Sensitivity Testing with the Oregon Statewide Integrated Model (SWIM2)

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Abstract. Oregon has a long history of developing and using integrated economic, land use, transport models. Development of the Oregon Statewide Integrated Model (SWIM) was commissioned by the Oregon Department of Transportation as part of its Transportation and Land Use Model Improvement Program (TLUMIP) within the larger Oregon Modeling Improvement Program (OMIP). The first version model, now named SWIM1, was used on numerous applications since the late 1990s. A more extensive second version, SWIM2, is now available. It uses the PECAS economic input-output activity allocation framework, an aggregate model of spatial development and micro-simulation models of freight and person transport. This paper describes the work done in the later stages of development of the SWIM2 model, including results of sensitivity testing, and reports on concurrent actions to transfer the model to agency operation. The sensitivity tests considered three alternative scenarios, comparing them to a reference case, covering the evolution of the statewide spatial economic and transport systems over an 19-year period. In one scenario, highway capacity was increased substantially along an interstate corridor radiating out from the Portland metropolitan area for more than 100 miles. In the other two, the costs for vehicle travel were increased four- and ten-fold over 1998 costs. The model system was found to respond consistent with a priori expectations. Population and employment shift to areas of comparatively better accessibilities, urban densities change, trip lengths and modes change, and floorspace development and prices respond to these changes in patterns that evolve across the state over time.

Word Count
250 Abstract
4,499 Document (including references)
3,000 3 Tables, 9 Figures @ 250 word each
7,499 (7500 max)
INTRODUCTION

Several mandates introduced in the 1990s created the impetus for Oregon to develop tools to meet the analytical needs introduced by the mandates; including amendments to the Clear Air Act, Transportation Efficiency Act (TEA 21), the Oregon Transportation Planning Rule, and Oregon growth management and quality communities’ policies. Policy-makers started looking beyond roads to discuss the entire system, linking land use, transportation and the economy. Analytical tools to facilitate these holistic discussions did not exist at any practical level. Since that time several integrated land use transport models have been developed to fill this role. These include MEPLAN, TRANUS, DELTA/START, and others, as discussed in various scans contrasting these and other model frameworks. [1-5]

In 1995 ODOT initiated the Oregon Modeling Improvement Program (OMIP) to support the development and enhancement of planning tools needed to address the complex issues and relationships between transportation and land use. [6] In 1996, the Oregon Department of Transportation (ODOT) embarked upon the Transportation and Land Use Model Integration Project (TLUMIP). The goal of the TLUMIP program is to build and apply models to understand and predict the dynamic nature of policy impacts on the economy, land use and transportation. The approach was to expand upon modeling state-of-the-practice that was driven by economics, in order to be sensitive to the policy issues of the state. The TLUMIP approach is application driven, learning from past model development and applications.

Initial model development was streamlined and desired capability and enhancements noted for future development tasks. Thus, the first generation Statewide Integrated Model (SWIM1, a customized TRANUS framework [7-8]) and urban area model (UrbanSim [9]) were developed as an initial platform and proof-of-concept in the late 1990s. SWIM1 has been used in five major state and regional policy applications within Oregon since 2001[10-14]. Building on the experiences with SWIM1, ODOT embarked on a more extensive SWIM2 model. The original plans for the SWIM2 were very ambitious [15-17] and later scaled back to meet timelines for anticipated analysis [18]. Even so, the current endeavor represents one of the most ambitious efforts to date to develop an integrated economic, land-use, transport model of an entire US state.

SWIM2 has recently completed a multi-step calibration. This included calibration of the individual sub-models in isolation; assembling, running and calibrating the modules together as a full model; and testing the full model for a baseyear and over time. The focus of this paper is presentation of results from three model scenarios, with a brief discussion of full-model over-time calibration efforts. Additionally, information is shared on some of the practical, often overlooked, challenges required to prepare the model for Agency-led policy applications. The information shared within this paper is likely to be of interest to modelers considering or pursuing integrated models or similar policy questions. Additional information on the SWIM2 model development [15-18] and its review and guidance by an International Peer Review Panel with expertise in integrated modeling [19-20] can be found in the references.

OVERVIEW OF SWIM2

The Oregon Statewide Integrated Model (SWIM2) structure is shown in Figure 1. The top half of the figure shows the spatial activity model, which starts with a regional economic model (ED). The model-wide construction and industry activity totals are then allocated to zones (3000 zones in Oregon and surrounding counties) (floorspace development allocated in ALD, industry activity in PI), using a spatial input-output model that respects economic relationships among businesses and households, and responds to price signals and travel costs. PI is an earlier version of the PECAS model [21-22], while ALD is an aggregate land use model. A synthetic population is then developed (in SPG) consistent with the employment totals. Home and work locations are assigned consistent with the labor flow patterns from PI. It should be noted that there is currently no feedback to the economic model. Thus the regional economic activity is not impacted by changes in land use and commodity prices resulting from location decisions and travel costs in the rest of the model. SWIM2 operates using a system of geographic zones that cover the entire state of Oregon and a ‘halo’ of about 50 miles including counties immediately adjacent to the state boundaries. This system is shown in Figure 2.

The bottom half of the figure shows the transport components of the SWIM2 model. They include micro-simulation tour-based models of personal travel (PT) and commercial/goods movement (CT), and simple model of external truck travel (ET). PT simulates daily activity patterns and resulting trips for over 5 million people in the study area (from SPG’s synthetic population). CT translates the flow of goods (in dollars from PI) into vehicle trips,
combining shipments for a typical weekday. The resulting vehicle trips are assigned to the network using a standard equilibrium approach.

An integrated model is significantly more challenging to calibrate than a standard transportation model. The addition of the economic and land use dimensions lead to a large number of potential calibration targets, not all of which are consistent with each other. The calibration targets typically don’t fall on a single year, e.g. US Census years do not align with household interview and US commodity flow survey periods. Additionally, some inputs, such as base-year floorspace inventory are unavailable and must be synthesized by various model components for use by other model components (e.g., floorspace prices by zone), introducing additional errors into an already complex process. The development team must attempt to have the model respect the various target datasets while being keenly aware of their variation in confidence levels and the inability to meet all targets with a high degree of accuracy. Integrated model calibration is an iterative development process, where at each cycle the level of accuracy of all models is incrementally increased, thus avoiding throwing any one module and its downstream effects too askew. Given these issues, more emphasis is placed on examining the overall behavioral response of the model to likely policy applications, such as the scenarios described in this paper, rather than focusing on a tight match to any set of static target data.

A three-stage calibration process was used to develop parameters values for the various SWIM2 modules. In Stage 1, statistical methods were used to estimate appropriate parameter values from available observed data such as household, which are expected to remain fixed. In Stage 2, initial values were established for all remaining parameters – considering the fit of each module in isolation. This required development of inputs for all modules, including those provided exogenously and estimates of those to be provided by other modules. The Stage 2 calibration consisted of adjusting the parameters of a single model in order to best fit module-specific targets. In Stage 3, parameters were further adjusted for all of the modules simultaneously, considering the fit of all modules running together. At this Stage most the models operate in sequence, as would be expected during full model application. The SWIM2 Stage 3 calibration period is 1990-2000, enabling comparison of the model output to 1990 and 2000 Census data. The full model was wholly integrated to run as a unit, and the results assessed against targets and trends.

Stage 1 and 2 and the initial work of Stage 3 calibration is now complete. SWIM2 is able to reasonably replicate baseyear (1998) targets as well as over-time trends for a 1998-2006 time period. The baseyear model output compared well against observed zonal employment and population, county-to-county labor flows, statewide tonnage by commodity, trip lengths (goods, person tours by purpose, and trucks by commodity), mode split by trip purpose, trip rates (tours per pattern, trips per tour), and screenline traffic count. The 1990-2000 10-year calibration assessment is ongoing. Further detail associated with the model calibration was presented at the Fifth Oregon Symposium [19].

As noted above, as an extension of the formal calibration of SWIM2, policy sensitivity tests were conducted to assess the behavioral response of the model to various input changes. The following tests were performed for an 19-year period (2006 to 2024):

- **Increased Highway Capacity:** Oregon Interstate 5 (I-5) runs north/south through the state and serves as the major west coast corridor connecting Mexico to Canada. Congestion in this corridor inhibits person and goods movement, especially in the Willamette Valley where over 70 percent of the state’s population resides. This scenario consists of increasing the number of lanes on I-5 and I-205 from two or three lanes in each direction to four lanes (five lanes if four lanes already existed) in each direction. The new lanes were added on I-5 from Eugene, OR north to the I-5/I-205 interchange, all of I-205 through the Portland area and into Washington State until rejoining I-5. This represents a significant increase in highway capacity along 100 miles stretch in the Willamette Valley.

- **Increased Travel Costs:** Costs equivalent to a four-fold and a ten-fold increase to the 1998 cost of travel were assigned to each highway/road network link across the entire model area.

By design, each scenario consisted of an unrealistically large change, in order to clearly delineate the direction of the impact on the rest of the system. These “proof-of-concept” tests reveal how the model responds to changes in the policy levers built within the model.
PREPARATION FOR MODEL APPLICATION

The intention of the Oregon modeling program has always been to develop tools for Agency staff to perform policy analysis. The true success of the program is therefore measured by the usefulness of these tools in making informed policy decisions. Model development is the first phase of creating this functionality. Model implementation is a distinctly different phase requiring as much effort as the development phase. Preparation for model application must be approached with careful consideration of the practical aspect of modeling real-world policies. Thus, the undertaking of model sensitivity testing was combined with initial model application preparation to transfer this knowledge from the development team to the model application team.

The model was implemented at the ODOT offices as part of the sensitivity testing and final phases of model calibration. Once the model was ready for performance evaluation, a strategy was formed to move from the development phase to model application. Several tasks were identified as necessary preparation for real-world policy applications.

- **Training.** Agency staff needs to be trained on how to use the model. Scenario set-up and familiarity with the graphic user interface is necessary for staff to run the model independently. This training will be provided as the team works through the evaluation scenarios; continuing support will be needed once the model is in use, with reduced outside support needed over time.

- **File Management.** File organization and archiving are very important aspects of modeling. An 19-year model run produces 65 GB of data, so efficient management of disk space is important. Improvements have been made to organize model files to reduce redundancy and improve user-interface, e.g., separate scenario-specific user inputs and output from common calibrated parameter files.

- **Model Variability.** A solid understanding of the model responsiveness to specific policy-levers and variability due to micro-simulation is important before going into policy application. The test scenarios were designed to reveal model responsiveness, identify performance issues and push the model beyond likely real-world changes to understand the limits to the model’s performance.

- **Output Processing.** A major task associated with the evaluation of the test scenarios is creating automated scripts to summarize model output in a form useful for reviewing, interpreting and reporting model results. This also allows savings in model run storage space (e.g., currently 5-10MB for 19-year model run) if the summaries can replace the full model outputs. Some functionality will be added to the model itself in the future, as well as use of other data processing tools to facilitate output processing and runtime.

RESULTS OF SCENARIO 1: INCREASED HIGHWAY CAPACITY

The study area is the state of Oregon and adjacent counties in neighboring states. Seventy percent of Oregon (population 3.7 million in 2007) live in the Willamette Valley, which includes the metropolitan areas of Portland-Vancouver (2.1 million persons), Salem/Keizer (378,000 persons), Corvallis (85,000 persons), and Eugene-Springfield (343,000 persons). Figure 2 illustrates the Willamette Valley in blue. Other key Oregon cities include Bend (160,000 persons) in central Oregon on the east side of the Cascades mountain range which partitions the state vertically, and Medford (202,000), in Southern Oregon. In the Increased Highway Capacity Scenario, I-5/I-205 highway capacity was increased to four or more lanes from the current two and three lane capacities. The change was made in the corridor extending from Eugene north to the I-5/I-205 interchange south of Portland and continuing on I-205 north through Washington State until joining I-5 again. We hypothesized the following model responses to an increase in highway capacity within the Willamette Valley:

- Reduced travel times along corridor
- More growth in urban Willamette Valley
- Greater dispersion of households
- More long distance commuting
- Lower floorspace prices in Portland, higher in outlying areas

Modeling results support these expectations and provide additional insights. Increasing Willamette Valley highway capacity leads to higher residential growth within the southern-Willamette Valley (Eugene and Corvallis), the Portland metropolitan area, and statewide relative to the Reference case (Figures 3). Salem, located in the middle of the valley experiences only limited change in growth patterns. Eugene, located at the southern terminus of the new capacity, clearly gains the most (5 percent over reference case) with its improved accessibility to other Willamette Valley population centers. The two MPOs outside of the valley (Rogue Valley/Medford and Bend) lose residential
growth slightly (1-2 percent) relative to the Reference scenario. Overall, increasing I-5/I-205 capacity further concentrates statewide activity within the Willamette Valley, as Figure 4 show graphically for year 2024. Some additional growth spills south of the Willamette Valley and the coast as the capacity improvements makes these areas more connected to the dominant Willamette Valley economy.

Employment growth patterns are similar to the residential patterns in both location and magnitude, as illustrated over time in Figure 3. Eugene again has the largest increase in employment though slightly less than for households relative to the Reference scenario. There is some oscillation over time in the Salem and Corvallis areas, as the model adjusts for the higher accessibility gained from increased highway capacity over time. Corvallis has strong economic ties to Albany, a bedroom community due east, likely allowing Corvallis to accommodate more employment growth. The model seems to be perpetuating the jobs-housing imbalance, reacting to the tighter urban growth boundary in Corvallis where businesses often out-bid residential uses and agglomerate in centralized urban locations.

These geographic shifts in activity are also reflected in the 2024 floorspace prices and supply relative to the reference scenario, as illustrated in Table 1. The amount of 2024 floorspace in the Increased Capacity Scenario is slightly greater than the reference scenario across the state in general, except for the smaller MPOs outside the Willamette Valley (Rogue Valley and Bend). This is consistent with the change in household and employment growth. The minimal change in floorspace prices indicate that the model is adding floorspace in balance with the increase in demand, as expected. The non-residential floorspace quantities and price changes are more muted. Prices are slightly lower in most areas of the state, except for slight increases in Portland and Corvallis. Eugene is especially interesting to look at since the employment growth is fairly high, yet floorspace prices remain the same as the reference scenario.

Table 2 illustrates year 2024 truck trip length and travel times across the state and within the Willamette Valley. The Increased Capacity scenario shows slightly longer truck trip lengths relative to the reference scenario, while truck travel times are about seven percent shorter. Thus, the capacity improvements lead to significantly faster truck travel times. No discernable parallel impact was identified in person trips, as shown in the constant time and distances of Table 2 auto tour results. This is consistent with the lack of change in mode split (Table 2 and Figure 5).

RESULTS OF SCENARIO 2: INCREASED DRIVING COST

Auto and truck travel costs were increased four and ten-fold relative to the 1998 base year costs for 1990 and modeled as costs on the network links. These high travel costs are roughly equivalent to an $8 and $20 per gallon fuel price, respectively. We hypothesized the following model responses to increased travel costs:

- More compact urban development
- Less intercity commuting
- A larger proportion of economic activity attracted to Portland
- Higher floorspace prices in Portland
- Higher share of transit and non-motorized trips
- Shorter trip lengths

Increasing the driving costs so dramatically on all model roadways was a significant test for the model. Because the model has no feedback to the region-wide economic totals, a fixed set of activities had to be allocated within the model region (Oregon + adjacent counties), despite the high travel costs. As shown in Figures 6 and 7, a significant shift occurred in the location of activity within the state in the two Increased Cost scenarios relative to a Reference case. A large amount of activity (households and employment) was attracted to the centrally located cities of Salem and Bend, while southern Oregon activity concentrated in Rogue Valley. Corvallis had significant household growth relative to the Reference scenario, rebalancing its historic employment focus. Only minor change (2-3 percent) was observed elsewhere.

It is interesting that with higher driving costs the model finds the attractiveness of Salem increasing relative to nearby Portland. Salem, Rogue Valley, and Bend are all more centrally located within the study area making them more attractive geographic locations to remain accessible in the face of high driving costs. The model seems to suggest that the inertia of growing along existing urban patterns is overshadowed by the need to reduce travel costs. As a result, new activity centers are carved within the state which favors transit-accessible locations. A similar
growth pattern occurs in the more extreme 10-fold Increased Cost scenario, with the same cities again showing activity gains over the reference scenario, with additional losses in Metro Portland and non-MPO areas.\footnote{It should be noted that growth percentages can be misleading as a 1 percent change in the much larger Portland area is equates to significant growth in these smaller cities (e.g., 5 percent in Salem or 25 percent in Corvallis).}

Overall MPO growth trends hide shifting occurring within the urban area as seen graphically in Figure 8. An MPO rarely completely gains or loses activity relative to the Reference case, instead comprising a mix of changes. This is best exemplified in the 10-fold employment plot, where central Portland gains, but larger losses elsewhere in the region leading to a small net loss (Figure 7). In general the growth seems to be in downtown areas, drawing from the hinterlands, as would be expected.

One interesting finding is the impact of the model’s fixed economy assumption on the results. SWIM2 includes a ‘halo’ of counties adjacent to Oregon to capture boundary effects. However, the halo appears to act as a reliever of the model’s economic pressures. In the Increased Capacity scenario, growth in the Willamette Valley from increased accessibility led to declines in the halo, which would be more correctly handled by an increase in the model wide economy. In the Increased Cost scenarios, the impact is dramatic. Under the 4-fold costs, centralization to regional cities occurs, pulling with it much of the halo population. Thus, all Oregon regions report growth (Figure 6). If the economy were responsive, a sharp reduction in modelwide growth would provide a more realistic pattern of growth and decline within Oregon. With 10-fold costs, travel so prohibitive internally that access to the model’s import/export markets become more attractive (no driving cost increase imposed externally) leading to growth in the halo areas accessible to the largest, closest external markets. This shift to these export gateways means less growth in Portland and non-MPOs relative to the other scenarios.

Table 3 shows that the land use model has responded by increasing floorspace quantities to meet the growth in activity, with Rogue Valley, Salem and Bend residential development reporting the strongest gains relative to the Reference case. The model is more challenged in meeting the demand for residential space, needing to increase prices 30 percent on average in the 4-fold case. The higher than average price increase in the high-growth Salem area could an inability to respond quickly enough to Salem’s growth in demand under these scenarios. Non-Residential demand, in contrast, can be accommodated in a much more modest price increase. The difference between residential and non-residential price increases is under investigation, possibly due to aggregation of floorspace types or across the full MPO region, inertia imbedded in the allocation of the annual construction dollars budget, zoning compatibilities that allow residential to push out other uses, and higher non-residential base prices. In the ten-fold scenario, the model increasingly struggles, building twice the amount of new housing but still lagging demand, as indicated by an average residential price increase of 60 percent. Salem exhibits even higher prices, possibly due to Salem zoning constraints or the non-linear nature of the model’s floorspace price functions.

In addition to statewide shifts, a significant increase in zonal activity densities occurred within the urban areas (Figure 9). The centrally located cities of Rogue Valley, Salem, and Bend show a pronounced densification, as clearly indicated by the shift in the density curves. This reflects the immense shift of growth to these regions and the resulting, more compact, development required to accommodate it.

As would be expected, changes in trip lengths and travel times with the Increased Cost scenarios were more dramatic than the earlier Increased Capacity Scenario, as shown in Table 2 and 3. Average truck trip lengths across the state decreased 4 percent while truck trip times were 10 percent lower model-wide with the 4-fold Increased Cost scenario. The shorter trips put less vehicle miles on the roadway system, leading to higher average speeds than the Reference case despite no increase in capacity. Auto tours were quite a bit shorter in both distance and time (30-40 percent less), indicating the expected higher sensitivity to transport costs relative to commercial traffic.

The higher travel costs had a significant impact on person travel mode choice (Table 2). As expected, there was a significant shift away from auto towards other modes, particularly walk/bike. With walk tours limited to 6 miles round trip, this is a clear indication of densification even in non-MPO areas. The transit share was certainly limited by unrealistically modeling a fixed supply of transit services. Additionally, only commute travel benefited from transit service, as only these flows used a composite accessibility measure that accounted for all modes.

The work reported here concerns the behavior of a model of Oregon. In the strictest sense the indications that are obtained concern just this model specifically. But the reasonableness of these indications do have some broader
implications - in particular, that a comprehensive statewide integrated model of this sort can be developed and implemented in a practical working situation. Other agencies actively or considering the development of similar integrated models should be encouraged.

It should be re-iterated that the significantly high travel costs results are likely somewhat altered because of the static overall economic activity model-wide. In some cases, such as travel times, results can be muted. In other cases, such as the growth and density shifts in Salem and elsewhere, effects might be amplified. Notwithstanding, we are encouraged by seeing the model respond in the directions expected.

CONCLUSIONS

The performance of the Oregon SWIM2 integrated model is judged a success on the basis of the testing done so far. The direction of predicted changes as well as relative magnitude pass the initial test of reasonableness, but further investigation is to be carried out as the work with the model progresses.

The initial results from the three test scenarios appear reasonable over multiple dimensions. Higher transport costs across all highway modes caused growth to shift into the denser urban areas of Oregon. The number and distance of trips increase. Adding capacity to the populous area of the Willamette Valley has marginal effects statewide, but noticeable effects within the I-5 corridor. Space prices and development densities responded to shifts in population and employment consistent with expectations.

The changes in the system over time follow patterns that make sense. Population and employment and associated floorspace inventories grow in the most attractive areas responding to price signals. Truck and auto trips respond appropriately to changes in capacity and costs. The ability of the model to capture the walk/bike share is an impressive achievement, a key benefit when modeling dense land use scenarios.

The scenario results highlighted the artificial constraint of assuming a fixed economy where growth in one region means declines elsewhere within the model area, or tapping links to external markets. The effect within Oregon was mitigated somewhat by including a halo of zones within the study area. Still the halo is artificially placed in the role of major economic actor. The results with the Increased Cost scenarios in particular suggest an elastic response within the model’s overall economic activity model (the ED module) is needed – avoiding reliance on the halo to provide this responsiveness.

Several successes have been realized in this modeling work. The model runs over time covering nearly 20 years and accommodating “extreme” changes in the system. Including a halo area around the state border takes on a useful role in mitigating boundary effects. The effort needed to obtain computing capability was well worth the time and expense. Careful consideration and effort spent on sound file management, naming conventions, and organization aided progress through-out. Also key to the understanding of model results is using a base Reference scenario. Creating a valid Reference scenario requires significant time and data collection, but saves resources in the long run.

Clearly, many challenges remain. In addition to evaluating and refining the model with additional sensitivity tests, several implementation challenges remain. Model runtimes are longer than desired. A 19-year run takes 3.5 days to complete and outputs consume 65GB of disk space. An additional three hours are required to process the model output into summary tables and graphs. Convergence became more time consuming in the later years, revealing the potential for longer runtimes for some analyses, and the need for a convergence criteria that expands with increased economic activity. The model produces a large quantity of information, which must be quickly reviewed and synthesized into conclusions to meet the deadlines of policy analysis. A methodical, careful approach to automating the production of data summaries is critical to building an understandable, descriptive story in a timely way.

Overall, the SWIM2 model has demonstrated reasonable behavior, consistent with expectations, in the testing that has been described here. The reasons for confidence in the results and the appropriateness of some further adjustments were identified as intended in a calibration exercise. This testing is judged to have been essential in taking SWIM2 from development to implementation and policy application. Further scenario testing will be key to increased confidence in the model. The initial indications are positive, and the expectation is that a version with the few identified enhancements will be available soon to support Agency policy applications.
ACKNOWLEDGEMENTS

The integrated modelling and analysis work described here was sponsored by the Oregon Department of Transportation (ODOT), and managed by the ODOT Transportation Planning Analysis Unit (TPAU). Funding for SWIM model development has largely been provided by the Federal Highway Administration. The development and initial calibration of the SWIM model within the larger Oregon Model Improvement Program (OMIP) was completed by a consultant team led by Parsons Brinckerhoff, including HBA Specto Inc., and EcoNorthwest. Special thanks go to Alex Bettinardi and Brian Gregor of ODOT for key graphics and analytical input for this paper.

REFERENCES

6. Oregon Department of Transportation (ODOT), Transportation Development Division, Transportation Planning Analysis Unit (TPAU), “Oregon Modeling Improvement Program – Statewide Model,” presentation to the Oregon Transportation Commission. (May 2001)


Figure 1. Oregon Statewide Integrated Model (SWIM2) Structure

Figure 2. Oregon Statewide Integrated Model (SWIM2) Model Area
Figure 3: Increased Capacity relative to Reference case: Total Activity by MPO over time

Legend

- Total
- Metro
- SalemKeizer
- Corvallis
- EugeneSpringfield
- RogueValley
- Bend
- NonMPO
Figure 4: Increased Capacity relative to Reference case: 2024 Map of Total Household Change

Table 1: Increased Highway Capacity relative to Reference case: 2024 Floorspace Changes

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Table 2: 2024 Truck Trip Characteristics

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Figure 5: 2024 Person Tours by Mode and MPO (selected modes)
Figure 6: Four-Fold High Travel Cost relative to Reference Scenario: Total Activity by MPO over time
Figure 7: Ten-Fold High Travel Cost relative to Reference Scenario: Total Activity by MPO over time
Figure 8: High Travel Cost relative to Reference Scenario: 2024 Map of Activity Change
Table 3: Increased Travel Costs relative to Reference case: 2024 Activity and Floorspace Changes

<table>
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<tr>
<th></th>
<th>2024 Increased Travel Cost Scenario relative to Reference Case</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Residential</td>
</tr>
<tr>
<td></td>
<td>HHs</td>
</tr>
<tr>
<td>Metro</td>
<td>-0.5%</td>
</tr>
<tr>
<td>Salem/Keizer</td>
<td>13.9%</td>
</tr>
<tr>
<td>Corvallis</td>
<td>9.1%</td>
</tr>
<tr>
<td>Eugene/Springfield</td>
<td>0.9%</td>
</tr>
<tr>
<td>Rogue Valley</td>
<td>25.1%</td>
</tr>
<tr>
<td>Bend</td>
<td>17.4%</td>
</tr>
<tr>
<td>NonMPO</td>
<td>2.2%</td>
</tr>
<tr>
<td>Oregon</td>
<td>3.0%</td>
</tr>
</tbody>
</table>

Travel Cost Increase (10-fold)

|                | Residential                                                   | Non-Residential                                           |
|----------------|---------------------------------------------------------------|
| Metro          | -8.2%             | -7.53%             | 61.32%           | -4.7%                         | 4.88%       | 0.02%              |
| Salem/Keizer   | 9.0%              | 13.95%             | 164.97%          | 32.0%                         | -0.02%      | 8.12%              |
| Corvallis      | 1.8%              | 1.6%               | 51.06%           | -7.2%                         | -1.48%      | 0.83%              |
| Eugene/Springfield | -2.3%       | -1.42%             | 35.06%           | 2.2%                          | 2.71%       | 0.46%              |
| Rogue Valley   | 23.0%             | 22.13%             | 61.92%           | 16.5%                         | 3.33%       | 0.5%               |
| Bend           | 9.7%              | 9.62%              | 65.73%           | 2.2%                          | 2.74%       | 2.07%              |
| NonMPO         | -9.6%             | -12.17%            | 50.16%           | -8.9%                         | -2.19%      | 2.92%              |
| Oregon         | -5.0%             | -5.32%             | 61.84%           | -2.0%                         | 2.34%       | 1.17%              |
Figure 9: 2024 Zonal Population Densities (persons per acre)

Oregon

SalemKeizer

Reference
mean = 6.92
Driving Cost 4x
mean = 7.96
Driving Cost 10x
mean = 7.61

Corvallis

Reference
mean = 8.34
Driving Cost 4x
mean = 10.39
Driving Cost 10x
mean = 10.89

EugeneSpringfield

Reference
mean = 9.21
Driving Cost 4x
mean = 9.84
Driving Cost 10x
mean = 9.55

RogueValley

Reference
mean = 15.11
Driving Cost 4x
mean = 23.5
Driving Cost 10x
mean = 23.55

Bend

Reference
mean = 8.41
Driving Cost 4x
mean = 10.42
Driving Cost 10x
mean = 10.08

NonMPO

Reference
mean = 3.1
Driving Cost 4x
mean = 3.5
Driving Cost 10x
mean = 3.2