The Economic Impact of Increased Congestion for Freight-Dependent Businesses in Washington State

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Congestion in the transportation system necessitates select businesses to operate on a less efficient production function. A survey of freight-dependent businesses in Washington State was used to calculate the costs of congestion and economic impact of increased congestion. As these businesses spend more to provide goods, responses suggest consumers would pay 60 to 80% of the increased cost. Primary areas of increased cost were identified as additional trucking and inventory costs. Results identify an additional $8.7 billion in consumer costs for a 20% congestion increase. The economic impact is a loss of $3.3 billion in total output and over 27,000 jobs.

INTRODUCTION

The economic vitality and livability of any state readily depends on reliable, responsible, and sustainable transportation. Maintaining the transportation system at a level that allows for the safe, efficient movement of freight is an essential component. Wasted fuel, lost productivity, and reduced mobility on the urban road network are estimated to cost the nation's network users roughly $85 billion annually (HDR 2009). Congestion alone has been found to cost users roughly $37.5 billion, $10 billion (2000 dollars) of which is attributed to trucking firms and those receiving and shipping freight (Winston and Langer 2006). As impressive in magnitude as this estimate is, reporting the cost of congestion alone is not sufficient to affect public policy at the state level. Instead, transportation agencies need additional knowledge to understand the manner by which industries are impacted by congestion, what their likely response will be to increasing congestion, and the net impact of these industry responses to the economy.

To answer these questions, Washington State Department of Transportation's (WSDOT) Freight Systems Division, in coordination with Washington State University's (WSU) Freight

Policy Transportation Institute and the WSU Social and Economic Sciences Research Center (SESRC) designed and implemented a cost of congestion study, with a goal of providing WSDOT with specific information about the impacts of congestion on businesses dependent upon goods movement, and how these impacts are subsequently felt through the state's economy (Taylor et al. 2012).

REVIEW OF LITERATURE

Typically, economic impact studies report how an economy changes when an external source of funds moves into a regional economy (e.g., a new manufacturing plant locates in a town, or a highway is constructed or improved). The literature on the mechanisms by which the construction of, or investment in, highways produces economic shocks to the regional economy is extensive and largely identifies the short term impacts generated by the construction activity itself (Stephanedes 1989; Babcock et al. 2010; Babcock and Leatherman 2011) as opposed to the longer term employment and output changes, which are often demonstrated to be minimal at best (Stephanedes and Eagle 1987) and generally not uniform in effect (Peterson and Jessup 2008). Adding context to potential for economic development following an investment in new highway infrastructure, Chandra and Thompson (2000) find certain industries grow following investment, while others have more ambiguous outcomes and each witness spatial allocation implications.

Contrary to the consideration of investing in new infrastructure as a component of economic development, congestion is somewhat unique in that "new" money is not being injected into the economy. Instead, congestion causes freight-dependent businesses to operate less efficiently. In other words, they operate on a different, less efficient production function. Highway congestion often acts as a mitigating factor of the achievable benefits of agglomeration in urban areas, particularly in relation to firms who are heavily dependent on truck transportation

(Weisbrod et al. 2001). Allen et al. (1994) highlight that given the trucking industry's rather competitive structure, it may be assumed that much of any cost reduction resulting from an infrastructure improvement will be passed onto the shippers. These effects are subsequently felt throughout the regional economy. The function served by freight transportation in the economy and the suggested transmission of any cost reductions to shippers, who are the direct consumers of freight services, motivates a need for a regional economic framework. Freight movement enables trade networks between industries and their market locations. Improvement to the routes reduces travel cost and thus production costs of goods, as well as reducing uncertainties and risk that come with unreliable delivery. These combine to increase industrial productivity (Weisbrod 2007). Increases to the efficiency of a freight network then produce positive effects felt via job creation and economic activity (Allen et al. 1994; FHWA 2001a, 2001b, 2001c; Weisbrod 2007).

While it is often speculated or assumed, that investments in transportation infrastructure contribute to economic growth and increased productivity (FHWA 2004), the actual measurement of such a response resulting from a specific investment in a component of the system is often difficult to establish (Peters et al. 2008), and its full implementation is thus often underdeveloped or overlooked entirely. Improvements via investments in transportation infrastructure that seek to minimize the barriers to travel have an effect of shrinking space and time (Lakshmanan 2011). Subsequently, carrying an analysis forward only at the level of a benefit cost analysis (BCA), may prove insufficient by not establishing the expanded 'network' effects felt by freight dependent and other service based sectors that rely on the services obtained on the transportation network. Peters et al. (2008) suggest that the individual parts of a transportation system may not capture its true economic value, and as such, the best measure may be one of the overall network quality. Additionally, Munnell (1990) found that a state's investment in public capital has a significant impact on the state's private employment growth. Thus, in an approach identifying and accounting for economic impacts beyond the direct benefits, analysts may more fully capture the produced externalities of the infrastructure investments not captured by the BCA (Munnell 1990; Nadiri and Mamuneas 1996, 1998; NCHRP 1998; FHWA 2004). It is in this type of approach that transportation benefits (or costs) are transferred to economic impacts via labor, market, business and trade development, as well as increases in Gross Domestic Product (GDP) or Gross Regional Product (GRP), and other organizational changes (Lakshmanan and Anderson 2002; Lakshmanan 2011) and logistics reorganization (FHWA 2004).

In this light, and in the growing legislative demand for performance based investment prioritization (e.g. MAP-21), regional transportation agencies and several state departments of transportation have sought economic frameworks to capture the economic impacts in terms of employment, gross state product, and personal income, in addition to the transportation performance benefits (Kaliski et al. 2000; FHWA 2002; EDRG 2008; Kansas DOT 2010; North Carolina DOT 2011). The Texas Transportation Institute's (TTI) Urban Mobility Report (UMR) shows roughly a tripling of the annual hours of delay per commuter from 1982 to 2005 in cities of all sizes, with only slight relief during the recent recession. The most recent versions of the UMR have begun to attempt to account for the incorporation of urban truck delay, realizing that trucks experience delay and accrue costs differently than do commuter vehicles. Via their directed consideration of truck delay, the researchers identify that despite making up only 7% of the vehicle traffic, truck delays account for 22% of congestion costs in 2011 (Schrank, Eisele, and Lomax 2012).

While TTI and many of the above cited works develop operable mechanisms to explore the benefits (e.g. through performance measure calculations such as travel delay and wasted fuel costs) and economic impacts that are generated from an infrastructure investment or system of investments, little has been explored to understand (via stated preference) the responses of freight dependent businesses to the potential for facing increasing congestion. Therefore, to explore fully the relationship between congestion, associated costs to industries, and the ripple effects to the state's economy, a new set of data and industry relationships was needed. Prior to this study, the effects of congestion as stated by freight dependent industries in Washington State had not been measured. Therefore, the results here provide the WSDOT essential new information to respond to the impact of congestion in the state. Additionally, the process developed and employed for Washington provides a replicable process to implement in other states or regions.

METHODOLOGY: DEVELOPING AN IMPACT ASSESSMENT

To generate data on the relationship between congestion, cost to industries and the state's economy, a four-step methodology was developed, beginning with an extensive survey of freight-dependent businesses. Survey results were then used to obtain a direct cost of congestion to freight-dependent industries. The direct costs were subsequently used as inputs to a series of regional and statewide IMPLAN I-O models (Figure 1).

Step 1. Survey of Freight Dependent Industries

A survey of freight dependent businesses[1] was conducted by WSU's SESRC through a developed Computer-Assisted Telephone Interview (CATI) protocol and administered between 2009 and 2011. A total of 6,624 private-sector freight companies and carriers were invited to take the CATI, representing industries from agribusiness, construction, global gateways (e.g., ports, etc.), food manufacturing, manufacturing, retail, trucking warehousing, wholesale, and lumber companies. An initial sample of 2,500 cases were drawn from the population by randomly selecting 1,000 trucking companies and then proportionately sampling among the remaining industries with oversampling in the smaller industries so a minimum of 60 cases were drawn from each of the 10 sectors. Respondent industries were grouped in accordance with their 2-digit NAICS codes to make them compatible with the IMPLAN aggregation used in later stages. The surveyors recorded completed surveys from 1,062 businesses (29.6% after accounting for the eligibility factor). Questions were formulated to gather data necessary to input into the economic assessment tool, including queries about industry classification, main freight activity, average hourly trucking costs, trucking cost components (e.g., wages, fuel, etc.), inventory carrying costs, and strategies to combat congestion. Respondents were asked to identify and direct their responses to the region of the state where they face the most congestion or where the majority of their shipments occur. The identified region was then used to provide context for the remainder of the survey questions. Six Washington State regions were provided as response options: Northwest, Southwest, Central basin, Northeast, Southeast, and Central Puget Sound Metro Area (Table 1). The key component of the survey asked respondents a series of questions regarding how they would react if their travel time increased by 20, 30, and 40% due to congestion. Even at the lowest level of congestion increase, a majority of respondents (58%) indicated that the addition of at least one more truck would be included as a component of their strategy to combat the congestion increase. Additional qualitative comments provided by respondents highlight the interaction of additional trucks with other strategies such as longer operating hours, adjusted delivery times, adjusted delivery routes, among others. Thematically, the comments tended towards the development of a strategy to avoid the potential loss of customers and business.

Step 2. Direct Costs of Congestion

The increased truck needs were translated into cost information using respondent provided hourly trucking costs. Hourly trucking costs were annualized by multiplying the hourly rate by 2,080 hours per year. For example, if hourly trucking costs for an additional heavy truck is $76, then the yearly operating cost for the truck is calculated as: (2,080hrs)x($76/hr) = $158,080.The annual cost of operating a truck was then multiplied by the number of trucks necessary to combat the various congestion increases as identified by the survey respondents. Each company's total trucking cost due to increased congestion was then normalized by their reported annual revenue to calculate the percentage trucking cost increase. The annual cost of operating a truck was then multiplied by the number of trucks the respondents said would be necessary to combat 20, 30, and 40% congestion increases. Each company's total trucking cost due to increased congestion was then normalized by their reported annual revenue. To calculate state and regional mean trucking cost percentages, the individual companies' percentages were analyzed for outliers. Observations with a trucking cost percentage greater (or less) than two standard deviations from the industry mean were considered outliers and removed from the data before any additional processing was conducted. State level trucking cost percentages were calculated as the mean of all observations, by industry. Similarly, regional means were calculated by region and industry. Any regional industry means that were comprised of less than three observations or did not exist in the survey dataset were supplanted with the industry state level mean.

A series of survey questions asked respondents if they held inventory and the value of those goods. This series prompted the respondent to estimate how much more inventory would need to be held if congestion levels increased. It was assumed that companies that do not currently hold inventories will not be induced to hold inventory to combat congestion. Respondents were asked to identify their inventory carrying cost as a percentage of inventory value and the components of that carrying cost. The total value of inventory was first divided by the number of days of inventory held to calculate a daily inventory value. The number of additional days of inventory was multiplied by the daily inventory value and the carrying cost percentage to calculate the inventory cost due to congestion. The inventory and the trucking cost percentages from survey respondents that measure the increased costs due to congestion, provide an integral component for the calculation of the economic shock created by congestion.

Step 3: Cost Realization

Survey respondents were asked what strategies their companies would employ if travel times permanently increased by 20%. These responses provided insight to how individual businesses would manage increased congestion and the resulting costs. Over half of the respondents indicated that they would continue their current operations and pass the costs on to consumers, and another 20% said the additional costs would be absorbed by the company. Two other groups of firms indicated that they would modify their business operations to manage the travel time increases; 16% would change routes and 3% would relocate. Finally, 6% reported that they would go out of business.

These responses can be further analyzed to describe the range of costs that consumers might face due to increased congestion. First, while individual firms might go out of business their consumers will likely still exist. Therefore, it can be assumed that they will be provided goods from other firms that still face congestion costs. Second, altering business operations to manage increased travel time is not free of costs. Firms will only incur these costs to the point where profits are equivalent to employing the other strategies. Uncertainty about costs from firms that alter their business operations makes it infeasible to calculate exact costs to consumers from congestion. Therefore, all of the results are presented at 60% cost realization [for 80% cost realization evaluation, see (Taylor et al. 2012)]. In other words, consumers could likely expect to pay 60% of the increased cost of congestion. The 60% estimate is generated by survey responses. In responding to questions regarding cost management, 60% of respondents indicated that they would pass on the costs of increased congestion to consumers, while 20% said they would absorb the costs, and the remaining 20% indicated an alteration of business operations. Subsequently, assessment were conducted in the model at both the 60% cost realization, and the 80%. It is important to note here, that this analysis takes a snapshot view of the increased cost of congestion, thus not considering the more long term effects of the potential of freight consumers to switch transportation modes, thus affecting the overall impact on consumers, or make other such long-run adjustments that enable a more elastic scenario development. The consumers' cost of congestion for freight-dependent businesses, however, does not provide a complete measure of the economic shock. How businesses spend resources to combat congestion must be considered as well.

Traffic congestion occurs when traffic demand meets or exceeds transportation capacity. Freight-dependent businesses are not able to control the capacity of the transportation system, so they must develop strategies to avoid congestion and/or employ resources to offset its effects. Economic theory suggests that businesses will allocate resources optimally to maximize profits. This optimal allocation of resources specifies a production function. When faced with congestion, firms must reallocate resources and operate on a different and less efficient production function.

Step 4. Economic Costs and Benefits

The cost of congestion is modeled two ways simultaneously. The first value is negative to simulate the decrease in purchases of services and non-freight dependent goods by consumers (consumer cost). The second value is positive and simulates freight-dependent businesses adding employment and assets to combat congestion (societal benefits). The economic impacts that result from these two offsetting impacts are the net impacts of increased congestion for freight-dependent businesses.

Before gross congestion costs can be separated into cost and benefit categories, the costs incurred due to exported state goods must be examined. From the consumer cost perspective, the costs attributable to exports do not belong in the state or regional I-O models. If firms are able to pass the congestion cost on to consumers, these costs would be paid for by consumers who do not live in Washington State. From a societal benefit perspective, the inclusion or exclusion of these costs is not as clear. This uncertainty primarily comes from the elasticity of demand for the exported goods. It could be argued that firms would be less capable of passing along congestion costs to export customers because their demand for these goods is more price elastic than for in-state consumers. Furthermore, if firms are not able to increase export prices, it is feasible that in-state consumers would be charged even higher rates. Due to the uncertainty of the existence or direction (i.e., cost or benefit) of congestion costs attributable to exported goods, they were subtracted from the gross congestion costs for consumer costs and societal benefits. Therefore, the costs and benefits used in the I-O models are those paid by consumers and spent by freight-dependent businesses in Washington State.

Additional considerations resulting from the inclusion of inventory adjustments by firms must also be addressed before applying them to either or both of the cost or benefit side of the model. Three components involving inventory should be considered. First, obsolescence and pilferage are legitimate expenses for firms, but they do not garner benefits to society. Second, taxes are transfers from businesses and households to government. These dollars are used to provide non-market goods and services and do not circulate through the economy like spending in other economic sectors. This is not to say that government spending, such as defense expenditures, does not have a multiplier effect. Rather, we consider the model as a point in time and thus future reinvestment via government spending is not accounted for in the year of analysis. Therefore, all three of these components are included in the consumer cost calculations, but are excluded from the societal benefit calculations.

In regional I-O modeling, it is necessary to know the size of the direct costs and where they are accrued. This spatial component applies to consumer costs and societal benefits. Since congestion costs have been limited to those paid and spent in Washington State, there is no real distinction to be made for the state level model. However, this is a critical step to understand how different regions of the state may be affected by congestion.

Trade flow data from IMPLAN specifies the value of exports from one region to another. By linking all the regional models within Washington, an industry level map of the interregional transfers ('trade' between regions of Washington) was created. Augmenting this information with the total production and export data (also from IMPLAN) provides a complete picture of where goods from each region are shipped. This distribution of production was transformed from values to percentages and used as a roadmap (trade flow matrix) for assigning consumer costs and societal benefits to the region where they would be accrued.

The consumer costs and societal benefits of congestion are entered into the I-O models as changes to the baseline economy. Additionally, the models require that a pattern of spending be specified to define what industries are affected by the change and by how much. The following sections discuss how all of the cost categories were incorporated into the regional and state I-O models.

Consumer Cost. Consumers' income must increase or their total expenditures must decrease for them to pay the increased cost of freight-dependent goods. Assuming that consumers' income is held constant, the amount spent on services and non-freight dependent goods must decrease by the cost of congestion. The household consumption function from IMPLAN was modified to incorporate the spending decrease into each regional or statewide model, while simultaneously accounting for the societal benefits described in the following section.

The household consumption function specifies the percentage of a consumer's dollar that is spent in each industry in the economy. Furthermore, it shows how much of that industry expenditure is spent in the local economy. The magnitude of the industry specific consumer expenditures in these consumption functions varies depending on the household's income level and the region. We do not have information on which households will incur congestion costs; therefore a composite consumption function was created for each region.

The composite function was calculated as a weighted average industry expenditure for all income ranges. The number of households in each income range was used for weighting. The composite consumption functions were then modified to remove all freight-dependent industries and normalized to sum to one. Finally, scenarios (based on 20, 30, and 40% congestion increases) were created in each model with the composite consumption function and the corresponding consumer costs.

For the regionally constructed models, the congestion costs for each regional industry were multiplied by the trade flow matrix to assign the appropriate congestion cost values to each region. State level costs were calculated after subtracting the costs attributable to exports. The state and regional consumer cost values at each congestion level were then summed across industries to calculate total consumer costs. The vast majority (95%) of the consumer cost of congestion is attributable to trucking costs.

Societal benefits. Societal benefits occur when freight-dependent companies begin to spend additional money on resources to counteract increased congestion. For modeling purposes, adding societal benefits to the economy is straightforward. Spending on the insurance and capital is placed in the corresponding IMPLAN industries. Wages are modeled as an increase to employee compensation.

Warehousing and trucking input expenditures are not discrete goods, therefore existing consumption functions were used to estimate the distribution of expenses across industries. To model warehousing expenditures and trucking input expenditures, the "warehousing and storage consumption function" and "the transport by truck industry consumption function" were used. Scenarios for each congestion level were created in each model using the appropriate consumption function and expenditure values.

Societal benefits are accrued in different regions of Washington based on where the expenditures will be made. Trucking expenses (i.e., wages and inputs) are presumed to be spent in each firm's home region. Capital and insurance inventory costs are also accrued in the home region. Warehousing, handling, and clerical expenses are accrued in the destination regions. Handling and clerical expenses are considered to be inventory wage expenses. State level benefits were calculated after subtracting the costs attributable to exports. The state and regional societal benefit values at each congestion level were then summed across industries to calculate total consumer costs (Table 2).

Net effects. The net economic impacts are calculated through the I-O models, and the net effects are provided in Table 2 for illustrative purposes. Juxtaposing the societal benefits and consumer costs from congestion by region shows the range in the effects. The Northwest and Southeast regions have benefits in excess of their consumer costs. The deficit in the other regions ranges from $1.3 million in the Northeast to $205 million in Puget Sound. The net effects presented here differ from the economic impacts because they do not account for how the industries or households spend or withdraw money in the local economies.

RESULTS

The strength of an I-O model comes from the vast amount of data that it contains to describe how industries and institutions in an economy interact. These interactions allow the model to estimate the full impacts from a change in the economy. The direct costs are entered into the model as the changes to the primary industries (specified in the spending patterns). Multipliers are then used to calculate the direct, indirect, and induced impacts. Direct impacts are a measure of how the local economy is affected by changes to the primary industries. Indirect impacts are the changes that would occur in the industries that support the primary industries. Induced impacts quantify the economic changes that results from household incomes being altered in the direct and indirect phases.

In this case, freight-dependent industries spend money on employees and inputs when transporting and storing goods to counteract increased congestion. This money is spent on goods that are supplied by local purveyors or imported. In turn, the local purveyors spend additional money on employees and inputs from inside and outside the local economy. Employees of the freight–dependent industries and the purveyors also spend their additional income on goods and services from the local economy or imports. All of this additional spending is financed by in-state consumers who are paying higher prices for freight-dependent goods and decreased profits.

The remainder of this paper discusses the economic impact estimates from increased congestion in Washington State. The estimates are annual figures in 2011 dollars and are based on 2008 IMPLAN datasets for Washington State and six regions of the state.

Statewide Model

There are several measures that can be used to illustrate economic impact. Table 3 presents three of the most common measures for a 20% congestion increase in Washington. Employment is a straightforward metric that shows the number of full and part-time jobs affected by increased congestion for freight-dependent businesses. The net employment effect of a 20% congestion increase is a decrease of 27,256 jobs (0.7%). The value of economic output from the state decreases by $3.3 billion (0.5%). Total value added (sales minus cost of inputs) also decreases by $2.6 billion (0.8 %).

As congestion increases to 30% and 40% levels, the losses increase substantially. An additional 10% congestion increase causes job losses of 40,859 and output to decrease by $4.9 billion (a 48.5% increase) (Taylor et al. 2012). A further 10% congestion increase would cut 57,239 jobs and decrease output by $7 billion (a 42.9% increase) (Taylor et al. 2012). The magnitude of all the economic impacts from congestion increases is large. However, the changes relative to the industry totals are reasonable.

Table 4 shows the total impact for each industry in the state and the percentage change from their baseline employment and output. Almost half (10 to 11) of the industries have a change in employment and output of plus or minus 1%. The industries losing the most jobs, in percentage terms, are Health and Social Services, Educational Services, and Arts-Entertainment-Recreation. The 60 % cost realization job losses in these industries range from 3.4% to 4.5 %. These three industries also have the greatest percentage losses in output value, 4.1% to 4.9%.

These results are understandable considering that Health and Social Services expenditures are almost entirely local (84%) and it is the largest non-freight dependent household expenditure category, second largest overall (Taylor et al. 2012). The Educational Services and Arts-Entertainment-Recreation expenditures are highly localized as well (63 and 83%, respectively). These industries, however, are two of the smallest based on employment and output. Therefore, any decrease in household expenditures for these industries has a large effect.

Seven industry sectors (in addition to the Government sector) had positive changes to their employment. Administrative Services and Transportation and Warehousing are the only industries with employment job changes greater than 2% (2.3% and 7.6%, respectively). Transportation and Warehousing was the only industry with output values increasing by more than 3%. The gains to freight-dependent industries were expected as more resources are devoted to the transportation of goods to combat congestion. The only freight dependent sectors with losses are the Agriculture and Construction industries. The Agriculture industry losses are negligible; however the Construction industry losses are not. This loss is largely attributable to the industries interdependence with the Real Estate and Rental industry. The Real Estate and Rental sector receives the third largest proportion of household expenditures (17%) and 95% is spent locally. Two non-freight dependent industries, Administrative Services and Management of Companies, show positive changes from increased congestion. Both of these industries provide support services for businesses and benefit from the increased expenditure by freight-dependent businesses.

As congestion levels increase to 30 and 40%, the magnitude of the impacts also increases (Taylor et al. 2012). The relative order of industries being affected by congestion does not change. Health and Social Services continues to take the largest losses in jobs (6.8% and 9.6%, respectively) and output value (7.5% and 10.5%, respectively). Similarly, Transportation and Warehousing gains in employment by 11.7% and 16.4% and output values grow by 9.5 % and 13.4%.

It is important to note that the cost calculations are based on the survey responses and relying heavily on the respondents' ability to forecast cost changes for congestion increases may be erroneous. However, some general comments can be made. As congestion increases, the number of industries negatively affected increases, as does the severity of the losses. For example, at a 20% increase in congestion, 38% of the industries have employment losses greater than 1%; that percentage grows to 43% when congestion increases by 40%. The average negative employment effect for those industries, changes from 3 to 4% up to 6 to 8% as congestion increases from 20 to 40% (Taylor et al. 2012). Correspondingly, the industries that gain from congestion have average employment increases of 5% and 7to 8% at congestion levels of 20 and 40 %, respectively (Taylor et al. 2012).

Regional Model

The trade flow matrix derived from the Washington-regional IMPLAN models contains a vast amount of information on where goods are produced and used. These data allow us to allocate consumer costs and societal benefits in the region where they are accrued. Thus, the magnitude of the congestion impacts varies significantly across the regions. Table 5 shows the total effect of congestion for the three primary metrics in each region. All of the regions are negatively affected by increases in congestion, but the Puget Sound region faces the largest costs in absolute and percentage terms. Their output decrease of $3.6 billion (0.8%) is greater than all other regions combined. The industries affected the most in each region closely follow the state level results (Taylor et al. 2012). At 20% congestion increases, 10 of the industries in each region have total employment and output effects of plus or minus 1% of their baseline levels. For the industries with losses in excess of 1%, the average employment and output effects range from 2 to 4 % of the baseline level. Health and Social Services, Educational Services, and Arts-Entertainment-Recreation industries consistently have the largest percentage losses in all of the regions. The Real Estate and Rental industry appears in four of the seven regions as the second most affected for output losses. The Accommodation and Food Service industry ranks as the third most affected industry in the Puget Sound and Southeast regions for employment losses.

The Administrative Services and Transportation and Warehousing industries consistently have the highest gains from congestion across the regions (20 % congestion increases). Wholesale Trade and Mining industries also appear in at least two regions as one of the top three gaining industries. For the industries with gains in excess of 1%, the average employment effects range from 3 to 6% and output effects range from 2 to 5 % of the baseline level.

CONCLUSION

Washington's economic vitality and livability depend on reliable, responsible, and sustainable transportation. Maintaining the transportation system at a level that allows for the safe, efficient movement of freight is an important component of this sustainable system. To this end, the findings of this study suggest several "lessons learned" and recommendations for WSDOT.

Congestion causes freight-dependent businesses, such as manufacturing, retail and wholesale trade, agriculture, construction, and timber/wood products, to operate less efficiently by increasing the amount of time for each truck trip and increasing the time that trucks (and drivers) spend in traffic; thereby, spending time in an unproductive manner. This study estimates that a 20% increase in congestion experienced by commercial trucks would result in over $14 billion of increased operating costs to Washington's freight-dependent industries. Since many freight industries have the ability to pass on their rising transportation costs in the form of higher cost goods, consumers and service industries may feel the biggest impacts from increasing congestion. When multiplied into economic impacts, this translates into losses of over 27,250 jobs (0.70% of statewide total) and $3.3 billion (0.51% of statewide total) in economic output (2011 dollars).

The results suggest that economic impacts of rising congestion will be felt in every region of the state. However, they will be the most acute in the central Puget Sound Metropolitan region. The investment prioritization process should take this into account when selecting the most efficient projects to alleviate congestion. An increase of 20% over today's congestion levels is projected to cause more than 21,700 job losses (0.90% of the Puget Sound regional total), as well as decreased regional output of over $3.6 billion (0.82 % of the Puget Sound region's total output). The other five regions in Washington State would see decreased regional output of between $31 million and $290 million (between 0.21 % and 0.80 % of each region's total output), and would cause each region to lose between 345 and 2,200 jobs (between 0.31% and 0.77% of each region's total jobs).

These demonstrated economic impacts suggest that WSDOT should prioritize investments that enhance mobility for trucks and freight industries as a way to support the state's goals of a strong economy. Washington State law directs public investments in transportation to support economic vitality, preservation, safety, mobility, the environment, and system stewardship. A demonstrated economic link between truck congestion and increased costs to consumers and industry means that WSDOT could prioritize investments to enhance the mobility of trucks.

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ENDNOTES

[1]The population for the survey consisted of all businesses registered in the State of Washington and companies in freight dependent sectors or designated as owning and operating trucks or other freight vehicles in Washington State. The population list sent from the employment security department (ESD) included a total of 83,000 cases. After SESRC removed 9,519 obvious duplicates and substantially incomplete (uncontactable) cases a total of 73,481 businesses remained.

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