, Philadelphia, New York and Washington DC. Centralised warehousing is a relatively new process that uses information technology and scale economies to enable high turnover stocking strategies to maximise productivity (FHWA, 2012; TPICS, 2013).

*Computer software clusters* located along rail transit routes in former warehouse districts in San Francisco and Boston. Both clusters are in cities that have very large, diverse and highly educated labour markets. They are located near transit stations, feature access to urban amenities, have direct transit access to major universities with R&D technology programs, and also have transit access to an international airport. (EDR Group, 2013B)

An *intermodal "logistics park" cluster* in Will County, Illinois. This industrial park at the south of the Chicago metropolitan area provides Midwest manufacturers with highway access (via I-80 and I-55, and Chicago's outer beltway I-355). It is adjacent to an intermodal rail terminal where products can be transferred from trucks to freight trains going directly to the west coast ports of Los Angeles, Long Beach, and Seattle-Tacoma, serving Asian trade routes. It is used for import of electronic and retail goods into the region from Asia, and export of regional agricultural products to Asia. (TPICS, 2013).

These *ex-post* case studies of transport-driven business clusters do have some common features: the clusters are spatially distinct, they are all highly specialised in terms of the type of business located at them, and they all feature strong connectivity to wider markets (labour markets freight delivery markets, or intermodal transport facilities depending on the type of cluster). In each case, it may also be observed that the cluster developed for a specific sector of the economy because transport improvements enabled the use of newly emerging technologies, such as just-in-time delivery, centralised warehousing and collaborative processes for software development. In other words, they built on improvements in market scale and location connectivity, but these types of clusters were also highly specialised, industry specific, and not widely seen elsewhere. The implication is that localisation benefits can be observed and measured, but they should not be assumed to necessarily be widely applicable for other industries or areas. The body of *ex-post* case studies provides a basis for economic development impact models that estimate major changes in income growth only when certain combinations of factors come together.

There are no examples of retail or commercial clusters listed here. Since these projects represent shifts in where local residents spend their money rather than sources of new income coming into the state, the regional economic impact models generally show that they do not generate any net income growth at a state level. They do not affect any of the strategic factors nor the economic impact factors used in the MCA rating systems of State DOTs (Table 1), so they get priority ratings only if they support public policy goals of revitalising economically depressed areas or generating in-fill development.

A conclusion to be drawn from the *ex-post* case study literature is that market access impacts are about much more than just scale economies. More fundamentally, they are about enabling new forms of economic activity to occur, new technologies to be implemented, and strategic policy goals to be achieved.

**Emergence of evidence on threshold factors**

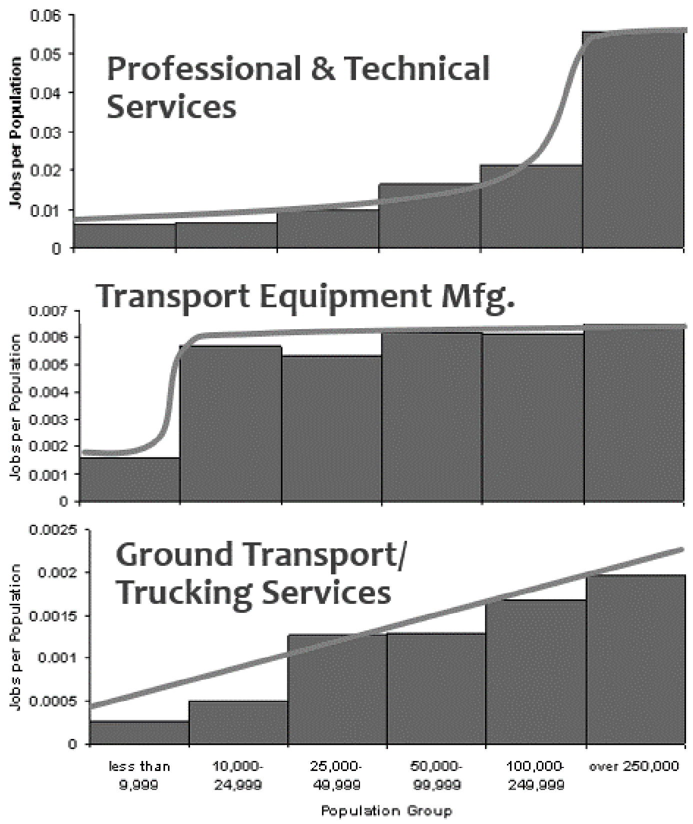
The third of our three evaluation attributes is *accuracy*. To maximise accuracy, an *ex-ante* evaluation should be capable of distinguishing projects that will lead to observable impacts and address critical local needs and deficiencies, from other projects that will have less dramatic and more diluted benefits. In that respect, *evidence-based analysis* can have significant advantages over theoretically driven *ex-ante* models when it comes to planning and decision processes that require estimates of anticipated project benefits and impacts. The reason is that the evidenced-based case study analysis can reflect both interaction effects and catalytic effects which are tied to benefit thresholds. This is in contrast to theoretical models that most often apply constant elasticity, coefficient and mark-up factors, and assume constant trade-offs among independent cost and benefit elements.

In fact, the use of MCA ratings increases the need for efforts to distinguish the components of productivity, which can include effects of improving reliability along with access to wider labour markets, to wider customer markets, and to intermodal terminals that are windows to even larger markets. This has helped fuel the need for studies that examine these individual elements of productivity. Many of them were examined in a recent literature review conducted for the NCHRP study of productivity impacts (EDR Group et al, 2013a).

Five types of threshold effects have been identified and measured as a result of *ex-post* evaluations and other statistical studies. They are: (a) labour market scale effects, (b) commuting time thresholds, (c) labour force participation rate thresholds, (d) regional truck delivery thresholds and (e) intermodal access time thresholds. Findings on these five types of thresholds are summarised below.

- *Labour market size thresholds.* One of the findings from a series of studies sponsored by the Appalachian Regional Commission is that the concentration of specific industries in a labour market area will differ depending on the size of that overall labour market (EDR Group et al, 2007). This labour market size effect is independent of transport conditions within the area. As shown in the chart below, some industries (such as transport equipment manufacturing) that have relatively modest worker training and education needs can exist in all but the smallest labour market (i.e., those with at least 10 000 workers), and show no further gain from larger labour markets. At the other extreme, professional and technical services, which require more specialised skills, tend to gain productivity and concentration in very large labour markets (i.e., over 250 000 workers) where there is a sufficient size of customer base and a higher likelihood of finding workers with the required matching skills. Others such as transport services continue to increase in concentration as labour market size grows, which suggests continuing scale economies of operation but no specialised worker skill or customer requirements that would require a minimum size labour market (Figure 4).

Figure 4. **Relative concentration of industries by size of labour market**




*Source:* EDR Group et al, 2007.

- *Regional truck delivery market size thresholds.* Truck deliveries are naturally subject to threshold effects related to both regulations on daily driving hours and business hours of operation. The area that can be served with same day product and service deliveries is roughly three hours from the place of origin. This is based on a window of eight hours of operation, with an allowance of three hours for each of the outbound and inbound trips, plus one hour at each end for pickup and delivery. Statistical studies have confirmed that manufacturing industries tend to locate where they can maximise the size of same-day truck delivery markets rather than locating where labour market access is maximised. This reflects an optimisation of product buyer-supplier supply chains. The result is that both worker compensation and business concentration levels for manufacturing firms tend to rise with greater three-hour truck delivery markets – a clear indication of a threshold and a productivity effect.

  This finding is demonstrated by statistical analysis of the relationship between concentration of industries in a county and various measures of market access and intermodal connectivity from the population centre of that county (Table 2). Higher numbers and darker shading denote a stronger relationship; the three-hour delivery market is shown to be important primarily for manufacturing industries (Alstadt et al, 2012).

Figure 5 illustrates the wage effect by showing the area of where automobile parts suppliers are clustered, and it can be seen that manufacturing wages are high not just where the population centres are located, but also along major highway corridors between those centres.

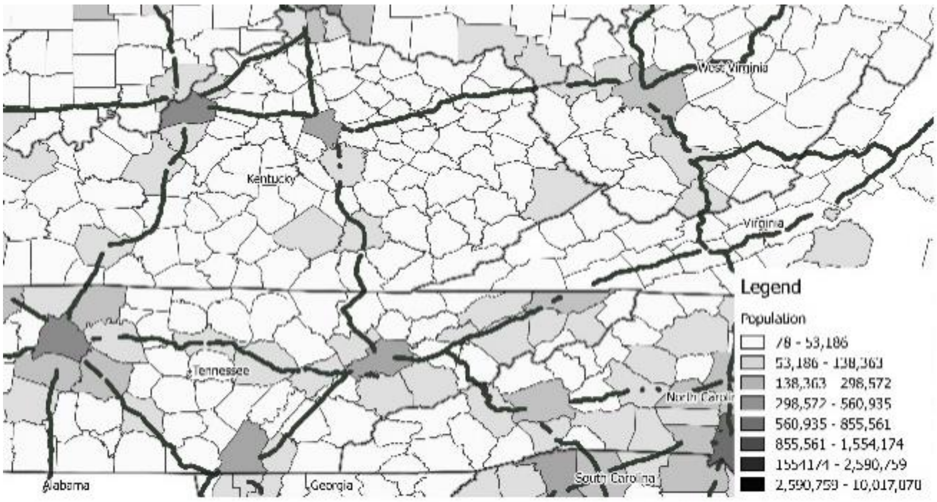
Table 2. **Sensitivity of industries to access measures**

| NAICS | Sector Description | Sensitivity to Access Measure (1-10 scale) | | | |
|---|---|---|---|---|---|
| | | 40-min Market | 3-hr Delivery Market | Commercial Airport | Rail Intermodal |
| 111 | Crop Production | 3 | 5 | 0 | 3 |
| 112 | Animal Production | 0 | 5 | 0 | 3 |
| 113 | Forestry & Logging | 5 | 0 | 2 | 0 |
| 114 | Fishing, Hunting & Trapping | 0 | 3 | 0 | 3 |
| 115 | Support for Agriculture & Forestry | 3 | 0 | 0 | 0 |
| 211 | Oil & Gas Extraction | 0 | 0 | 0 | 0 |
| 212-213 | Mining & Support Activities | 3 | 0 | 4 | 5 |
| 221 | Utilities | 5 | 0 | 3 | 5 |
| 230 | Construction | 8 | 5 | 7 | 8 |
| 311 | Food Products | 3 | 0 | 0 | 0 |
| 312 | Beverage & Tobacco Products | 10 | 0 | 0 | 3 |
| 313 | Textile Mills | 5 | 5 | 2 | 3 |
| 314 | Textile Product Mills | 5 | 10 | 0 | 0 |
| 315 | Apparel Manufacturing | 5 | 5 | 0 | 0 |
| 316 | Leather & Allied Products | 5 | 3 | 2 | 5 |
| 321 | Wood Products | 0 | 5 | 0 | 5 |
| 322 | Paper Manufacturing | 0 | 5 | 0 | 5 |
| 323 | Printing & Related Activities | 10 | 10 | 7 | 0 |
| 324 | Petroleum & Coal Products | 6 | 0 | 0 | 0 |
| 325 | Chemical Manufacturing | 5 | 3 | 4 | 3 |
| 326 | Plastics & Rubber Products | 8 | 10 | 0 | 3 |
| 327 | Nonmetallic Mineral Products | 5 | 5 | 2 | 0 |
| 331 | Primary Metal Manufacturing | 3 | 5 | 4 | 0 |
| 332 | Fabricated Metal Products | 10 | 5 | 2 | 0 |
| 333 | Machinery Manufacturing | 0 | 5 | 2 | 0 |
| 334 | Computer & Electronic Products | 3 | 5 | 2 | 3 |
| 335 | Elec Equipment, Appliances | 0 | 10 | 3 | 0 |
| 336 | Transportation Equipment | 5 | 5 | 3 | 3 |
| 337 | Furniture & Related Products | 5 | 10 | 3 | 0 |
| 339 | Miscellaneous Manufacturing | 5 | 5 | 3 | 0 |
| 420 | Wholesale Trade | 10 | 0 | 3 | 0 |
| 441-454 | Retail Trade | 8 | 3 | 3 | 5 |
| 481-487 | Transportation | 5 | 0 | 3 | 0 |
| 491-493 | Mail, package delivery & warehousing | 10 | 0 | 2 | 3 |
| 511 | Publishing Industries (except Internet) | 10 | 0 | 10 | 0 |
| 512 | Motion Picture & Sound Recording | 10 | 3 | 9 | 0 |
| 513 | Broadcasting | 10 | 0 | 5 | 0 |
| 514 | Internet & data process svcs | 8 | 3 | 5 | 0 |
| 521-523 | Monetary, Financial, & Credit Activity | 10 | 0 | 3 | 0 |
| 524 | Insurance Carriers | 10 | 3 | 5 | 0 |
| 525 | Funds, Trusts, Financial Vehicles | 5 | 5 | 5 | 0 |
| 531 | Real Estate | 10 | 0 | 7 | 0 |
| 532 | Rental & Leasing Services | 10 | 0 | 5 | 0 |
| 541-551 | Prof. Scientific, Technical, Services | 10 | 3 | 10 | 0 |
| 561 | Admin & Support Services | 5 | 0 | 10 | 0 |
| 562 | Waste Mgmt & Remediation | 3 | 5 | 3 | 0 |
| 611 | Educational Services | 10 | 5 | 3 | 0 |
| 621-624 | Health Care & Social Services | 8 | 0 | 0 | 0 |
| 711-713 | Recreation & Amusements | 5 | 0 | 10 | 0 |
| 721-722 | Accommodations, Eating & Drinking | 5 | 0 | 7 | 0 |
| 811-812 | Repair, Maint. & Personal Services | 5 | 0 | 7 | 0 |

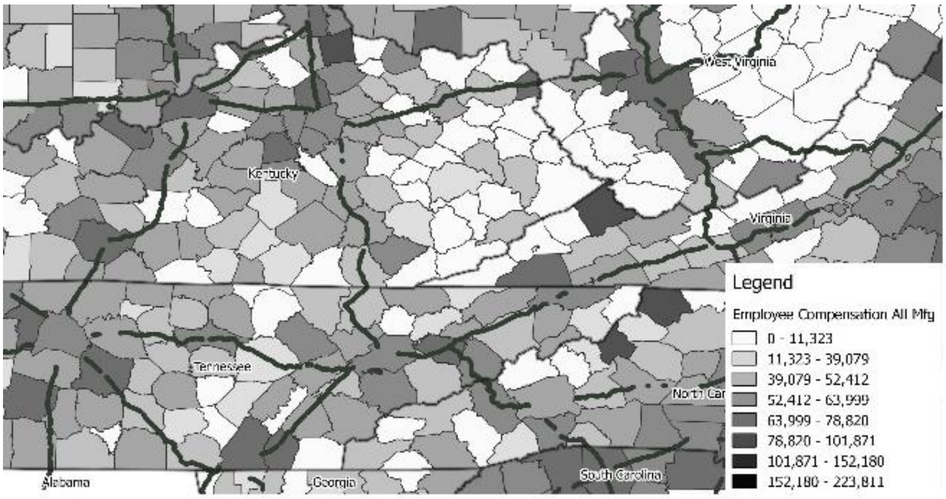
*Source:* Alstadt et al, 2012.

Figure 5. **Population concentration and manufacturing wage rates among counties in central Appalachia**

a. Population



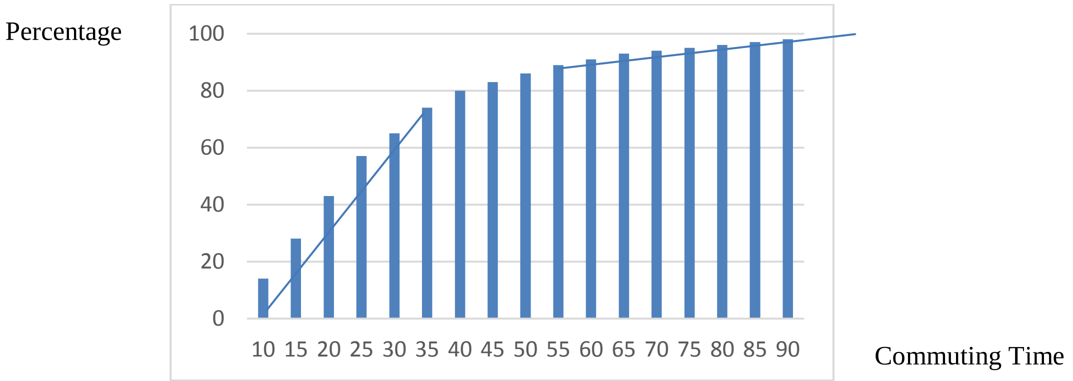

b. Average Annual Manufacturing Wage




*Source:* analysis by the author, based US Census and Bureau of Labour Statistics, 2010-2013.

- *Commuting time thresholds.* While travel time from home to work can vary widely within a labour market, there are travel time thresholds that reflect worker preferences to avoid very long commutes. Most planning studies assume that this threshold value is a somewhere between 30 and 45 minutes. This interpretation is supported by the American Community Survey, which indicates that 2/3 of all commutes in the US are less than 30 minutes, 80% are less than 40 minutes and 90% are less than 55 minutes (Figure 6). However, in small to medium size communities in the US, the entire metropolitan labour market area will tend to have driving times within 40 minutes, so the economic impact of reducing commuting times becomes of significant importance only for the larger metropolitan areas.

Figure 6. **Distribution of commuting time (cumulative per cent)**




*Source:* American Community Survey, 2009.

- *Labour force participation rate thresholds.* It has been theorised that transport improvements can enhance labour market participation by enticing more workers into the labour market. However, there is little observational evidence in the US of these effects actually occurring in *ex-post* studies. The only exception is in rural areas where there is high unemployment, and in those areas there is some evidence that labour force participation goes up when additional employment growth occurs (Bradley, 2000; EDR Group, 2007).
- *Intermodal terminal access thresholds.* For industries that depend on worker or customer travel to/from broader external markets, there is a premium value in having access to major airports. For other industries that depend on freight deliveries for incoming delivery of parts and outgoing shipments of finished products, there is a premium value in having access to major seaports, intermodal rail terminals and/or air cargo terminals. For instance, a statistical study of the relative concentration of industries among US counties showed that low travel time to a major airport is a major determinant of business location for two sets of industries: (a) tourism and conference serving sectors (including recreation, lodging and restaurant), and (b) finance, professional and technical services, which have high rates of worker business travel (Alstadt et al, 2012 and Table 2 above).

## Use of case study and empirical analysis findings

### Adaptation of *ex-post* empirical findings to inform economic impact forecasting models

The findings from case studies and other empirical studies of productivity elements indicates that actual impacts can sometimes be larger and sometimes smaller than would be predicted by applying constant model factors based on national averages. Project characteristics – such as the type of access, connectivity or reliability change – will matter to specific types of industries. Local factors – particularly those relating to industry mix, and project setting – will help determine which industries are affected. Together, project characteristics and local factors interact, causing some projects to have significantly higher or lower impacts than would otherwise be expected. Regional economic analysis methods can incorporate these considerations in predictions of impacts on investment, job and income growth.

The two regional economic model systems that are widely used by State DOTs for prioritisation and major project evaluation have been updated in recent years to incorporate these very factors. Both REMI TranSight and TREDIS now incorporate "economic geography" concepts by featuring separate inputs for changes in local *labour/commute* market access and regional *freight delivery* market access, as well as traditional travel time and travel cost savings effects. (The latter model also includes inputs for changes in access to intermodal terminals.) *Logistics* impacts are a major concern to many State DOTs, and these models also consider how delivery reliability also affects business competitiveness. The inputs to both systems include project induced changes to both travel characteristics and accessibility characteristics, and both systems then consider how different industries value and respond to those changes. (Table 3 shows the transport input variables for one such system.) As a consequence, characteristics of the local economy play a major role in model predictions of economic impact. Since these systems have multi-regional CGE-type formulations, they also estimate changes in domestic and international export flows, inward investment flows, labour supply/demand and wage rates over time. Both also show fiscal (government revenue) impacts.

Table 3. **List of transport changes that are economic model inputs**

| |
|---|
| **Generalised Cost Factors by mode (car, truck, transit, rail, air, marine, bike), trip purpose and time period** |
| Trips |
| In-vehicle travel time, vehicle-hours of travel |
| Wait/schedule delay time |
| Out of vehicle travel time |
| Vehicle-miles of travel (VMT) or vehicle-kms (VKM) |
| Congestion (percentage congested VMT or buffer time) |
| Vehicle occupancy |
| Fare/Fee/Toll – per person, per vehicle or per mile or km |
| **Accessibility Characteristics by mode (car, truck, transit, rail) and time period** |
| Local* market for labour commute to work (car, transit only) |
| Local* market for goods and services delivery (truck only) |
| Regional* market for same day passenger trips (car/bus and pass. rail only) |
| Regional* market for same day freight delivery (truck only) |
| Long distance access: time to cargo airport (truck only) |
| Long distance access: time to air passenger terminal (car and transit) |
| Long distance access: time to intermodal rail freight facility (truck only) |
| Long distance access: time to passenger train station (car and transit only) |
| Long distance access: time to marine cargo port truck and freight rail) |

*Note:* * Local market is typically within a 40-50 access time; regional market is for same day return trip (typically within three-hours access each way).

*Source:* http://www.tredis.com/resources/tech-docs

A decade ago, this class of regional economic impact models (that feature spatial accessibility and business reliability factors) was not available to State DOTs. The development of these models, and their use to inform prioritisation and evaluation by State DOTs, is a direct result of evidence based analysis studies that focused on understanding behavioural factors affecting business activity growth. Besides providing potentially better sensitivity to distinguish impacts of competing transport projects, another implication of these models is that they have expanded the definition of GDP impacts to include logistics, supply chain, export growth and inward investment impacts.

## Application of economic impact forecasting models to inform *ex-ante* project evaluation

In addition to being used for prioritisation by state DOTs, the regional economic impact models are also being applied in *ex-ante* studies to support "alternatives analysis" for major investment projects. In all such cases, they are used as a supplement to benefit-cost analysis (BCA) and financial impact analysis (FIA). Their main use is to help assess strategic economic development goal achievement, and to show how industry growth impacts would be expected to occur across space, time and elements of the economy. (Wang, 2012, provides an overview of this same issue in the Australian context.)

There are examples of such application across US, Canada and Australia. Three examples of published alternatives analysis studies that have used EIA in combination with BCA and FIA are shown below. In each case, the market access and connectivity aspects of the project and their wider economic development impacts were estimated via an economic model. Each example is listed below, along with a brief description of its strategic economic development goal and reference for further information.

- the North Beaches BRT proposal in Sydney, Australia (Transport for NSW) – intended to establish a link between the emerging Global Arc high tech area, a new medical centre, and downtown Sydney (Weisbrod, Mulley and Hensher, 2015).
- the King-Main LRT proposal in Hamilton, Canada (Ontario, Metrolinx) – intended to improve the link from McMaster University to downtown Hamilton, and support improved feeder service for the commuter rail link to Toronto (Steer Davies Gleave, 2010).
- the new Ohio River bridge proposal linking Indiana and Kentucky (Indiana Finance Authority and Kentucky Transportation Cabinet) – intended to link between a new Riverport industrial zone to the UPS "WorldPort" freight hub at Louisville International Airport (Weisbrod and Duncan, 2015).

There are three potential advantages associated with the approach of conducting EIA with BCA and FIA, and doing so in a consistent manner. They are:

- It enables economic, strategic and financial considerations to be considered and presented in a more holistic way. They may be considered together via a formal multiple accounts evaluation or via a policy discussion process.
- It also can be more satisfying for decision makers, as it meets the three criteria set forth at the beginning of this paper: *relevance* in terms of aligning evaluation and objectives, *practicality* in terms of representing the role of project settings and contexts, and *accuracy* in terms of portraying impacts relative to needs and deficiencies.
- It can also enable consideration of ways that projects can address public goals of achieving reasonable levels of efficiency, equity and "strategic policy" achievement.

The idea of requiring these multiple forms of economic analysis to be done together and in a consistent manner is certainly not new. For instance, the US Environmental Protection Agency's *Guidelines for Preparing Economic Analyses* states that "For most practical applications, therefore, a complete economic analysis is comprised of a BCA, an EIA, and an equity assessment." (EPA, 2010, p.1-5). It further states that "For any regulation, it is essential to ensure consistency between the EIA and the benefit cost analysis (BCA). If a BCA is conducted, the corresponding EIA must be conducted within the same set of analytical assumptions." (EPA, 2010, p. 9-2).

## Implications for benefit accounting and decision support systems

### Strengths and weaknesses of *ex-post* analysis and evidence-based decision support methods

The assembly of *ex-post* case studies in the US, and their focus on economic outcomes (rather than travel forecasting accuracy) was originally motivated by a desire to more easily show politicians the value of investing in transport. Besides helping to generate examples of the positive impacts of funding transport projects, though, the case studies have also fed public interest in ways that transport investments enable new technology processes, industry clusters and commodity flows (trade routes). That topic has driven interest among some state DOTs in better distinguishing projects that have strategic importance for economic development because they connect certain markets, business activity centres and intermodal gateways. It has motivated improvements in regional economic impact models so that they can better distinguish such investments from the many other transport projects that have less clear-cut economic development consequences.

All of the above-mentioned factors help explain the increasing interest of State DOTs in adopting multi-criteria scoring systems that include factors which (directly or indirectly) relate to productivity, connectivity, reliability and accessibility effects, as well as broader economic development. Of course, one can question the *trade-off in effort* between generating increasingly complex scoring systems that call for calculation of detailed metrics, and simpler systems that are more straightforward and less demanding but perhaps less capable of distinguishing differences among projects.

The presence of *ex-post* case studies also provides an opportunity for direct use. That raises an obvious concern about *transferability* of results. The TPICS/EconWorks database of *ex-post* case studies in the US has search and interpolation tools that can be misused. It is not hard for proponents of any project proposal to point to success stories and claim that they demonstrate the value of their new proposal. About the only way to minimise that situation is to also make use of more sophisticated economic impact and decision support models that can account for differences in local settings and contexts.

### Measurement issues: additionality and double counting

A continuing issue in economic impact measurement is *additionality* – the extent to which observed economic growth impacts are net growth or merely transfers of activity. Most governments consider economic activity shifts within their jurisdiction as a zero net gain, but inflows of money and investment from outside to be a net gain. Of course, that entire situation becomes complex in the US context because there are three levels of transport funding and decision-making – federal, state and local/metropolitan. Each level may view the same economic development in a different way, and that has in fact spurred interest in distinguishing transport projects that are of local significance, state significance and national significance.

The multi-criteria rating systems and economic impact models that have been discussed in this paper do attempt to address those distinctions. This can be seen in the MCA scoring systems shown in Table 1, which variously include rating points for projects that involve "key corridors," "global gateways," "freight routes," "supply chains," and "intermodal facilities" – all means of differentiating projects that have broader area economic significance. Further differentiation is made in the calculation of state-level economic growth impacts via economic impact models. The economic models used by State DOTs also usually include capabilities to distinguish shifts among regions within the state and between state and national impacts. The latter is done by considering trip ends. For instance, pass-through traffic is a gain at the national level but may generate little or no benefit or income for residents of the state. There are requirements that projects with federal funding must be assessed from a national viewpoint, but some states switch to a state-level viewpoint for evaluation of projects that are fully state funded.

The topic of *double counting* is more difficult to unravel. The fundamental issue is whether a project prioritisation or selection process is being unintentionally biased by some projects being assigned more benefit than is rightfully deserved. In BCA, incorrect benefit-cost ratios arise if the total benefit calculation is upwardly biased by the inclusion of two or more benefit elements that overlap in coverage – i.e., at least partially reflect the same effect. For MCA, though, overlap among input elements may not be problematic if the MCA weighting system is adjusted so that there is no skew in the relative ranking.

The problem that arises is that many of the MCA rating factors, and factors affecting wider economic impacts (in EIA), are theoretically distinct from each other but tend to be significantly *correlated* in their incidence. This is probably an unavoidable consequence of combining measures of direct user cost savings with measures of accessibility effects and secondary impacts on transport-reliant industries. For instance, consider the case of a section of highway that has a high volume/capacity ratio. The most likely outcome will be slower traffic and hence more delay for travellers (which is a cost factor). But this congestion condition may also reduce travel time reliability, and late shipments may increase loading dock and stocking costs for freight shippers and receivers (which is a logistics cost). If this situation occurs often, then it will cause businesses to add more buffer time to product and service delivery schedules. It may thus shrink the market area from which deliveries are made from a given location, or the effective density of opportunities that are accessible from it (which is an accessibility factor). And the congested road may also reduce access to supply chain routes, intermodal and international gateways, and other factors that are also sometimes part of MCA ratings. Similar examples of compounding impacts may occur if there is congestion at a rail terminal, airport runway or seaport dock.

Now in theory each of these above-cited impact elements is a distinctly different effect, and one can also construct examples where one of these forms of impact occurs without any of the others. But in practice, they often occur together. As a result, one cannot be certain that the coefficients which were statistically derived to reflect their impacts adequately control for those correlations. This same issue was examined in a US guide to measurement of transport impacts on productivity, and the position that was taken in that report is that correlation does not necessarily translate into double counting (Weisbrod et al, 2014). But if research studies derive valuation or elasticity factors separately for each effect without controlling for other correlated effects, some impacts may be under- or over-estimated.

Another question that arises is whether wider economic impacts are merely a way to generate larger numbers than would otherwise emerge from consideration of user benefits alone. In the case of US practice, this is not the case because the relationship between social benefit metrics in BCA and GDP impacts by economic models in EIA are not closely correlated. In the context of State DOT use, a project that has large time savings for travellers may generate little impact on the State’s economy if the traffic is largely pass-through movements. On the other hand, a project with may have a dramatic impact on the economy if it affects the competitiveness of the state’s export shipments.

**Completeness and accuracy of impact elements**

*Ex-post* case studies and associated research on micro-level (small area) impacts do help identify ways to improve project ranking and selection. They include the following:

- *Local project details and local context matters*. Characteristics of project size and type can interact with characteristics of local settings to affect the size and nature of economic development impacts. Thus, location setting factors can and should be considered in the evaluation of proposed projects.
- *Economic development impacts do not automatically occur everywhere.* Consequently, state DOT staff tend to accept claims of wider economic benefits in cases where there are specific types of access improvements for specific business activity centres. However, there is more reluctance to embrace studies where there are only non-specific claims of agglomeration benefits.
- *Freight and intercity connectivity need to be recognised alongside passenger access effects.* After all, transport projects can enable GDP growth not only via market scale economies, but also by enabling new technology adoption and spatial activity shifts that increase net exports. This finding increases the importance of recognising freight logistics and intermodal connectivity effects – a point that is also emphasised by Hoel, et al. (2011).
- *Thresholds factors exist*. There are practical travel time thresholds affecting the size of labour markets, freight supply chains and intercity business travel markets. These thresholds can affect passenger and freight demand, and the ability of businesses to implement new technologies. The implication is that if threshold factors are recognised, some projects would rise and others would fall in ranking lists.
- *Time lags exist.* Broader (non-user) economic development impacts occur over time, and may take over a decade to occur depending on the type of project and local setting. The implication is that these time lags should be incorporated into BCA and EIA studies, as otherwise the expected GDP impacts may be overstated.

The multi-criteria rating systems used by many US states are an attempt to measure strategic economic development goal achievement along with the more traditional user benefit measures, so that both can be considered together in decision processes. Consequently, these rating systems are usually designed to be sensitive to the explanatory factors and threshold factors that have emerged from case studies and associated statistical studies – i.e., the bullet items listed above.

**Conclusion**

Ultimately, we can gain insight into more sophisticated planning and realistic modelling if we consider broader impact factors in decision frameworks. Insight can be gained by examining how the creation of new spatial, temporal and distributional linkages may affect technology adoption and activity patterns.

Finally, there is a need to make use of broader analysis metrics to better communicate economic development impacts to public and private stakeholders. Better communication is enabled when agencies can tell more of a “story” regarding who, when and how wider benefits and other impacts are expected to occur. And to provide that story, more *ex-post* case data is needed and more empirical research is needed that actually pools findings across nations, and among academic and consulting communities.

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