Oregon Statewide Model (Gen1)
THE OREGON STATEWIDE MODEL

Analysis of the bridge investment strategies relies primarily on an integrated statewide transport-land use model. This model was developed by ODOT as part of the Oregon Model Implementation Program. The integrated statewide transportation modeling concept was introduced by ODOT in 1995. The intent is for Oregon cities, counties, metropolitan planning organizations and state agencies to work together in using state-of-the-art transportation modeling tools to aid decision-making and policy development.

Background

The Oregon statewide model used for this analysis is a complex set of computer programs and data that describes the relationships between Oregon's economy, land use patterns, and transportation flows. It is one of the most advanced models of its kind in the United States, integrating these elements across the entire state. It was developed as an analytical tool to help policy makers better understand these complex relationships.

The statewide model simulates land use and travel behavior mathematically and relies on various data, such as business sector exports and transportation operator characteristics. This statewide model complements regionally focused Metropolitan Planning Organization (MPO) models. Figure B-I represents the fundamental model interactions, highlighting the interdependence of the economy, land use, and transport.

The core of the model is an input-output economic model of commodities by standard industrial code in dollars. The amounts correspond to the production and consumption of goods and services. As the model distributes these goods and services regionally, it looks for available land or locations that minimize costs for the production (industry) and consumption (households) of goods and services. This is the land use or land allocation portion of the model.

After the production and consumption of activities are located, the model generates the travel required for production and consumption of these goods and services. This travel is translated into vehicle and freight trips on the transportation system. These trips are assigned to travel the system via the least cost available path. As the number of vehicles and roadway congestion rise so does the cost of using the roadways. The model reiterates until there is little change in transport route choices. At this point the model advances to the next time period, where travel costs to obtain goods for production and reach markets for consumption influence purchase decisions and business locations. The model continues operating in this iterative fashion until it reaches a predetermined forecast year. Policies can be introduced at any point for testing.
How the Model Works

The Oregon Statewide Model is a set of computer programs that are run in a linked fashion to simulate changes in the distribution of activities (industry and household) and travel over time. It is implemented in the TRANUS modeling package with some functions being carried out in Excel spreadsheets. The three primary elements of the Statewide Model are an economic model, location model and a transport model. The economic model determines the growth of the state’s economy. The location model allocates production growth among zones and simultaneously determines the amount of trade occurring between zones by economic sector. The transport model converts the trade flows into trips, calculates trip generation by trip type, apportions the trips among modes, and assigns the trips to the road and transit networks. Figure B-2 shows how these models are linked through the economy.

Figure B-3: Sequence of economic, location, and transport modeling
Figure B-4: Schematic representation of input-output model of the economy

Figure B-3 shows how these programs are linked to simulate changes over time. For each time period, the economic model passes final demand to the location model. The location model determines the location of activities and transactions, while the transport model converts the transactions into transportation flows (tons). It simultaneously determines the travel costs between zones. The resulting travel costs are then passed to the location model for the following time period, while consumption cost of goods faced by external zones impact overall next period state growth within the economic model.

The economic model incorporates a model of the study area economy. It is like an economic input-output (I-O) model that includes a spatial dimension embodied in the location model. I-O models represent the trading relationships between sectors of the economy. Each sector of the economy produces goods and services that are consumed by other sectors of the economy. Products flow in one direction, dollars in the opposite direction. This is illustrated in Figure B-4.

Some of the goods and services that are produced are purchased by other economic sectors for use in their production processes and are called intermediate production. Other goods and services are exported from the area or are sold to private individuals or government. These are not used to produce other goods or services and are called final production. Every increase in final goods production induces a chain of intermediate goods production. For example, the production of houses by a construction company requires the production of lumber by a sawmill, which requires the production of saws and other machinery. I-O models track these production and consumption relationships and allow induced demand to be calculated from changes in final demand. The Statewide Model is based on an I-O model produced by IMPLAN. This is a system of software and data sets
originally developed by the U.S. Forest Service for policy analysis and now maintained by the Minnesota IMPLAN Group, Inc.

The economic model simulates the growth of the economy based on increments in exports. Baseline increments are assumed in each five-year period, to replicate Office of Economic Analysis (OEA) state employment forecasts under nominal conditions. However, actions that impact the cost of producing goods in Oregon, such as bridge restrictions on trucking costs, can affect the demand for exports with subsequent impacts to the economic production and demand for labor within Oregon. Specifically, the model assumes that if bridge limitations result in a one percent increase in consumption costs for those outside of Oregon to buy Oregon goods (external zones), they will buy one percent less with a resulting decrease in Oregon production (i.e., unitary elasticity in the demand for exports with changes in external consumption costs). Economic model final demand and production growth increments by industry sector is passed to the location model to be used in the next five-year period.

The statewide model adds a spatial dimension to the I-O model. In addition to calculating total induced production for the model area, it determines where the induced production is most likely to occur. This is done through a chain of computations that consider cost of producing and consuming the goods and services in different zones. Production/consumption costs are in turn affected by land prices and transportation costs. The chain starts with forecasts of the growth of final production for all goods and services by each economic sector for the analysis period (five-year increment).

These forecasts were derived from population and employment forecasts developed by OEA. The process of forecasting final demand started with the extrapolation of recent changes in employment by economic sector. The results were modified based on national economic trends, such as the growth of service industries relative to other industries, and state employment forecasts. Then, final demand was incrementally increased while monitoring resulting modeled population increases to arrive at a total population forecast that is consistent with the long-range OEA forecast. It should be noted that although the resulting population forecast in the base model matches that of the OEA closely, the forecast of employment is high. That is to be expected because the economic model is static and therefore does not anticipate changes in labor productivity. The OEA forecasts, on the other hand, are based on trends that implicitly account for increasing labor productivity. This difference is not significant, however, because the study’s purpose is to compare the relative effects of policy alternatives, not to forecast future conditions.

The forecasted increments of final demand are then allocated to zones based on the proportions of the total sector production in each zone and the price of production in each zone. The model component that does this was calibrated from 1990 and 1995 economic data. After the growth of final demand is allocated by zone, the statewide model computes induced production and allocates that to zones based on the cost of production in each zone. The zonal production costs depend on the cost of consuming intermediate production from other zones, which depends on transportation costs. It also depends on the cost of consuming land in the zone that depends, in turn, on supply of land in the zone and the aggregate demand for using it. The model cycles through numerous iterations of calculating induced production by economic sector, allocating the production among zones, determining if land constraints exist, and adjusting prices. This goes on until the change in prices from one cycle to the next is very small.
The results of the location model are the allocation of annual production in dollars by economic sector to each zone. Annual production in dollars is converted to employees based on current labor productivity rates by sector ($/employee) and households ($/household). The location model also produces a set of annual dollar flows of goods and services by zone and by economic sector. These monetary flows are converted by another program into transportation flows (e.g., daily tons of freight).

The transportation model takes the transportation flows, assigns them to paths and computes transportation costs. It does this through several steps. First, a set of possible pathways between each pair of zones must be determined for each type of trip and each mode of travel. The model identifies several distinct pathways for each combination of zones, trip type and mode. As pathways are determined, the cost of traveling each of them is computed. The cost includes the amount and value of travel time (including driver wages), distance-related costs (including tolls, weight-mile taxes, vehicle maintenance) and transfer costs. Next, the model calculates the number of trips of each type to convey each transportation flow. This trip generation component of the transportation model considers trip generation as a function of the cost of travel (elastic trip generation). For example, a business located in a more remote location may make fewer trips to transport the same amount of goods to market than will a business located in a more accessible area. In this way, the model considers how increased costs due to congestion can suppress trip making and how new facilities that reduce travel costs can induce trip making.

Following trip generation, trips are split among modes and assigned to the pathways determined previously. In the statewide model, the modal structure is simplified, consisting only of passenger and truck freight modes. Once mode splits are determined, trips are assigned to pathways based on the relative costs of traveling by each of the paths. The resulting assignment of trips is then evaluated to determine levels of congestion and how congestion affects travel costs. This results in a recalculation of travel costs for each of the paths. The program then cycles back to the trip generation step to refigure trip generation rates based on the recalculated travel costs, then to mode split again, then trip assignment and back to recalculation of travel costs. This cycle is repeated over and over until there is very little change in trip assignments from one cycle to the next.

The results of the transportation analysis are tables of trips and costs between zones by mode and type. Another program converts these tables into interzonal costs that the activity model uses for the next 5-year period of analysis.

A convenient way to summarize the overall structure of the statewide model is provided in Figure B-5. This figure depicts the interaction among the major model elements. The top box represents the economic flow in the model, primarily based on IMPLAN Input-Output data. The 12 industry sectors and 3 household income groups are identified as both consumers (rows) and producers (columns) in the Oregon economy. These economic flows are based on fixed demand coefficients, each of which is indicated by an "f." The demand coefficients, or technical coefficients, are derived from the Input-Output matrix of monetary transactions representing the Oregon economy. Land is also consumed (column), but its demand is modeled as elastic ("e").
The arrows leading to the lower box represent the translation of economic flows into transport flows through a land use-transport interface. The economic flows contributing to each transport demand category are indicated by the numbers in the Transport Flows matrix of Figure B-5. Transport categories 1-3 are commuter flows that travel between households and industry. Non-commuter flows are represented by transport categories 4-7, related primarily to the service, retail and government sectors. Freight demands, category 8-10, are dominated by activity in the remaining sectors. The lower right box represents the transport modes within the model. Arrows leading to it represent the accommodation of people or freight in particular vehicles.
OREGON MODELING IMPROVEMENT PROGRAM PEER REVIEW PANEL
APPRAISAL OF MODEL VALIDATION

Integrated land use-transport models are ideally suited for examining the widely acknowledged but often poorly quantified relationships between these important and complex realms. The impetus for the Transportation and Land Use Model Integration Program (TLUMIP) was a list of policy and investment issues facing the Oregon Department of Transportation. Many of these issues were associated with interdisciplinary topics such as growth management, sustainable development, modal tradeoffs and their economic consequences, and of course the synergy between land development and travel behavior. None of these issues can be studied or usefully analyzed using only traditional travel demand forecasting models.

The first generation TLUMIP statewide model was built upon a proven foundation. Aggregate models of the type developed in Oregon had been successfully applied elsewhere around the world, although almost none at the geographic scale attempted in Oregon. They have been successful at addressing many complex issues involving economic, land use, and transportation elements. The Bridge Limitation Study currently being studied by the Department is an excellent example of the complex, dynamic issues that can be usefully studied with such models. We commend the Department for their foresight in applying the model in such settings.

The Department has asked us to address the issue of model validation, and the practical implications for interpreting the modeling results. This was a topic of earnest discussion early on in our review of the TLUMIP work plan. A considerable amount of experience has been gained in the calibration and validation of traditional urban travel demand forecasting models, including the most relevant criteria for assessing their validity. Comparable experience with integrated land use-transportation models, which are considerably more complex with respect to the interactions they portray, has not yet been gained. Several objective criteria for model validation were decided upon, and the first generation models were rigorously assessed in terms of them. We found that the models met or exceeded the validation targets, suggesting that the models were robust and ready for trial and implementation. Indeed, this last phase of validation-assessment of model performance in real-world applications—is an important indicator of the model’s validity.

The modeling process outlined in the Bridge Report is a well thought out and relevant application of the model. The results presented in the Appendix of the report suggest that the model is providing intuitively sensible results that are consistent with its validation. The decisions made by the Department should of course incorporate information from other sources as well. The evidence suggests that the TLUMIP models are providing useful results that should inform decision-makers about the issues at stake.

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OREGON MODELING STEERING COMMITTEE
ASSESSMENT OF STATEWIDE MODEL APPLICATION

The Oregon Modeling Improvement Program (OMIP) was developed to consider the broad changes that are required in how we work together to make decisions, the number of interactions that must be considered in this decision-making process, and the tools necessary to provide solid information for efficient and effective decision-making. OMIP brings together local, state and federal agencies, and private interests who have expertise with and/or will use the modeling products.

The Oregon Modeling Steering Committee (OMSC) is an integral part of the OMIP and provides a high level of cooperation among metropolitan planning organizations, state agencies and the federal government. This results in broad problem-identification and problem-solving collaboration. The data and analysis tools available to decision-makers are uniform statewide and supported by the federal government as a result of this collaboration. Development and application of the statewide model is a significant part of the OMIP and OMSC has provided continued oversight for implementation of the model. For complex projects, a subcommittee of the OMSC is generally established as a technical resource and to review parameters and results for reasonableness and accuracy.

The OMSC was instrumental in providing technical review and recommendations for the first application of the statewide model for the Willamette Valley Livability Forum (WVLF) Alternative Transportation Futures Project in 1999-2000. This type of high-level policy analysis was a good first application of the statewide model for the OMSC to understand how it works, to evaluate parameters used in the model, and to analyze reasonableness of results. The ability to include economic considerations in transportation decision-making was an important element of this project. This was a successful application of the model and was recognized by the WVLF as a significant decision-making tool for assessing complex policy choices.

Since then, the statewide model has been applied to other projects. Two examples include evaluating the feasibility of diverting traffic from I-5 in the Willamette Valley to Central and Eastern Oregon and to encourage growth in those areas. It was also used to evaluate induced growth pressures on rural Yamhill County as part of the Newberg-Dundee Bypass Environmental Impact Statement. For both projects, the statewide model provided information that is not available through standard modeling procedures.

The current Oregon bridge problem is the type of issue that the statewide model was developed to address. The ability to evaluate the economic and transportation results of different funding strategies and improvement packages, when combined with other traditional engineering analyses allows decision-makers to make informed decisions on this important infrastructure issue. The application of the statewide model to the bridge project provides information on economics and transportation that would not be possible given current methods of economic analysis and standard modeling tools. The results of this analysis are sensible and provide information to help decision-makers make informed choices for significant expenditure of public funds.

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