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Benefits of Transportation Investments: How You Measure Matters

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Congestion in the truck transportation industry results in significant costs throughout the economy. For example, a 2011 survey of Washington state freight-dependent industries found that a 20% increase in congestion faced by the freight dependent industries would result in an impact of nearly 1,800 jobs lost and a reduction of $244 million in regional output from the state's Central Basin region alone (Taylor et al., 2013). Much of the output of the Central Basin is agriculturally-driven. The estimated impact is largely generated as a result of the freight dependent businesses increasing spending on resources to counteract the increased congestion. In turn, prices of freight dependent goods are increased and consumers must decrease purchases of services and non-freight dependent goods to pay for the increased costs of freight dependent goods. In essence, congestion causes general inefficiency, requiring the truck transportation industry to be less productive.

Given the economic inefficiency of congestion, infrastructure investments that reduce freight travel time and operating costs along the supply chain can be considered to represent a technology improvement that permits the industry to become more productive, for a given level of capital and labor. These efficiencies are generally realized through reduced driver time on the road resulting in reduced labor costs; reduced vehicle repair and operating costs; and increased trip miles per unit of time per vehicle, resulting in more productive individual vehicles and requiring fewer trucks to accomplish the workload.

It is a widely held view that our country is underinvesting in all types of infrastructure at a time of high need. In their most recent grading of the U.S. infrastructure, the American Society of Civil Engineers identified a backlog of more than $3.5 trillion in overdue maintenance. This backlog, among other conditions, earned the U.S. infrastructure a D+ average. The roadway system fell on the low end of the report card, earning only a D (American Society of Civil Engineers, 2013). At the federal level, major funding and authorization legislation governing surface transportation investment includes the most recent 2012 Moving Ahead for Progress in the 21st Century Act, commonly referred to as MAP-21 (U.S. Department of Transportation, 2015).

While much of the political discussion has focused on the source of revenue for infrastructure projects, with so great a need, it is not totally clear where the greatest return to public investment lies. An important contribution to that discussion is through economic analysis of investment impacts. The impacts of various investment options—and underinvestment—in infrastructure are important for the general public, and especially policy decision makers, to understand. Given that the impacts are systemic and challenging to capture quantitatively, economists have used multiple ways to estimate these impacts. Each approach has its limits and differing assumptions; and the right approach depends on the specific question and data at hand.

As we progress further into the 21st Century, the language of current and future federal transportation funding and bills, like MAP-21, point to a growing need among agencies for rigorous analysis of the economic impacts generated via efficiency and productivity gains resultant of infrastructure investment. The two most common methods used by transportation agencies in evaluating economic

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impacts are (1) the often used status quo Input-Output (I-O) model and (2) the Computable General Equilibrium (CGE) model. The CGE model is a more sophisticated method which has gained popularity over I-O in academic literature as well as among federal government agencies for a variety of applications—for example, the U.S. Environmental Protection Agency's Economic Model for Environmental Policy Analysis CGE—but not necessarily among state-level government agencies.

Efficient freight mobility is largely a result of successfully balancing the demand for transportation capacity and service with the quantity supplied of those services and capacities. In order to prioritize the investment in infrastructure and capacity to achieve efficient freight mobility, an accurate assessment of transportation demand, and the costs and productivity of transportation services is required. The need for prioritization arises particularly when funds are limited, requiring infrastructure investments be allocated to where the marginal returns of mobility are the highest—that is, where the biggest bang for the buck is to be had. These economic truisms are as applicable to the public sector as they are to the private sector. However, public sector entities, unlike their private sector counterparts, often experience difficulty in determining the impacts that result from public investments in freight-related infrastructure and activities, in assessing the costs of providing those facilities, and in determining the economic feasibility and viability of any infrastructure investment. In the private sector, decision makers must be responsible to the company's bottom line. In the public sector however, the bottom line is multi-faceted and includes public benefits and the ability to generate economic impacts to the region, not just one firm, or one sector.

Not only is an efficient freight system valuable for statewide interests, but also for the economic interests of rural agricultural communities within the state or region, as these communities are highly dependent upon the ability to efficiently deliver goods to local and world markets. A growing number of communities recognize that efficient freight movement is directly associated to the health of their local and regional economies. As a result, federal, state, and local governments are increasingly being asked to improve freight mobility through operational improvements and new public infrastructure.

To prioritize public investments in freight systems and to insure consideration of the contribution of freight to the overall system performance, states, and regions need a reliable method to analyze freight benefits associated with proposed highway and truck intermodal improvements that would lead to enhanced trade and sustainable economic growth, improved safety, and environmental quality, and goods delivery. In addition to quantifiable performance measures that aide in the identification of how well a project can meet a set of goals, public agencies need to effectively communicate the decision justifications to the public.

Options for Quantifying Economic Performance: Choosing the Right Approach

While the development of I-O models was groundbreaking, their limitations, largely due to flexibility of assumptions, can prove to be overly simplistic and without a real world practicality. These limitations continue to lead to various attempts to overcome them. The first of these came in the early 1960s with the development of Linear Programming (LP) models which allowed for the explicit introduction of input constraints and prices to the models. The CGE model can be thought of as an extension of these early LP models but borrowing from the I-O framework as well. The seminal work on CGE modeling is attributed to Johansen (1960), and is as a blend of neoclassical theory applied to contemporary policy issues (Bandara, 1991). Since the development of CGE models, there have been few credible attempts to argue for the use of I-O over CGE. One of these comes from West (1995) who maintains that in cases for which data is limited and the scope of the project is only for a small region the I-O model may be the only practical option. Rose and Liao (2005) add further argument with the suggestion that the difference between direct and indirect impacts is clearer in an I-O framework. However, they also provide a method for making that distinction in a CGE model. Most peer-reviewed articles dealing with the topic recommend always using CGE over I-O if possible (Seung, Harris, and Macdiarmid 1997; Rose and Liao, 2005; Dwyer, Forsyth, and Spurr, 2005; Dwyer, Forsyth, and Spurr, 2006; Partridge and Rickman, 2010; Cassey, Holland, and Razack, 2011).

Rose and Liao (2005) point out that because of these I-O limitations, it provides only an upper bound estimate of the impacts of a policy or project. Similarly, Dwyer, Forsyth, and Spurr (2005) suggest the method has "inherent biases that overstate the impacts on output and jobs." Attempts have been made to deal with these assumptions by extending I-O models (Rose and Liao, 2005). However, the basic problems remain.

In contrast, within the context of a CGE model, the restrictions found in I-O models, namely fixed prices, supply, and budget constraints, can be relaxed—albeit at the cost of adopting a new set of assumptions. The underlying premise of all CGE models is the assumption that if all markets in a given economy are in equilibrium, then any individual market within that economy will also be in equilibrium and therefore a market clearing price and quantity exists for any individual sector of the economy, as well as the whole regional economy. The conceptual flow of activities is relatively simple and straightforward with all firms in an economy producing their own unique goods from inputs—labor and capital—which are provided by the households. These goods, services, and commodities are then either utilized as inputs for other firms or consumed by households at the respective market clearing price.

Impacts vs. Net Social Benefits

Another issue that ought to be discussed when dealing with regional policy decisions is the difference between economic impacts, as measured through economic impact analysis, and net social welfare, generally estimated using Benefit-Cost Analysis (BCA). Welfare is touted as the more appropriate metric for decision making (Edwards, 1990; Abelson, 2011); however impact is very widely used. This is not for theoretical reasons, but rather because impacts are more readily understood by a general audience. An impact can be stated as a change in the number of jobs—a very easy to understand and increasingly demanded performance metric; net social benefits are defined in terms of utility, something only economists tend to discuss. It also could be the case that impacts are so popular due to the long-time dominance of I-O models in regional science. Unmodified I-O models are incapable of estimating net social benefits, leaving impacts as the only available metric.

CGE models, on the other hand, can be used to directly estimate social welfare—generally by calculating an economic measure, referred to as *equivalent variation* (Hirte, 1998; Böhringer and Welsch, 2004).

A Comparison of Results for Highway Improvements in Washington State

To date, most analyses of the impact of highway infrastructure improvements on state transportation system performance have focused on the impact on passenger traffic or the total vehicle count. However, there are important differences between passenger and freight transportation that need to be considered to accurately assess the impact of highway infrastructure improvements. This is particularly true when it comes to the consideration of such improvements on congestion and travel time reliability and determining the appropriate dollar value to use for changes in reliability for freight. It quickly becomes apparent that the matter is much more complicated than for passenger travel.

For passenger travel, the total value of a trip is calculated as the value to the driver and any passengers on board. The value to these occupants of the change in reliability is generally accepted to be their value of time multiplied by the change in travel time. While there is still a debate in the literature regarding the appropriate value of time to use (that is, is it the average hourly wage rate in the area—or should it be half of that for travel time, or other options), and whether the relationship between a reduction in reliability and social value is a simple relationship, it is clear that these issues pertain to the driver and occupants of the vehicle and thus are directly related to the operation of the vehicle.

Some have interpreted the valuation of time for freight transportation in a parallel fashion by using the hourly wage of the truck driver. However, the driver's wage reveals only part of the true value of time in a freight operation. Freight transportation typically involves at least a shipper and a carrier. The value placed on a reduction in travel time differs considerably across shippers of different products, distances involved in point-to-point shipments, transport mode, and other factors. Additionally, the perishability of a product, particularly fruits and berries, generates a freight value of time that moves beyond an operating cost perspective. As the perishability of product increases, the time sensitivity of the shipper increases, thus placing more concern the ability to reliably deliver products on time, without significant degradation.

The role of freight movement in a region is strongly tied to its relationship, to its 'core' and 'traded' industries. With several major west coast ports, the Northwest's economy is tightly bound to these traded industries, where we understand traded industries to be those industries that produce and sell more goods than what can be consumed locally, and thus are selling products to a national or international market and provide a flow of incoming dollars to the local economies. In Washington state, this is largely comprised of agricultural commodities including wheat, apples, and hay. Since the development of the interstate highway system, manufacturing industries have become interdependent upon the trucking industry. The degree to which an industry is dependent upon this system varies considerably. In their evaluation of Portland's traded industry use of transportation, the Economic Development Research Group, Inc. identified the agricultural industry (NAICS 111) as relying upon Truck usage for 73 percent of their transportation needs, while publishing industries (NAICS 511) are 35 percent reliant upon Truck and 36 percent on postal.

In Washington State, recent intercept surveys of trucks heading west on Interstate-90 towards the Puget Sound were significantly comprised of agricultural products. More than half (56%) of all trucks surveyed (n=2610) originated within the state and often destined for distribution centers (38%) and international ports for export (15%). Of those trucks destined for major ports (Seattle and Tacoma), the most prevalent commodities consisted of Hay, French Fries, and Apples; all strong

Washington based agricultural products. While these products all originate in the more rural eastern portion of the state in which congestion is a limited concern, their destinations route them through dense traffic that is frequently plagued by congestion, thus making highway investment in congestion relief a very relevant concern for the state's Agricultural regions.

Results Using the CGE Model

To assess the value in using a CGE based model to estimate the impacts generated by infrastructure investments, researchers utilized Washington based travel demand models (TDMs) to visualize the travel related impacts. In the scenarios assessed, the TDMs suggest congestion relief stemming from the infrastructure improvement. With congestion relief comes a reduction in cost of freight dependent good that in turn produces a positive effect, in that they simulate consumers increasing purchases of services and non-freight dependent goods, as well as a negative effect that simulates the trucking industry's response of reducing employment. Though it's potentially counterintuitive, the results indicate losses in trucking based jobs as a result of their newly gained capacity to increase their output with fewer trucks and drivers.

In addition to the jobs modeled to be lost in the trucking sector, the sector associated with other transportation modes and warehousing also projects some, though markedly fewer, losses in the CGE model. Most of the sectors demonstrate only marginal changes in employment levels, with most experiencing less than a five job changes. The sectors where job gains are substantial enough to take notice are found in several heavily freight dependent sectors. This is particularly true for the manufacturing sector, as well as agriculture and forestry. These two sectors combined more than offset the losses experienced in the truck-transport sector. Other notable sector employment gains include retail trade gains.

Results Using the I-O Model

It is important to preface the I-O model results by noting that the I-O will never produce a negative number when modeling an increase in output by a sector; getting back to some of the concerning limitations of such models. This goes for the sectors directly impacted as well as all the indirect and induced effects. In essence—due to lack of information about the number of trucks added or reduced—only one piece of the potential response is modeled. Congestion relief from the project is seen as producing a positive effect, in that it stimulates consumers to increase purchases of services and non-freight dependent goods (consumer benefit). The I-O model does not account for the trucking industry becoming more efficient and able to do more with fewer trucks. Given this, it is not surprising that in most of the sample scenarios conducted, the I-O model results in higher job growth estimates. However, taking the output change under consideration, CGE models result in greater changes than their I-O counterparts. This observation is a result of the flexibility built into the CGE model through increases in the productivity of the trucking sector for given levels of capital and labor (Sage et al., 2013).

Looking to the Future

Infrastructure improvement projects that reduce operating costs and travel time of freight users on the roadway is an activity that inherently affects the productivity and economic efficiency of the user; two critical components that are addressed in the National Freight Policy provisions of MAP-21. As readily available and user friendly as I-O models are, their major drawback is the inability to simulate a change in productivity directly. To assess the economic impacts of such infrastructure improvement projects, the benefits experienced by the users must be manually translated into a change in demand by freight users. Despite being able to compute the change in demand, the I-O model described here is not able to fully account for the improved productivity of the trucking industry, and thus does not confidently model how the trucking sector meets the increased demand.

Where infrastructure projects are large enough and productivity is increased to the point that now fewer trucks—and therefore fewer drivers—can meet the demand needs, we may experience a reduction in employment in the transport-by-truck sector. The I-O model does not pick this up. However, the CGE is able to directly model increased productivity of an industry and are thus able to model the entire economy-wide reaction to the infrastructure improvement that is a result of decreased operating cost and travel time. It is for this specific ability to model productivity changes that a regional CGE model should be incorporated into the prioritization. By implementing an economic impact study alongside the typical BCA, these analyses will better inform agency prioritization decisions with regard to the affect infrastructure projects have on freight systems and the regional economy that is necessarily interwoven with them. As more benefits accrue and are accounted for, the impact on the economy will continue to grow. Thus, as capabilities to account for benefits stemming from increases in reliability are developed, a more complete impact can be assessed.

The applicability of the above defined economic impacts models do not stop at the level of on-highway investments. Intermodal facilities such as truck-to-rail facilities frequently employed in agricultural regions--where goods are transferred from truck to rail for shipment to domestic markets, or through gateways to international markets--are often offered as a means of improving the efficiency of the freight movements in some marketing situations by taking advantage of the comparative advantage of one mode over another. Proposed public investment in such intermodal facilities raises at least two questions:

- Will the facility succeed in the private market place by generating a sustaining return as a commercial investment?

And

- Is any public investment justified based on the public benefits, or externalities, produced?

The intermodality adjustments are of particular importance in consideration of commodities like wheat and other bulk grains that frequently involve rail, truck, and barge transportation in route to the export market (Freight Policy Transportation Institute, 2015).

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