DRAFT VERSION 1

Title: Land Use and Transportation Impacts of the Columbia River Crossing Project – Results from an Integrated Model

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Abstract: Abstract: The Columbia River Crossing Project consists of replacing an existing 6 lane, over-age, I-5 Corridor Bridge with a 12 lane bridge with additional capacity for light rail, bicycles and pedestrians. We used an integrated transportation and land use model (MetroScope) to evaluate the land use and travel impacts of the bridge replacement. We tested three alternatives – a no build baseline, a build with no toll and a build with toll alternative. Overall, the bridge alternatives compared to no build produced impacts as expected – growth was shifted to areas experiencing the greatest travel time savings and real estate prices shifted accordingly; higher in benefited areas and lower in areas receiving little or no benefit. However, the land use shifts were small; 1% for dwelling units and -1.0 – 3.5% for real estate prices. The small changes were consistent with the travel time savings resulting from the project: 1.7% region-wide and 7.0% in Clark County, the most heavily impacted area. Imposing a $2 toll on the new bridge alleviated the land use changes; reduced overall housing prices and shifted demand slightly from single family at the urban edge to multi-family along the I-5 Corridor. Relative to the no build alternative building without a toll increased regional 2030 per capita VMT 0.6% and building with a toll reduced per capita VMT -1.9%.

Keywords: Location modeling, transportation, tolling, induced travel, land use impacts

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Introduction

Purpose

In this paper we report on the results of using an integrated transportation and land use model to simulate the future impacts of an expanded capacity replacement for the I-5 Interstate Columbia River Crossing (CRC). We evaluated the CRC project in regard to three factors widely discussed in the literature and often mentioned in public discussions prior to our study. These factors are induced traffic, impacts on land use and effects of tolling on traffic and land use. Our intent in performing the simulations was to provide substantive answers to questions that have arisen as part of the CRC planning process and have produced substantial controversy and potential project delay or abandonment. A corollary purpose is to provide an example of how the new generation of integrated transportation and land use models may be employed to provide useful information in the context of major infrastructure improvements. To perform the regional traffic and land use simulations we make use of MetroScope, a Portland Metro developed integrated transportation and land use model[1].

Background

The Columbia River Crossing planning process was initiated in 2005 and continues through the present date. As of July "nearly 100 million has been spent on planning alone…"[2]. Figure 1 displays the location and extent of the project as it is presently designed.

Figure 1: The CRC project replaces a 6 lane bridge with a 10 - 12 lane bridge, LRT and pedestrian/bike facilities and connector improvements.

The present design calls for replacing a 3 lane bridge built in 1917 and another 3 lane bridge built in 1958 with a 10 – 12 lane bridge estimated to cost between 3.5 and 4.0 billion dollars depending on configuration. The cost estimates include bike/pedestrian facilities and extending the present light rail line from the Oregon to the Washington side of the Columbia River.

Beyond engineering and design issues, the CRC project has aroused a number of controversies that may be summarized under the headings of induced traffic growth, unintended land use impacts and the efficacy and equity of tolling alternatives. Induced traffic as generally defined in the literature is that increase in traffic volume that results from a transportation improvement reducing travel times (effective price of travel) and thereby producing more travel than would otherwise be the case. Unintended land use impacts may be loosely regarded as the corollary of induced traffic as land uses increase in intensity due to the gain in access associated with the transportation improvement. Finally, beyond being a source of project revenue, tolling alternatives have been proposed as a means of reducing congestion, reducing induced traffic and remedying whatever land use impacts may be associated with a transportation improvement. In the context of the CRC projects all three issues have been cited by opponents and proponents of any particular CRC design.

While these controversies surfaced quite early in the CRC planning process, the planning team was reluctant to directly address the issues of induced traffic and land use impacts and did not release a tolling report until late 2009[3]. It was only in the spring of 2010 after insistence by local officials that the planning team contracted with Metro travel demand and economic and land use forecasting to perform the tests for approximately $70,000. The work was completed within a 5 week period in the early summer of 2010 and involved several runs on a 5 year and 10 year basis of both the traditional 4 step travel model and the MetroScope integrated transportation and land use model.

MetroScope Description

Before getting into the details of the CRC study, it is helpful to provide a brief description of MetroScope, the integrated transportation and land use model used for the study. MetroScope is an in-house model, developed in the late 1990's that has been in continuous use in several versions at Metro since the year 2000. Since 2007 MetroScope has a built in 400 zone travel demand model as well as residential and nonresidential real estate modules. Recent performance allows a complete model run in 5 year increments from 2005 to 2040 in under 15 hours. Figure 2 below provides a highly generalized schematic showing the models various modules and how they operate.

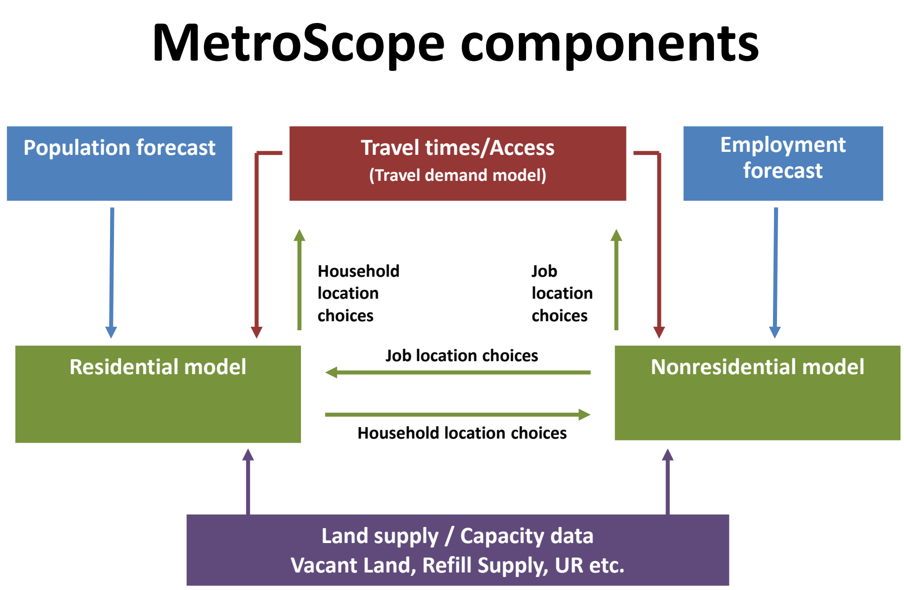


Figure 2: MetroScope in each iteration exchanges information between the transportation demand, residential real estate and nonresidential real estate modules so that all outputs are consistent with one another.

As noted in the schematic, MetroScope uses external region-wide control totals for population/households and employment generated from a region-wide econometric model. Likewise MetroScope uses a set of external policy driven assumptions about land use regulation and supply, redevelopment and infill and the level of urban renewal and subsidy to be incorporated in any particular scenario. The associated travel model in addition to infrastructure capacity provides for tolling, travel demand management and transit options.

MetroScope belongs to a class of market based, aggregate, supply and demand models that determine a vector of real estate prices that equilibrate real estate demand and supply in any iteration cycle while the travel demand model equilibrates travel times over the transport network. Information in any particular 5 year iteration cycle is passed between the residential, nonresidential and transportation modules such that prices, travel and real estate allocations are consistent between modules.

For the CRC study we elected to substitute the far more extensive 2000 plus TAZ travel demand model for the smaller but faster built in 400 zone travel model. This substitution allowed us to include all significant travel network detail and a full treatment of all non vehicle modes of travel. This enabled us to fully reflect the detailed transit and tolling changes associated with the CRC project in both the travel and real estate modules. In return for much greater usable detail, we accepted that the larger model procedure runs much slower; taking up to a week compared to 12 – 16 hours for the code integrated MetroScope version.

Literature Review

Relevance to MetroScope CRC Results

Important to interpreting the results of any urban simulation model such as the traditional 4 step travel demand model or the newer integrated models, is an ability to assess the validity of their results. Internally, at Portland Metro we find it helpful to regard simulation models as but one leg of the 3 legged evidence stool with the 3 legs being: one – empirical studies, two – simulation model results and three- theoretical model results. By way of explanation empirical studies are based on observable data but rarely are controlled or even uncontrolled experiments. Parameter identification, specification, self-selection and scale problems all engender considerable ambiguity in interpreting measurement results. Similarly, most simulation models incorporate some level of theoretical structure in a casual way and also rely on empirically based parameters. In addition, well designed simulation models can be used to “run experiments” with different policy options. However, due to the eclectic and casual nature of their construction, they leave doubts as to the validity of their results. Finally, theoretical models while rigorous and dependent only on well defined parameters, are most usually unrealistically limited and restricted by the requirements for mathematical solutions. As a consequence we regard no one source as particularly compelling and look for support from all three if possible.

We need also point out that the literature in the areas of induced traffic, land use impacts and even tolling (road pricing, TDM, etc.) is very large with 100’s of studies cited. Here we cite but a few of the studies and reviews of studies that reflect a range of empirical, simulation and theoretical results.

Induced Traffic

Littman (2010, p. 9)[4] publishes an extensive review of 22 empirical induced traffic studies and reports a range of "elasticities"[5]from .2 to 1.2. Lower elasticities are interpreted as a short term response to infrastructure induced changes in travel times and high elasticities presume an underlying change in land use to accompany the change in access. Littman in summarizing the studies also notes that elasticities decline as the size of the study area increases. He also points out that traditional travel demand simulation models do not incorporate longer run land use impacts. Fulton, Noland, Meszler, & Thomas (2000, p.13)[6] accounting for a variety of population and density differences estimate an elasticity range of .2 through .6 for the Mid-Atlantic region. Outside of empirical studies both simulation and theoretical models incorporate the outcomes that raising prices (increasing travel times) decrease consumption and lowering prices (decreasing travel times) increase consumption. At any rate it is reasonable to expect the travel response to improved CRC access to be positive but limited in extent.

Impact on Land Use

Littman (2010 (2), p.16)[7] cites several empirical studies of the 1980's illustrating the impact of transportation improvements (freeways of the 50 and 60's) on land use development and densities. Most of these studies based on data from the 50's through 80's cite substantial impacts from the Interstate Highway System (Baum-Snow, 2007)[8]. Iacono and Levinson (2009) [9]looking at recent data report much lower impacts of transportation on land use relative to existing and neighboring land uses. Many empirical studies of the impact of transportation on land use are fairly local in nature such as impact of rail transit on station areas (Cervero, 1993)[10]. Interestingly, most of the large scale studies of the impact of transportation on land use involve the use of simulation models. For instance, Vogt, Troy, Miles, Reiss (2009, p. 91)[11] report real estate changes on the order of -1.0 to 5.0% as travel times were allowed to fluctuate from constant assumptions over a 40 year period using the UrbanSim integrated model. Similarly, May, Shepard, *et.al.*(2005, p. 135)[12] found small impacts of transport strategies on land use in a number of European cities using a simulation model. Weidner, Knudson, Picado, Hunt (2009, p. 114)[13] find that a state wide regime of increased highway capacity dispersed households and employment, reduced central city prices and increased those of outlying areas. Overall shifts of 1 to 2% were observed with increased highway capacity within a 100 mile corridor. Moving to theoretical models the relationship between land use and transportation has always been completely explicit. Since the 1950's (for instance Stevens, 1958, 1960)[14] we have modeled transportation and land use as reverse sides of the same coin – minimizing transportation maximizes location rents – a classic primal-dual programming problem. Large numbers of urban and regional theoretical models have been developed since but the role between transportation and land use has remained pivotal. However, theoretical models provide no guidance on the degree to which land use should change in response to particular infrastructure improvements.

Based on a fairly limited literature review it appears that studies of impacts of transportation improvements on land use conducted on post war through 1980's data, suggest a much larger impact than do studies and simulation models calibrated on recent data.

Tolling Studies

Langer and Winston (2008, p. 156)[15] report on an empirically based study of the impacts of a widespread tolling regime on land use. Based on national data they find that tolling increases urban densities, decreases home prices and decreases VMT. Zhou and Kockelman (2009, p. 80)[16] in a simulation model study found that a region wide combination of tolling and road user charges reduced VMT 15%. Kalmanje and Kockelman (2004, pp. 50 – 51)[17] found that a general regime of congestion pricing produced home price reductions on the order of 1.5 to 6.0% in the Austin Texas region. Significantly, their model predicted a slight increase in CBD home prices (p. 51). Anas and Xu (1999, p. 470)[18] construct a theoretical model that predicts that congestion pricing results in increased densities and increased rents and wages in the central area. Similarly, Anas and Rhee (2006, pp 19, 27, 28)[19] develop another theoretical model that indicates that tolling results in increased rents, increased densities and decreased VMT. In sum existing literature points to some level of tolling (congestion pricing) as decreasing VMT, increasing densities and decreasing home prices with the possible exception of central locations.

What We Did

In order to evaluate the impacts of the CRC project we performed 3 runs of MetroScope in conjunction with the full Portland Metro travel demand model. The first run consisted of a “no build” scenario (Scenario 1033) which kept the bridge in its current configuration. The second run consisted of the “build with no tolling” scenario (Scenario 1063) which consisted of adding the 12 lane bridge configuration, the light rail line extension, and pedestrian/bike facilities. The final scenario (Scenario 1053) consisted of adding the same facilities but with the addition of a $2.00 toll for crossing the bridge. Significant is that the alternative Columbia River crossing, the Interstate 205 Bridge, was not tolled in this scenario leaving the possibility of cost sensitive travelers the option of diverting to the I- 205 corridor. Also following contemporary practice the toll was imposed during the traffic assignment phase of the 4 step model and further reflected in the trip distribution module as well.

To fully reflect the effects of tolling and the transit additions in the build alternatives, we modified the travel times that MetroScope is calibrated for by converting the logsum impedances back into travel times that account for the utility changes of the additional transit and the bridge toll. Figure 3 below illustrates the change in travel times resulting from the procedure.

Tolling and Transit Adapted to Travel Time in Land Use Modules – Logsums “Reverse Engineered” Back to Travel Times – More Transit Reduces Time; Tolling Increases It.

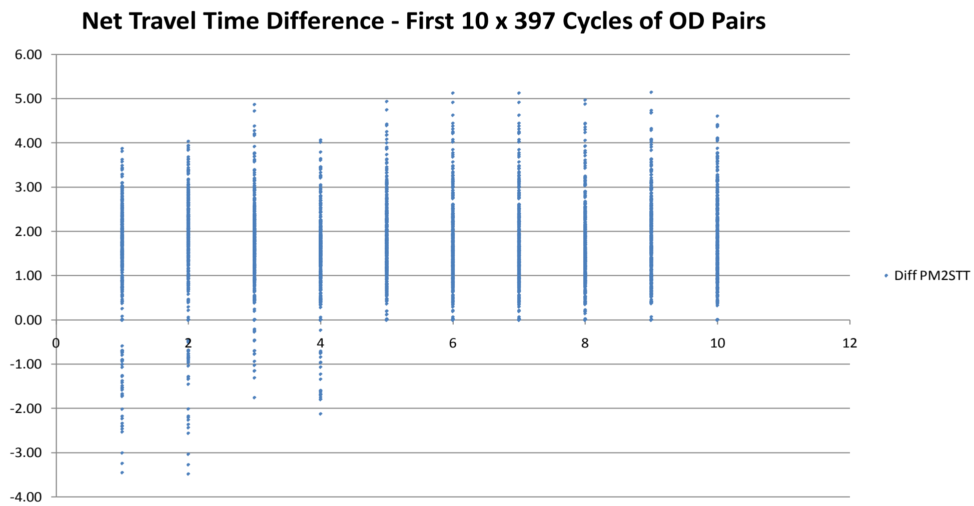


Figure 3: We transformed zone pair auto travel times to account for tolling and enhanced transit effects by adjusting travel time up and down as indicated.

Figure 3 indicates that for zone pairs with the transit additions but not subject to the toll, the “effective” travel time dropped between 0 and 4 minutes. For zones pairs subject to the toll effective travel time increased from 0 to approximately 3.5 minutes. Interestingly enough, zone pairs between the Portland CBD and Clark County experiencing both the toll and the transit improvements had very little change in net travel time as the transit roughly canceled out the toll.

What We Found

Induced Traffic and Travel Times

A fortuitous attribute of using regional simulation models is that we can examine outcomes from several perspectives at various spatial scale levels. The first helpful piece of information that we should know is just how much travel time savings does 3.5 – 4.0 billion dollars buy these days? Figure 4 below summarizes the impact of building the CRC project with and without tolling.

Results – Change in "Impedance" Measured in Minutes of Commute Travel Time

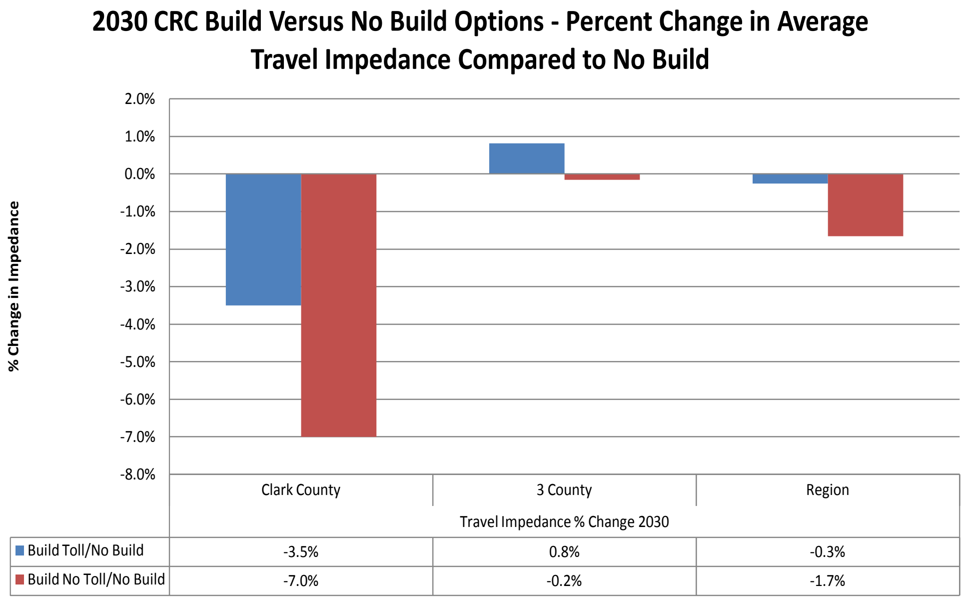


Figure 4: The CRC project slightly reduces travel "impedance" within the region. Imposing tolls minimizes the reduction in impedance.

In Figure 4 we compare the "impedance change" measured in minutes of travel time for 3 levels of geography – the 4 county region, the 3 Oregon Counties and the County most directly impacted – Clark County in Washington. Looking first at the largest scale – the region, the answer to our question is: not much. Without tolling the regional average reduction in travel time amounts to 1.7%. Furthermore, we note that the 3 Oregon Counties experience almost no gain while Clark County shows a 7.0% drop in travel time. Imposing a toll at the I-5 bridge reduces the impact even further – a .3% drop region-wide, an .8% increase on the Oregon side and a 3.5% decrease in Clark County.

Since the native geography of MetroScope is the census tract, we may also look at the travel time impacts on a more detailed spatial scale. Figure 5 displays the average travel time savings (impedance savings) by census tract.

Build with No Toll Benefits Clark County

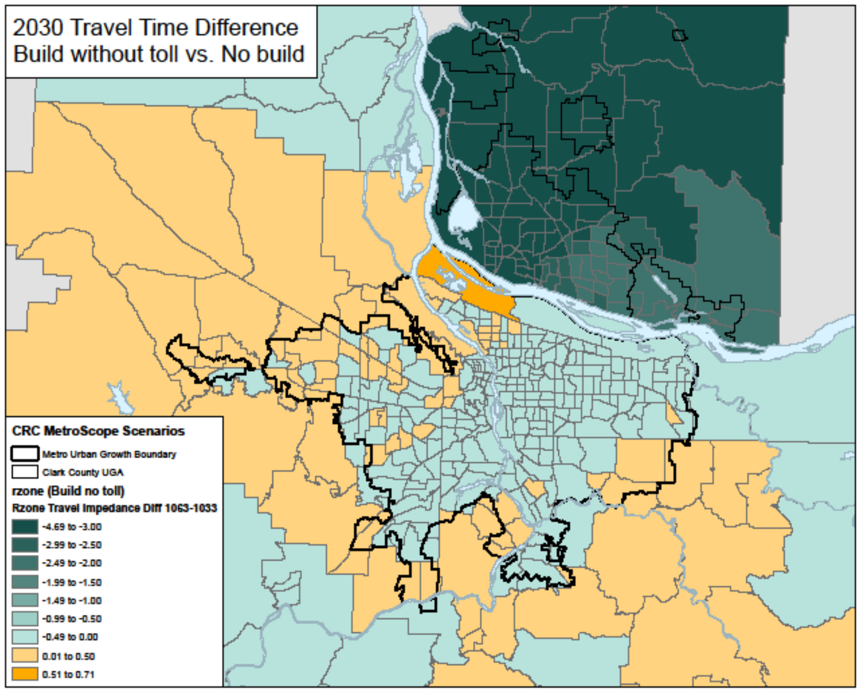


Figure 5: The limited travel impedance savings are concentrated in Clark County.

As widely anticipated with the Portland Metro Region the 12 lane CRC project does indeed provide the largest travel time (impedance) savings to Clark County while a few freeway dependent Oregon census tracts experience minor increases in travel time. Significantly, no Clark County census tract achieves a travel time reduction in excess of 5 minutes.

Figure 6 provides the same information for the Build with Toll option.

Build with Toll Reduces Travel Time Effects

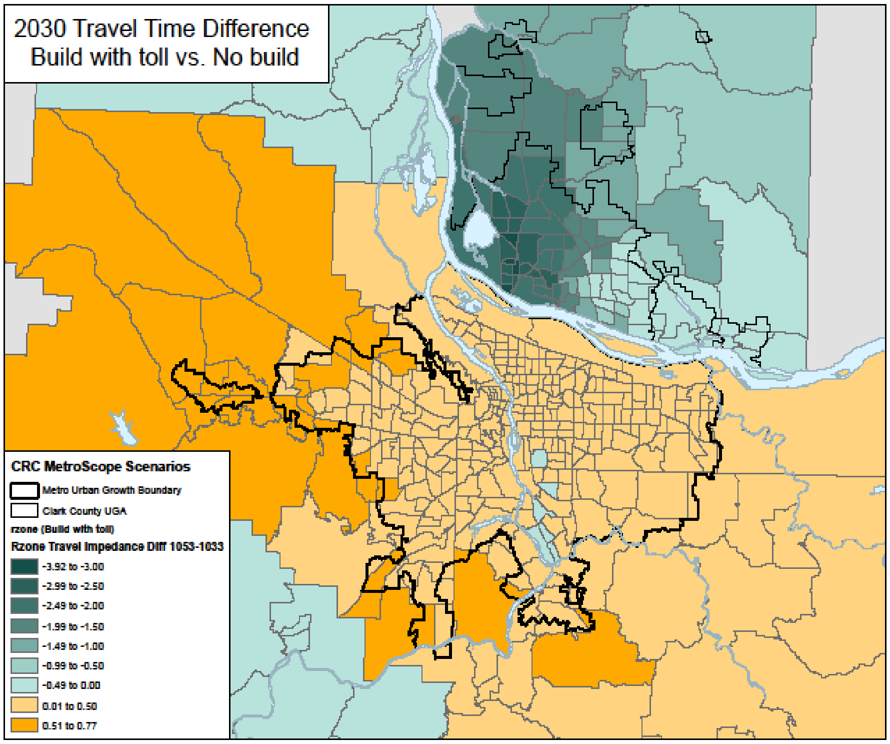
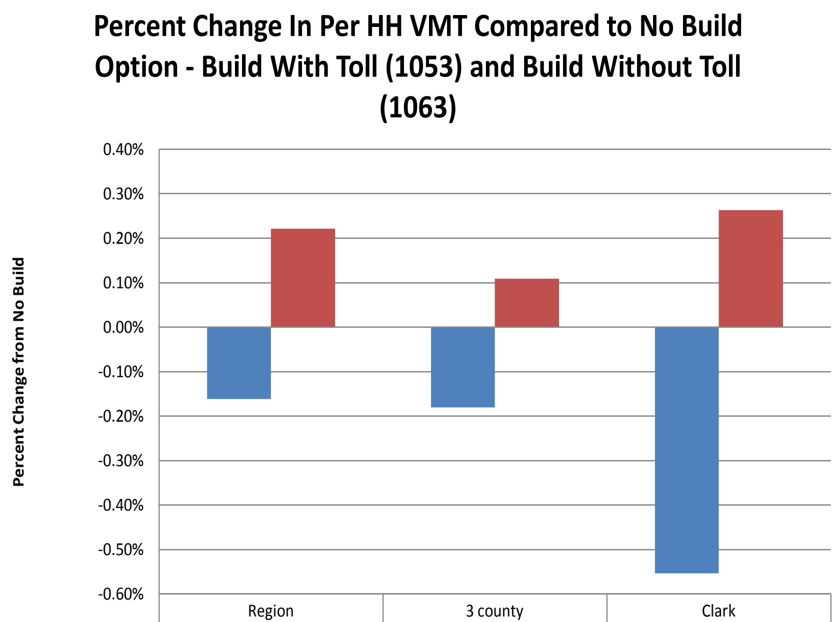


Figure 6: Tolling reduces the impedance savings throughout the region with the Oregon side experiencing increases in impedance relative to the no build option.

Figure 6 shows that while Clark County still experiences reductions in travel time (impedance), far fewer census tracts experience even a 3 minute drop in impedance. The Oregon side almost uniformly experiences a slight increase over the no build option. The impact on Oregon owes to freeway queuing effects resulting from diversion from I-5 to I-205 with increased freeway use in general disproportionately affecting peripherally located and freeway dependent census tracts in Oregon. Examining the results displayed in Figures 5 and 6 raises the issue of what is it that the CRC project is intended to achieve? Measured as travel time savings, the project in whatever configuration appears to have a very modest effect.

Moving directly to the question of induced traffic we first measure the change in commute trip lengths from the MetroScope land use modules to make an estimate of traffic change generated from land use changes. Figure 7 displays these results.

Induced Traffic – Effects of Land Use Change



	Region	3 county	Clark
Build toll/No build	-0.16%	-0.18%	-0.55%
Build/No build	0.22%	0.11%	0.26%

Figure 7: The CRC project produces a small increase in per HH VMT but imposing a toll decreases VMT below the no build alternative.

Figure 7 indicates that induced traffic effects exist but like travel time savings they are quite small. Region-wide the build without toll option lengthens commute trip lengths .22% with the range being .26% in Clark County and .11% on the Oregon side. The tolling alternative reduces commute trip lengths throughout the region relative to the no build alternative and up to .55% in Clark County.

Figure 8 provides a more comprehensive view of the travel impacts measured from the travel demand model and including all travel within the region.

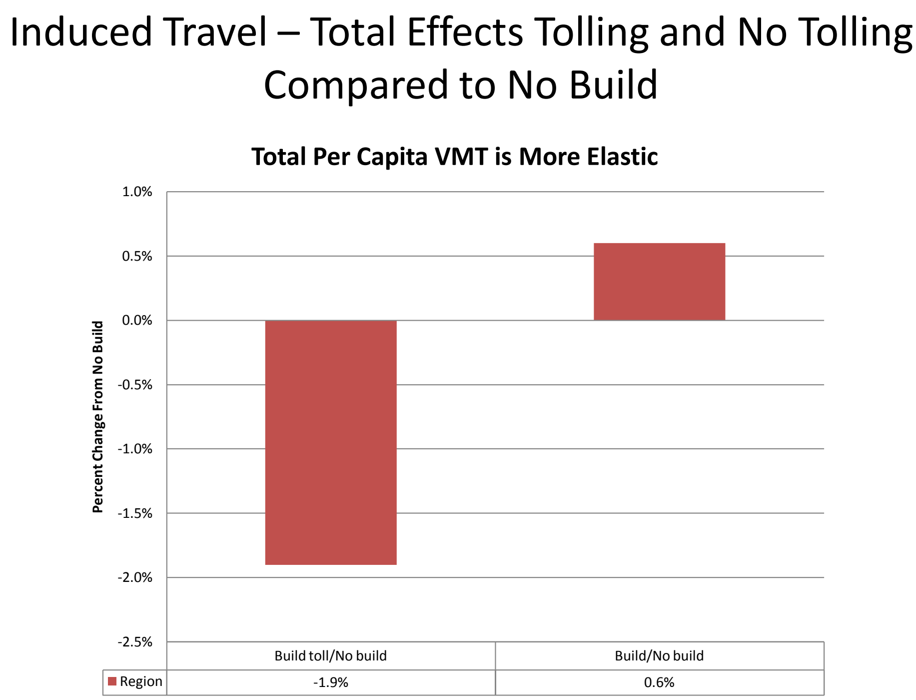


Figure 8: Comprehensive VMT estimates from the travel model indicate a regional increase in VMT of .6% without the toll and a reduction of 1.9% with the toll for the entire 4 County region.

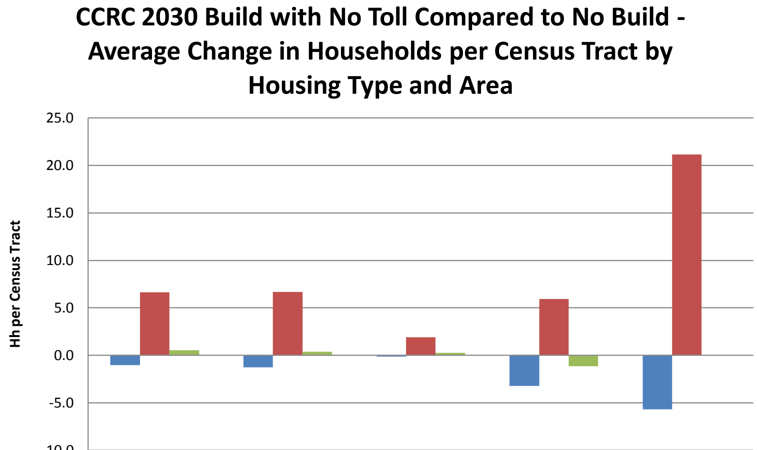
Figure 8 indicates that the build without toll option induces a .6% increase in vehicle miles traveled region-wide while building with the toll in place results in a 1.9% reduction. The build with no toll result suggests an "elasticity" of about .3; on the low side of the literature range but not unprecedented. The build with toll result however is much stronger than the change in travel times would suggest but may be explained by the change in location and housing type selection associated with the tolling option and reported on later.

In sum, at the most general level our results indicate that the CRC project produces a modest change in travel times over a limited area of the region and accordingly results in an even more modest impact on traffic generation. Our results also support the presumption that the impacts may be alleviated or even reversed by imposing tolls on the CRC project.

Land Use Impacts

Next we move on to land use impacts. We note here that we do not report on the nonresidential side but simply to note that there do exist equally voluminous data that point to the same results. Figure 9 presents the outcomes for the build with no toll option compared to the no build.

Land Use Impacts – Build with No Toll – Small (1%) Change Favoring Single Family on the Urban Edge



	osf	omf	rsf	rmf	total
3 county	-1.0	-1.3	-0.1	-3.2	-5.7
Clark	6.7	6.7	1.9	5.9	21.2
Region	0.5	0.4	0.3	-1.2	0.0

Figure 9: CRC building with no toll increases demand in Clark County; decreases growth slightly on the Oregon side and favors osf and omf (owner single family, owner mullti-family) over rmf (rental multi-family).

The most salient aspect of Figure 9 is that the land use impacts move in the direction we anticipate to Clark County and away from the Oregon Counties. Like travel time savings, the impacts are very small; usually less than 1/3 the size (measured as percentages) of the travel time impacts. In Figure 9 to enhance contrast we measure actual dwelling unit differences rather than percentages. We note that Clark County census tracts on average gain 21 units and Oregon census tracts lose about 6 units through 2030. Consistent with the claims of many new urbanists, we also see a shift from denser renter multi-family products towards more land consuming single family owner products located in the urban periphery. However, while consistent across space, these effects are very small and would likely not be detectable in an after the fact empirical measurement.

Figure 10 provides the spatial detail for owner single family (OSF) and owner multi-family (OMF) production.

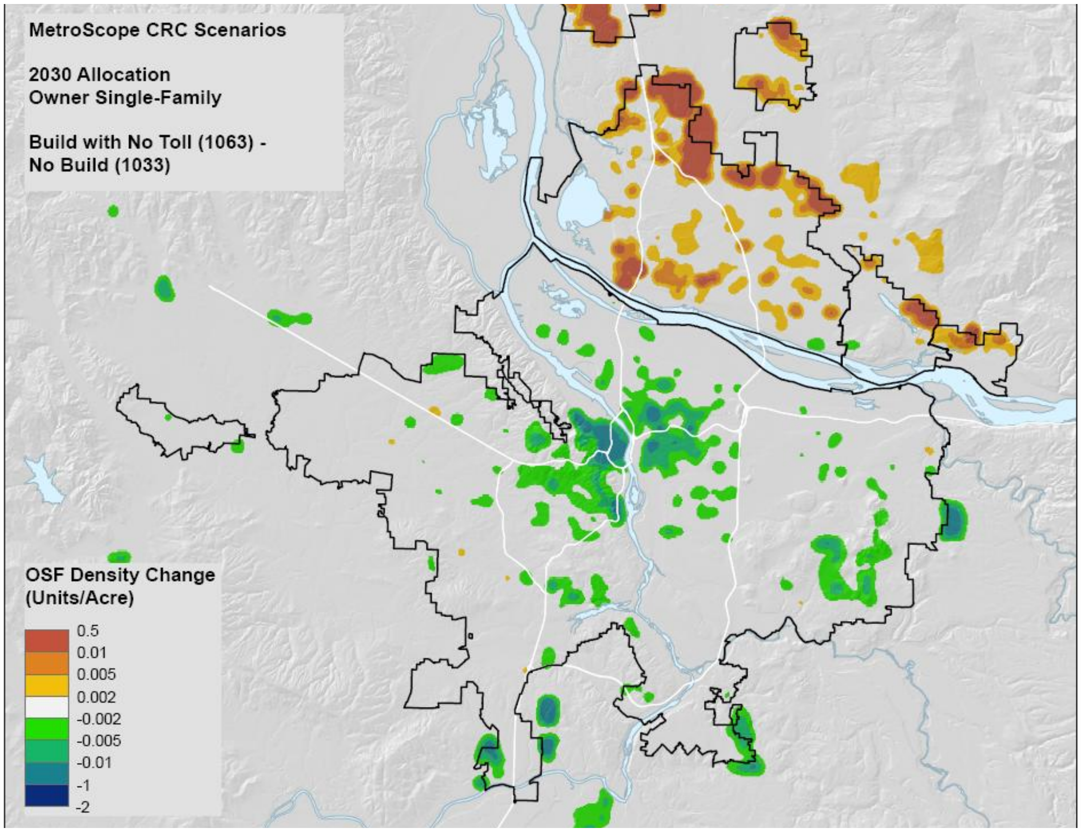
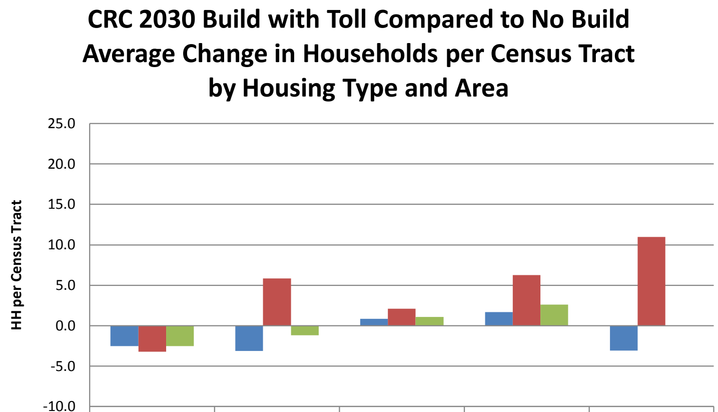


Figure 10: Compared to no build, the build without toll option clearly shifts osf allocation from Oregon central city locations northward to the edge of the Clark County Growth Management Area.

Figure 10 indicates that building the CRC without tolling reduces densities within the CBD on the Oregon side and increases them in Clark County, particularly at the edge of the Growth Management Area.

Figure 11 presents the land use impacts for the build with tolling option.

Land Use Impacts – Build with Toll –Small but Favoring Multi-Family and Central Locations



	osf	omf	rsf	rmf	total
3 county	-2.5	-3.1	0.9	1.7	-3.1
Clark	-3.2	5.8	2.1	6.2	11.0
Region	-2.5	-1.2	1.1	2.6	0.0

Figure 11: Tolling cuts in 1/2 the land use impacts of the CRC project and favors renter and multi-family over owner and single family.

Mirroring the travel time savings results the tolling option produces smaller effects than the build with no tolling option. Intriguingly, the tolling option also shifts housing production slightly in favor of renter and higher density multi-family products. Region-wide owner occupied products decrease and renter increase. Moreover, even in Clark County owner occupied single family output decreases relative to the no build baseline.

Figures 12 and 13 provide the details for owner single family and renter multi-family output.

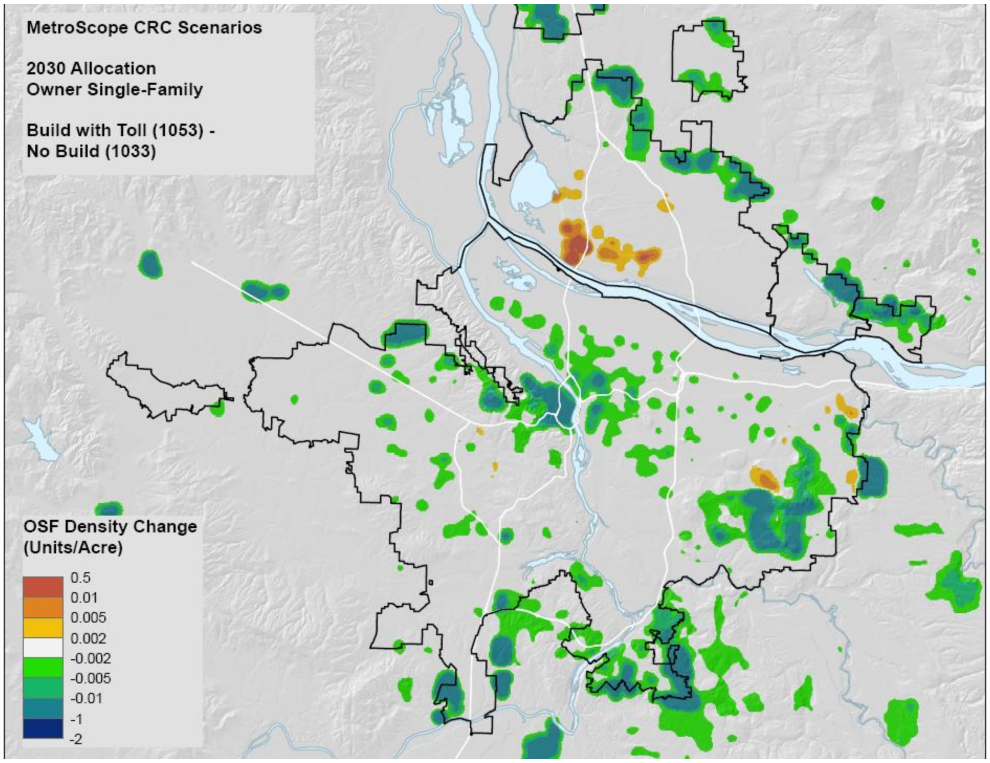


Figure 12: Tolling reduces single family most everywhere particularly at the urban edges. Only the Vancouver CBD has increases.

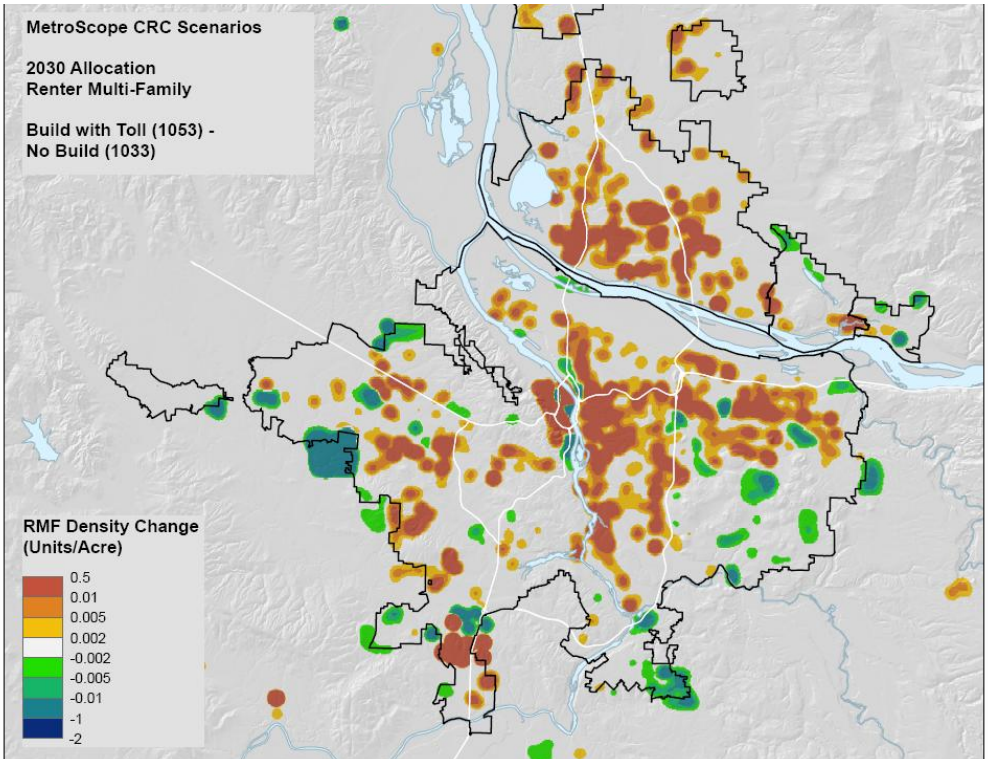


Figure 13: Tolling increases renter multi-family throughout the region particularly in dense central areas and along transit corridors.

In Figures 12 and 13 we may discern that the effect of the CRC tolling option is to shift from owner to renter and to higher density, more centrally located areas. Though the effects are small, they are consistent across housing types and space.

In terms of land use impacts the MetroScope runs indicate that though the CRC project does have small land use impacts in the direction presumed these impacts like travel time savings are very small. Furthermore, not only are these impacts ameliorated with a tolling option, the tolling option suggests shifts to higher density, more centrally located housing products than would be expected with the no build option.

Tolling and Housing Prices

MetroScope belongs to the class of aggregate, static, neoclassical equilibrium models. As such the model simulations are driven by price changes as the model for a set of input initial conditions and policy options, seeks to balance demand and supply by changing prices. Literally, for every action there is an equal reaction. If the CRC project benefits Clark County, then not only dwelling unit allocations but housing prices must rise. Equivalently, if the Oregon side loses dwelling units, then housing prices must decline. This equilibrium seeking, built into the model, reduces the impact of any particular policy option. Figure 14 displays housing price changes of the build without tolls option relative to the no build scenario.

Housing Prices – Build with No Toll – Increase for Clark; Decrease for Region

CRC 2030 Build with No Toll Compared to No Build Change in Location Prices by Housing Type and Area

	osf	omf	rsf	rmf	total
3 county	-1.3%	-0.7%	-0.6%	-0.7%	-1.0%
Clark	3.3%	3.1%	3.2%	3.1%	3.4%
Region	-0.4%	0.1%	0.2%	0.1%	-0.2%

Figure 14: Building the CRC project without tolling increases Clark County housing prices and reduces housing prices on the Oregon side.

Figure 14 indicates that prices change much as expected for all dwelling unit types within the Oregon side and Clark County. Clark County goes up 3.4% (compared to a 1% dwelling unit gain) and the Oregon side goes down 1% (compared to about 1/3 of a percent loss of DU.) Overall, housing prices drop .2% compared to the no build.

Figure 15 illustrates the spatial distribution of the price effects.

Owner Prices – Build with No Toll – Up in Clark and Down in Oregon

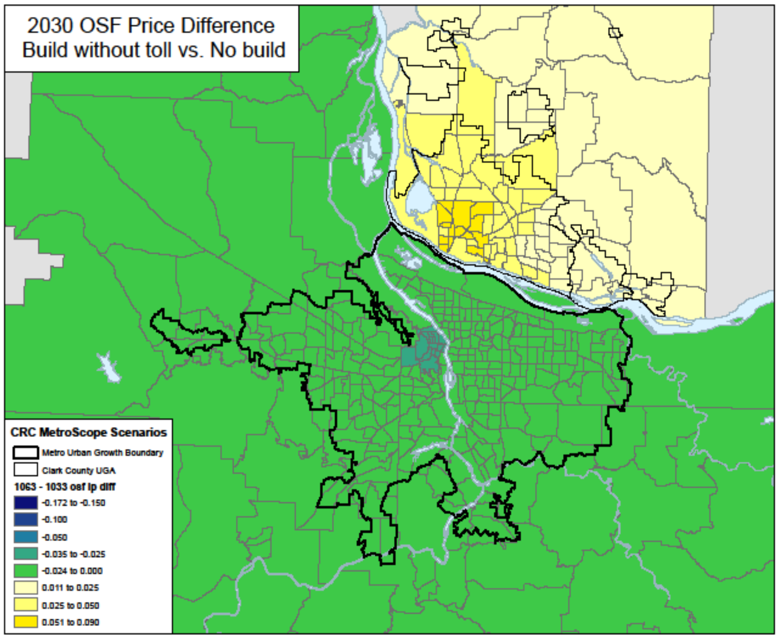
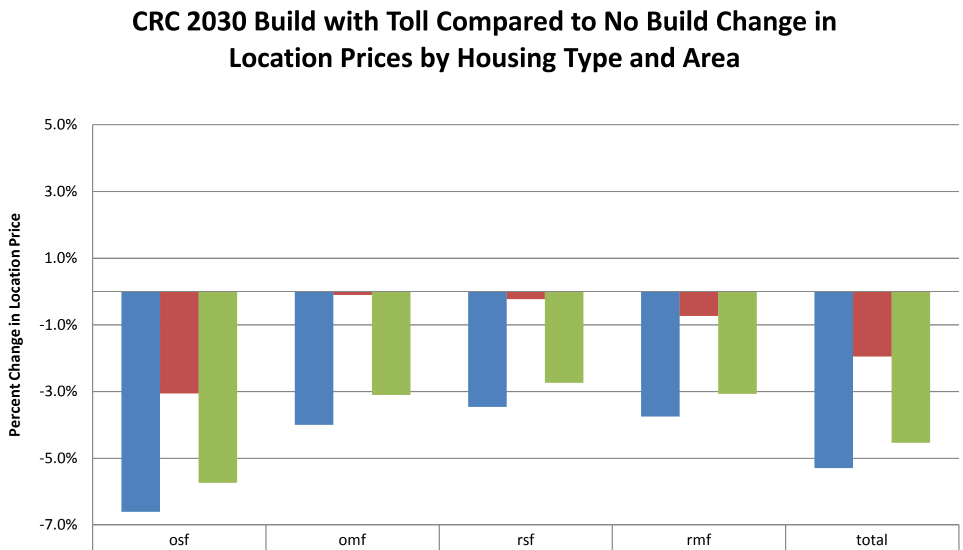


Figure 15: Building with no toll results in lowered prices on the Oregon side and increases on the Clark County side. The Portland CBD experiences the largest drop while the Vancouver CBD exhibits the largest increase.

Figure 15 indicates the largest price drops are in the Portland CBD and the largest price increases are in the Vancouver CBD closest to the CRC project. Building the CRC project without using a toll has very straight forward effects – a small bit of welfare is transferred from the Oregon side to the Washington side. Those familiar with the planning and political background of the project will not find this surprising. What is surprising is the very small size of the impact.

We now move to the question of how tolling impacts housing prices given the shift toward renter and higher density, more centrally located products that we previously discussed. Figure 16 provides the tabular results.

Housing Prices – Build with Toll – All Prices Drop with Largest Effect for Single Family



	osf	omf	rsf	rmf	total
3 county	-6.6%	-4.0%	-3.5%	-3.7%	-5.3%
Clark	-3.1%	-0.1%	-0.2%	-0.7%	-1.9%
Region	-5.7%	-3.1%	-2.7%	-3.1%	-4.5%

Figure 16: Tolling the CRC project drops housing prices throughout the region with owner single family dropping the most.

Figure 16 provides an outcome rarely seen in a price response to a public policy option; namely a *drop in prices*. Region-wide prices drop 4.5% in response to a 2 dollar toll very few commuters actually pay. Furthermore, the drop is spread across all housing types in most areas. Significantly, the largest drops are in the single family category that experienced the largest drop in demand with the tolling option.

Figure 17 provides the spatial distribution of the price impact for owner single family.

Owner Prices with Toll – Lower Everywhere Except Vancouver CBD (Transit Effect)

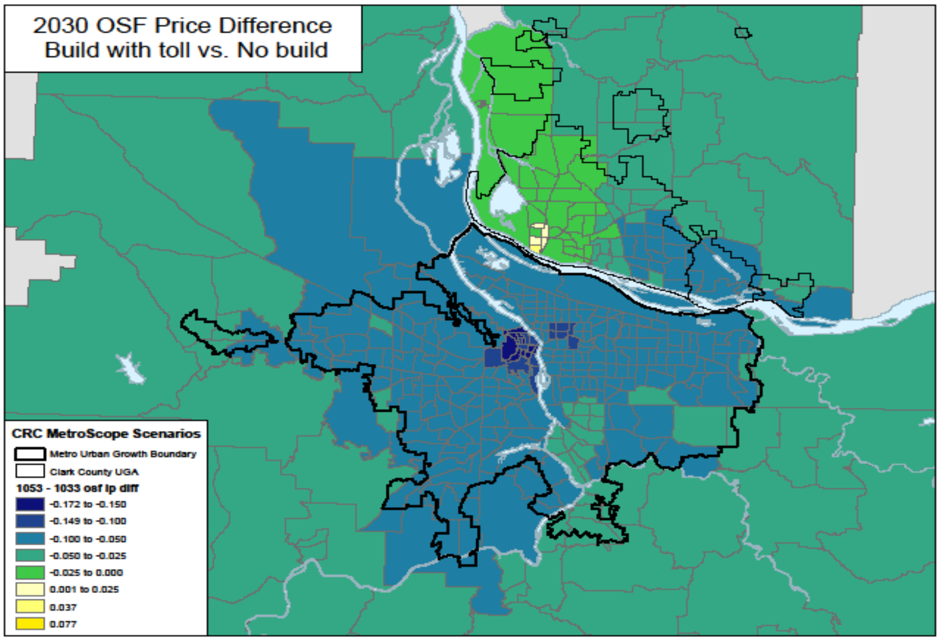


Figure 17: Only the Vancouver CBD sees an increase in prices with the tolling option.

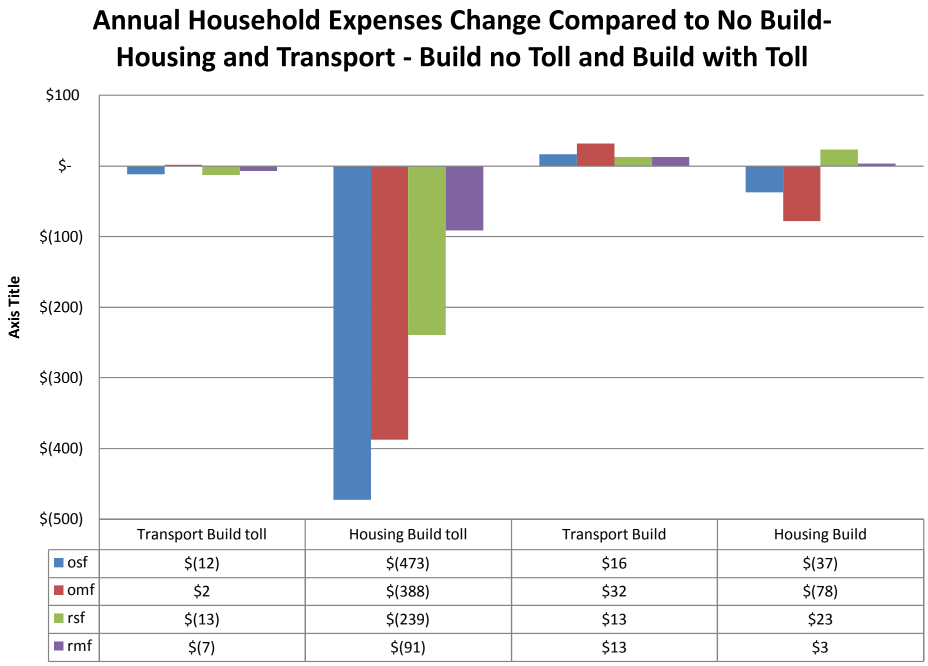
Figure 17 indicates that owner prices have dropped throughout the region with the exception of several census tracts immediately north of the CRC project in the Vancouver CBD area. The largest price reductions occur in the Portland CBD and in another area 2 miles to the east that also has a high degree of centrality.

Since the tolling option is applied only to the CRC project, it is presumptuous to assert any generality for its effect. It may indeed be an idiosyncratic effect limited to the very long trips that we both model and observe in reality for commuters who tradeoff high housing consumption for long travel times. Also, since the toll is only applied in one place, commuters using the alternative 1-205 bridge route certainly contribute to queuing and increased travel times throughout the region.

Public Welfare Effects of Tolling Options

The tolling options both shift slightly housing output toward higher density products and reduce somewhat the prices of all housing products. Examining the square footage of physical housing output indicated no decrease in consumption with increased size of single family housing offsetting the shift to smaller high density multi-family products. We also tabulate for all classes of households, census tract locations and housing types the annual household expenditure for transportation and housing. Figure 18 below summarizes those calculations for the build no toll and the build with toll compared to the no build alternative.

Public Welfare Impacts – Annual Household Housing and Transport Cost with and without Tolling



	Transport Build toll	Housing Build toll	Transport Build	Housing Build
osf	$(12)	$(473)	$16	$(37)
omf	$2	$(388)	$32	$(78)
rsf	$(13)	$(239)	$13	$23
rmf	$(7)	$(91)	$13	$3

Figure 18: Tolling the CRC project results in substantial annual housing expense savings throughout the region.

Figure 18 displays slightly higher annual transportation costs for the build alternative and mixed results for annual housing costs. Transport costs with the toll option fall slightly and housing costs fall substantially with the largest impacts for owner single family and owner multi-family (condos). In Figure 19 we have converted these annual costs into a discounted lump sum estimate of the dollar value of the reduced housing prices assuming no net effect on aggregate housing consumption.

Public Welfare Effects – Net Present Value of Tolling Savings and No Tolling Savings over No Build

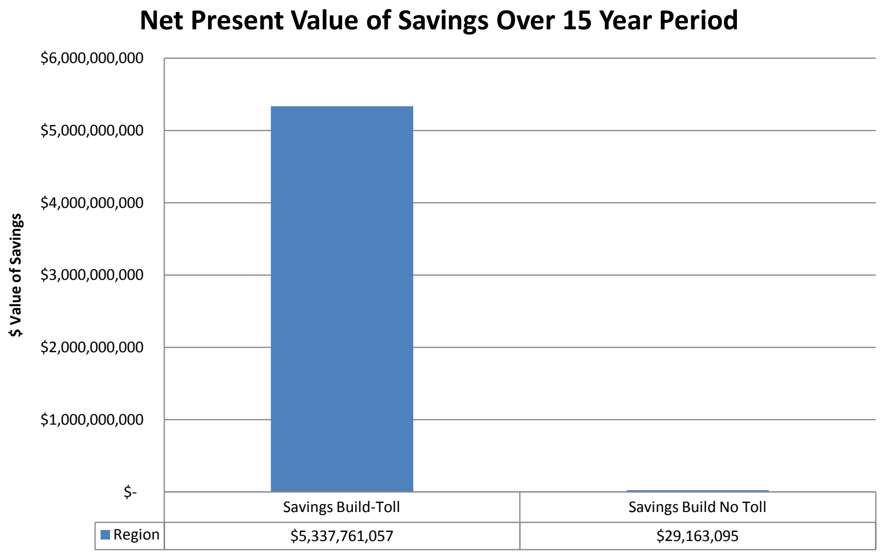


Figure 19: The present value of the tolling option summed over the entire region amounts to over 5 billion $.

Though not an exact measure of consumer surplus, the annualized cost savings of the tolling option amount to over 5 billion dollars; considerable in excess of the 3.5 – 4.0 billion $ cost of the CRC project.

Summary and Evaluation

In regard to the CRC project we used our in house integrated transportation and land use model, MetroScope, to evaluate three types of impacts associated with the the project. These are: induced travel, impacts on land use and the effect of tolls on travel and land use. Our results are as follows:

- Induced travel – Our results imply a change of about .3% growth of VMT for every 1% reduction in travel time. This is consistent on the low side with the results reported for other studies. Overall, growth of VMT in the region resulting from the CRC project is very small consistent with our measurements of the small regional travel time savings associated with the project.
- Impacts on land use - Impacts on land use occur but they are very limited and much less percentage wise (less than 1% at the regional scale) than the change in travel time. The CRC project produces small increases in single family home development in the urban periphery in Clark County primarily at the expense of

multi-family in the central areas of the region. Home prices for single family increase slightly in Clark County and decrease elsewhere.

- Effects of tolling on the CRC project – Applying tolls to the CRC project reverses the induced travel and land use impacts. It also has the salutary effect of reducing home prices, discouraging development at the urban periphery and encouraging higher density multi-family development within the urban core.

In our evaluation of these impacts we feel most comfortable with the induced travel outcomes as being consistent with findings elsewhere. The impacts on land use seem plausible given the fairly small regional reductions in travel time. Land use impacts are also consistent with other simulation model results and measurements from recent time periods. Given the widespread expectation that land use impacts are very large and some evidence from the pre 1990's era that they have been, we feel the issue is not completely settled. We conjecture at this point that fragmentary evidence points to the proposition that the value of access has declined since 1980's and that simulation models using recent parameters and calibrations are reflecting that outcome.

The most enticing yet speculative results involve the impacts of tolling. Given the interest in land use and transportation policies that mitigate GHG emissions, increasing the efficiency of existing transportation services, the need to fund replacement of aging infrastructure and supply new; the tolling results provide a strong incentive to declare tolling as a solution to our problems. However, we have considerable reservations regarding the generality of these results given the limited application of our tolling exercise. Also, while consistent in application with the approved methods of the previous CRC tolling study, one may argue that the traditional 4 step model with the tolling charge as an impedance add on within the traffic assignment module, does not fully reflect the behavioral aspects of the tolling choice. For these reasons we would urge extreme caution when interpreting the tolling results. Far more empirical measurement, simulation experiments and relevant theoretical investigations need be done.

End Notes - Bibliography

[1] Technical details of MetroScope are documented and available on request from the author at Sonny.Conder@oregonmetro.gov
[2] J. Rose, Oregonlive.com, (July 30 2010), "Independent Columbia River Crossing panel says new Interstate 5 bridge will need tolls.." http://blog.oregonlive.com/commuting/2010/07/independent_columbia-river_cro.html
[3] CRC Tolling Study Committee Report (January 2010) , http://www.columbiarivercrossing.org/FileLibrary/Tolling/CRC_TSCReport_AppendixC.pdf
[4] T. Littman, **Generated Traffic and Induced Travel – Implications For Transport Planning**, Victoria Transport Policy Institute, (July 2010), 34 pages.
[5] We use the term elasticity very loosely here as methods and objects of measurement vary considerably from study to study.
[6] L. Fulton, R. Noland, D. Meszler, J. Thomas, "*A* Statistical Analysis of Induced Travel Effects in the U.S. Mid-Atlantic Region", **Journal of Transportation and Statistics,** (April 2000), pp. 1 – 14.
[7] T. Littman, **Evaluating Transportation-Land Use Impacts,** Victoria Transport Policy Institute, (October 2010), 46 pages.
[8] N. Baum-Snow, "Did Highways Cause Suburbanization", **Quarterly Journal of Economics,** Vol. 122, No. 2, pp. 775 – 805.
[9] M. Iacono, D. Levinson, "Predicting Land Use Change – How Much Does Transportation Matter", **Transportation Research Record,** No. 2119, (2009), pp. 130 – 136.
[10] R. Cervero, "Land Market Impacts of Urban Rail Transit and Joint Development: An Empirical Study of Rail Transit Systems in Washington D.C. and Atlanta", *Development and Globalization: Selected Proceedings of the 6th World Conference on Transport Research.- Lyon France, World Congress on Transport Research,* Vol. 1, pp. 243 - 254.
[11] B. Voigt, A. Troy, B. Miles, A. Reiss, "Testing and Integrated Land Use and Transportation Modeling Framework for a Small Metropolitan Area", **Transportation Research Record,** No. 2133, (2009), pp. 83 – 91.
[12] A. May, S. Shepherd, G. Emberger, A. Ash, X. Zhang, N. Paulley, "Optimal Land Use – Transport Strategies Methodology and Application to European Cities", **Transportation Research Record,** No. 1924 (2005), pp. 129 – 138.
[13] T. Weidner, B. Knudson, R. Picado, J. Hunt, "Sensitivity Testing with the Oregon Statewide Integrated Model", **Transportation Research Record,** No. 2133, (2009), pp. 109 – 122.
[14] B. Stevens, "An Interregional Linear Programming Model", **Journal of Regional Science,** Vol. 1 (1958), pp. 60 – 98. And B. Stevens, "Linear Programming and Location Rent", **Journal of Regional Science,** Vol. 3 (1960), pp. 15 – 26.
[15] A. Langer, C. Winston, "Towards a Comprehensive Assessment of Road Pricing Accounting for Land Use", *Brookings-Wharton Papers on Urban Affairs 2008,* Brookings Institution Press, Wash. D.C. 235 pages.
[16] B. Zhou, K. Kockelman, "Lessons Learned in Developing and Applying Land Use Model Systems", **Transportation Research Record,** No. 2133, (2009), pp. 75 – 82.
[17] S. Kalmanje, K. Kockelman, "Credit-Based Congestion Pricing", **Transportation Research Record,** No. 1864, (2004), pp. 45 – 53.
[18] A. Anas, R. Xu, "Congestion, Land Use, and Job Dispersion: A General Equilibrium Model", **Journal of Urban Economics,** (1999), Vol. 45, pp. 451 – 473.
[19] A. Anas, H. Rhee, "Curbing excess sprawl with congestion tolls and urban boundaries, **Regional Science and Urban Economics,** (2006), pp. 1 – 32.