(MetroScope Version 4.1.1, Scenario 1770)

MetroScope 4.1.1 Validation, Phase One

For Peer Reviewing Metro's land use allocation forecasting model

Report Version 0.3 September 9, 2017

(See separate document for Sensitivity Test section)

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INTRODUCTION & STRUCTURE OF THIS REPORT

MetroScope is Oregon Metro's land use allocation forecast model. Staff in the Metro Research Center develop, maintain, and apply MetroScope to support Metro's growth and transportation planning responsibilities. A companion document (*MetroScope Generation 4.1.1 Methodology*) explains the model's history, purpose, structure, and mathematics. The purpose of this validation report is to make clear to a model peer review panel the current model capabilities. Staff plan to refine the model based on peer review feedback, after which the final version of this report will help Metro staff and stakeholder form an understanding of how much uncertainty to expect in MetroScope forecasts.

As the Methodology document indicates MetroScope contains two sub-models: residential and non-residential. This report is thus generally organized into these sections:

- Overview of the validation tests chosen
- General overview of the observed data chosen to provide validation comparisons
- Non-residential (employment) sub-model validation
- Residential (household) sub-model validation
- Sensitivity tests appendix (packaged in a separate document)

Each validation section discusses several validation variables or "indicators" in a consistent framework that shows:

- How Metro computes the forecast variable and observed comparison point
- How decision-makers and staff use the variable
- Any known data or computational issues pertinent to the variable
- Comparison of forecast versus observed data
- Metro staff discussion of the validation comparison

The employment sub-model section covers the first two elements in one place since they are common to all employment indicators.

The final version of this report will incorporate peer review and additional staff comments to add a final element to each "indicator" section: validation findings.

VALIDATION PROTOCOL

Research Center (RC) staff selected the following "indicators" as useful validation tests.

Validation test indicators

- Employment capture rate (UGB summary level)
- Employment growth (district summary level)
- Employment growth (Ezone summary level)
- Residential capture rate (UGB summary level)
- Tenure choice (UGB summary level)
- Structure type choice (UGB summary level)
- Household location choice (district summary level)
- Household location choice (Ezone summary level)
- Household location choice (census tract summary level)
- Renter housing cost (gross rent)
- Owner housing cost (value)

Validation procedure

RC staff compared MetroScope forecast metrics against observed data from various sources. Observed data came from the Decennial Census, Census ACS, ESRI Business Analyst, and Metro's own Regional Land Information System (RLIS) database. The historical comparison data is primarily 2010 to 2017, but staff used other periods where applicable to illustrate past variations in growth trends.

Staff ran MetroScope to produce the forecast data (Scenario #1770). The validation tests apply to the forecast marginal growth increment 2010 to 2020. Where applicable, forecast indicators and historical comparisons have been transformed and normalized so that the forecast variable represents a zonal share of growth during the increment.

Staff chose to validate over the period 2010 to 2020 instead of 2015 because 2010 is the only practically available base year and prior model testing demonstrated that MetroScope, like some other allocation models, needs to run through at least one full iteration to dampen out oscillations in the forecast outputs. Staff label this phenomenon model "ramp up".

OBSERVED DATA SOURCES

Household counts and tenure

For observed changes in household counts by location and tenure (own or rent), staff used decennial Census data from 2010 and ESRI estimates for 2017, available through ESRI Business Analyst or ArcGIS Online. ESRI's generates its demographic data using several input data sets, including Census 2010, county population estimates from the Census Bureau, IRS migration data, building permits and postal delivery information.
(http://downloads.esri.com/esri_content_doc/dbl/us/J10268_Methodology_Statement_2017-2022_Esri_US_Demographic_Updates.pdf)

Housing type

Multifamily residential development is highly heterogeneous in terms of location and number of units in the structure. Staff judged the small sample size and multi-year aggregation of the 5-year ACS data product to be too error-prone for validation targets. ESRI demographic data does not include structure type (single family of multifamily). Research Center staff thus used two internal data sets that the Metro Research Center developed for monitoring land development in the region. Metro's single family database identifies single family units from county assessor data using a number of attribute screens, overlays with other Metro data sets, and some manual clean up. Metro's multifamily database includes all apartments and condos in the region, along with dormitories and accessory dwelling units which have been excluded from this analysis. In some instances, ownership has been used to identify a multi-family structure. For example, a duplex located on a single tax lot would be considered multifamily with two units, while two attached housing units located on separate tax lots with no commonly owned land would be designated as single family. Metro housing unit data sets are complete for development up through 2015, so the observed data for validation is 2005 to 2015.

Employment

Staff chose Longitudinal Employer-Household Dynamics (LEHD) data for the observed employment in validation of the nonresidential forecast. LEHD data are available at the census block level, with industry details at the 2-digit NAICS (North American Industrial Classification System) level, along with public or private ownership.

Metro usually relies on confidential disaggregate Quarterly Census of Employment and Wages (QCEW) data that provides point locations for individual businesses. However, LEHD has several advantages over QCEW for this exercise. First, Metro only has access to the disaggregate QCEW data for the Oregon portion of the MSA so LEHD provides a consistent data source for both Oregon and Washington. Second, Metro has acquired the QCEW data by only intermittently and geocoded it using different methods over the years as geocoding tools and address data have improved. Standardizing the historical QCEW point data that we have in our possession was not feasible. Finally, due to confidentiality rules concerning the QCEW data, Metro would not be able to report out key employment-related validation statistics in public documents. There are similarities in the data sets because the employment information in LEHD is derived from QCEW, with some data obfuscation to mitigate confidentiality issues. In the Portland region, LEHD data include some

known geocoding errors, which we corrected in the time series. The LEHD data are available in annual snapshots from 2002 to 2014, providing us with the flexibility to choose different time periods against which to validate the model.

This report uses three time periods for comparison to account for swings in employment growth due to regional business cycles, starting with LEHD data from 2004 to 2014. LEHD provides a reasonable validation target for total regionwide employment; however, manufacturing employment (NAICS 31-33) declined over this period leaving staff with a negative observed growth increment against which to compare a positive forecasted growth increment. To alleviate this issue, we also include observed data from other periods, 2003 to 2008 and 2009 to 2014. These were periods during which manufacturing experienced a positive growth trajectory for employment in the region. The following charts illustrate employment growth relative to the start year (2004 and 2010 respectively) for both total jobs and manufacturing jobs in the region. (Source: LEHD OnTheMap)

Figure 1: Regional (MSA) Job Growth Relative to year 2004—Total Jobs and Manufacturing Jobs

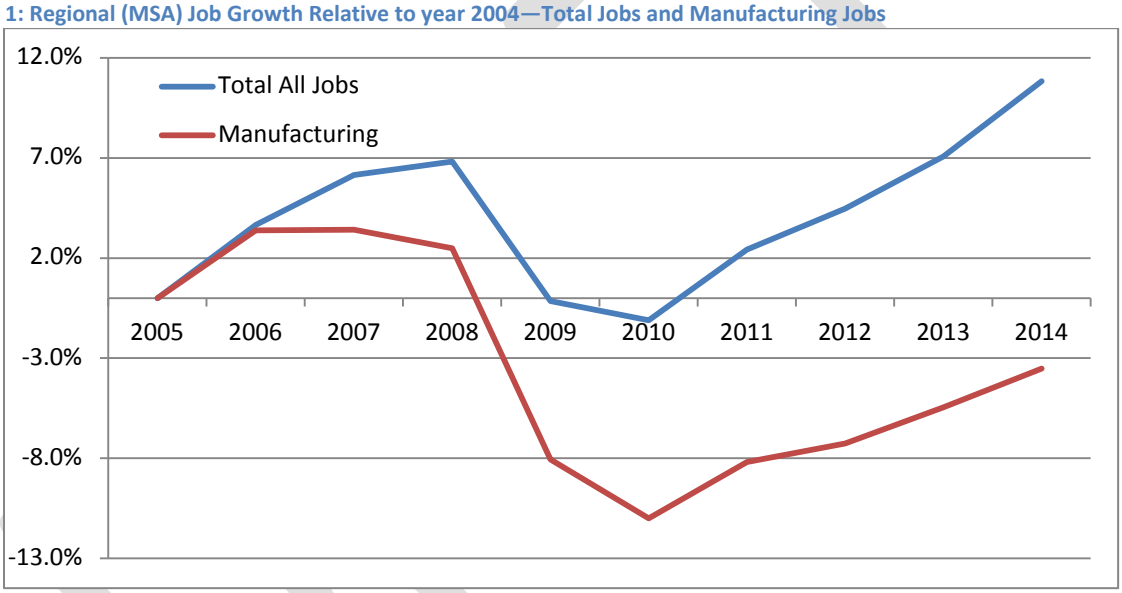
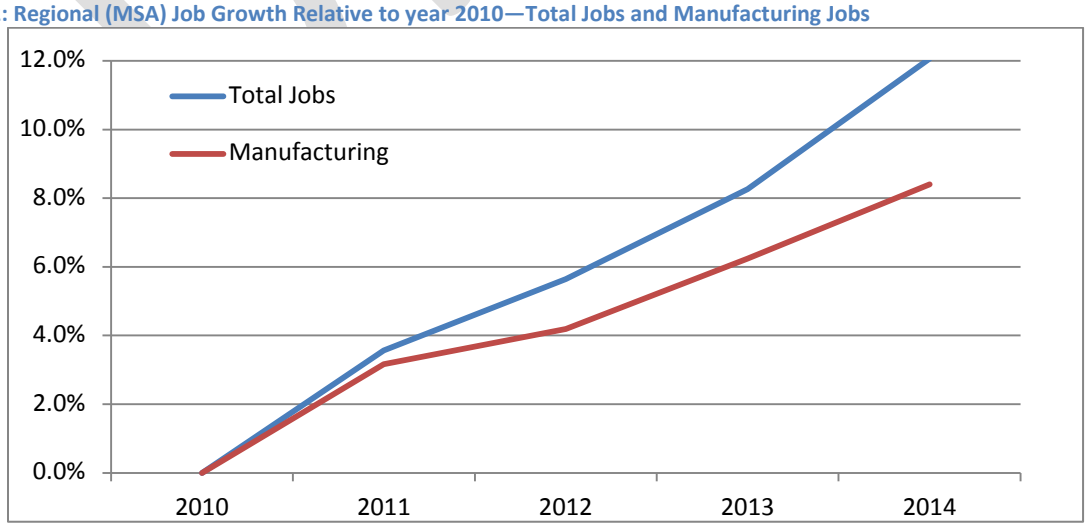


Figure 2: Regional (MSA) Job Growth Relative to year 2010—Total Jobs and Manufacturing Jobs



GENERAL VALIDATION THINGS TO BE AWARE OF

Geographic boundaries for modeled and observed data

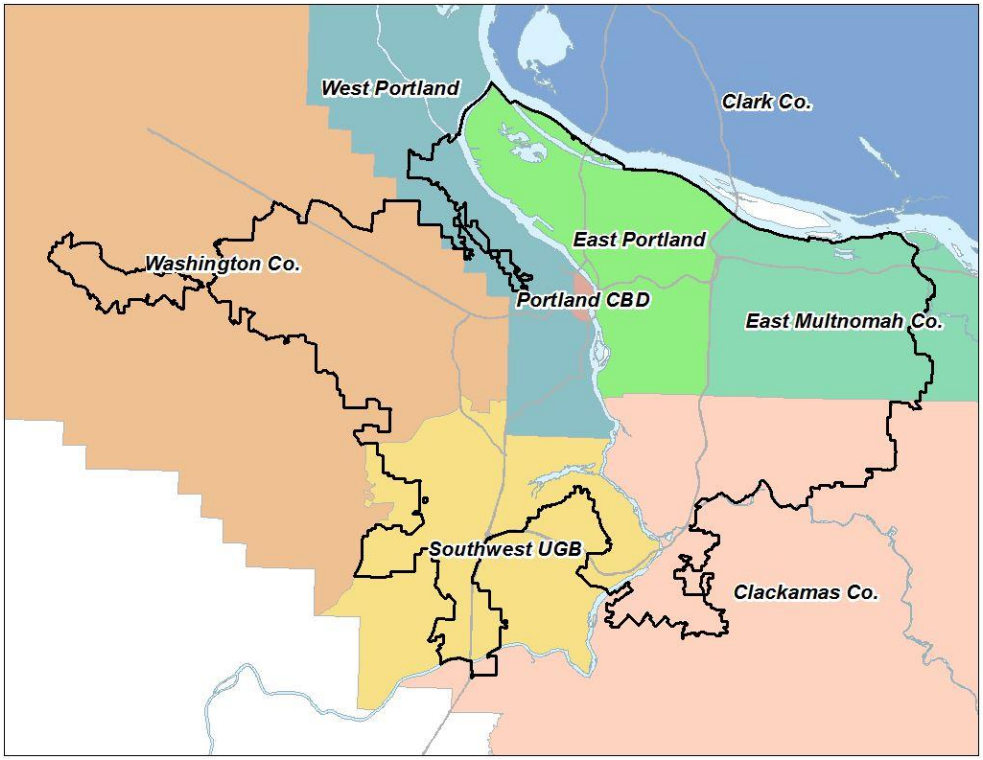
Model extent: MetroScope's The geographic extent and internal zone system approximates the Portland-Beaverton-Vancouver Metropolitan Statistical Area (MSA) but does not exactly match. The MSA is made up of seven counties, while the native MetroScope geography swaps out Skamania County, WA for the northern portion of Marion County, OR. Populations are about the same, but northern Marion County is more urban. This validation work uses MSA-level observed data as the comparison points for MetroScope's full geographic extent.

Table 1: Counties in MSA vs. MetroScope

County	MSA	MetroScope
Columbia County, OR	Yes	Yes
Clackamas County, OR*	Yes	Yes
Marion County, OR	No	Part
Multnomah County, OR*	Yes	Yes
Washington County, OR*	Yes	Yes
Yamhill County, OR	Yes	Yes
Clark County, WA	Yes	Yes
Skamania County, WA	Yes	No

** Metro has UGB authority for the urban parts of these 3 counties.*

Figure 3: MetroScope Model Geography (Districts and Urban Growth Boundary—*note that the MSA is larger*)



Eight districts: Metro uses a set of eight districts for some validation metrics to examine the performance of the model's spatial allocation. The 8-district geography only covers the four largest counties in the MSA (Washington, Multnomah, Clackamas, and Clark).

Urban growth boundary (UGB): The actual Metro UGB line will move with future UGB amendments. The current line is shown in the Figure 3 map. It does not follow other municipal or statistical boundaries. For the validation tests, the UGB line remains fixed through 2020. MetroScope operates using zones that are based on Census tracts, "Ezones" and "Rzones" for employment and residential data respectively. These zonal boundaries do not align with the Metro UGB, so UGB statistics must be approximated using the nearest tract boundaries. The approximated UGB geographies have been used for both the modeled and observed data to make them comparable.

Zone system: Within its modeled geographic extent MetroScope operates at two levels: Rzones (Census tracts) and Ezones (groupings of Census tracts). The modeled space includes 494 Rzones (tracts) and 72 Ezones. Employment lands forecast location outputs are at the Ezone level while residential location outputs are at the Rzone level.

Data limitations

The buildable land supply in communities outside and adjacent to the Metro UGB can impact regional growth distributions and forecast results. The most accurate and refined buildable land supply is data that Metro maintains inside the UGB. Data outside the UGB must be obtained from sources with more uncertainty.

Metro makes various assumptions for the buildable land supply for rest of the MSA counties in Oregon and Washington. Clark County is of particular concern because it represents a significant portion of the jobs, households, and buildable land supply in the metropolitan area but is subject to different development and planning laws than Oregon. These differences contribute to uncertainty in the quality and consistency of the model input data across space, and should be kept in mind when looking at spatial validation metrics including zonal allocations and UGB capture rates. The other MSA counties are rural counties and lack the sophisticated systems and other resources to tabulate needed land information data. These data uncertainties may adversely impact the quality of the spatial growth forecast indicators.

Temporal fidelity

MetroScope supports long term (i.e. twenty years in the future) decisions. The primary purpose of validation is to ensure reasonable forecasts in such a time frame and the model should not be expected to be accurate in any specific intermediate year. Staff chose the shorter validation time frames used in this report by necessity.

MetroScope forecasts marginal change

The model forecasts choices made by consumers and suppliers for new households (the growth increment or "the margin") coming to the region in the future. It does not simulate household or employment relocation within the region. All validation statistics that follow are thus incremental or "marginal," not total.

Market segmentation

MetroScope segments the consumer market for housing into 400 different household types via a joint distribution of household size (H), household income (I), age of head-of-household (A), and presence of school-age children (K). Staff refer to the household distribution as the "HIAK" inputs.

The model segments the market for employment space into fourteen employment sectors comprised of North American Industrial Classification System (NAICS) two-digit categories and combinations of NAICS categories as shown below. For validation purposes staff typically further aggregate the fourteen categories into four "supersectors" (see page thirteen).

Figure 4: Metro Employment Market Segments

Empclass	Sector	NAICS
1	Agriculture, Mining and Forestry	NAICS 11, 21
2	Construction	NAICS 23
3	Education (private)	NAICS 61 (private)
4	Health and Social Services	NAICS 62
5	Manufacturing - Durable	NAICS 321, 331-333, 335-339
6	Manufacturing - High Tech.	NAICS 334
7	Manufacturing - Nondurable	NAICS 311-316,322-327
8	Other Services	NAICS 81
9	Professional and Business Services	NAICS 22, 51-56
10	Retail and Consumer Services	NAICS 44,45,71,72
11	Transportation, Warehousing	NAICS 48,49
12	Wholesale Trade	NAICS 42
13	Government - Education	NAICS 61 (public)
14	Government - non-Education	All other public

EMPLOYMENT VALIDATION THINGS TO BE AWARE OF

How do employment indicators inform decision-makers, stakeholders, and analysts? Metro decision-makers typically focus more on the household forecast than the employment forecast. Employer location decisions are idiosyncratic, and land available for jobs is unevenly distributed throughout the region. However, job locations are an important factor in household location decisions, and also contribute significantly to travel patterns in the regional transportation model.

What affects the forecast of employment variables and/or assembling the observed, "real-world" observations of employment? There are some tax policy differences between Oregon and Washington. In particular, Washington has a sales tax and Oregon does not, so the current model may over-predict retail and service employment in Clark County and, consequently, to under-predict retail and service employment in Oregon.

City of Portland imposes a business income tax on employers that the other Oregon MSA counties do not. Portland city also imposes an Arts Tax on residents.

The LEHD data may suffer from geocoding errors and inconsistencies, as well as industry classification inconsistencies in the time series. Consequently, observed data may exhibit changes over time that do not represent real changes in employment but rather inconsistencies in mapping or classifying the data in different years. Locations of government employers, in particular, seem to have become more accurate over time. Some adjustments have been made to correct for this issue but only where the problem was obvious.

NON-RESIDENTIAL (EMPLOYMENT) SUB-MODEL VALIDATION

INDICATOR: EMPLOYMENT CAPTURE RATE (UGB SUMMARY LEVEL)

Background

How does Metro compute this variable? The employment capture rate refers to the number of jobs locating within the Metro urban growth boundary relative to the larger Portland MSA, typically reported as a percentage.

$$Capture\ rate = \frac{UGB\ employment\ change}{MSA\ employment\ change}$$

The modeled capture rate is calculated using an ezone approximation of the UGB, so the observed data have been calculated using that same approximated UGB. The four industry supersectors are defined as follows:

retail = NAICS44_45 + NAICS71 + NAICS72

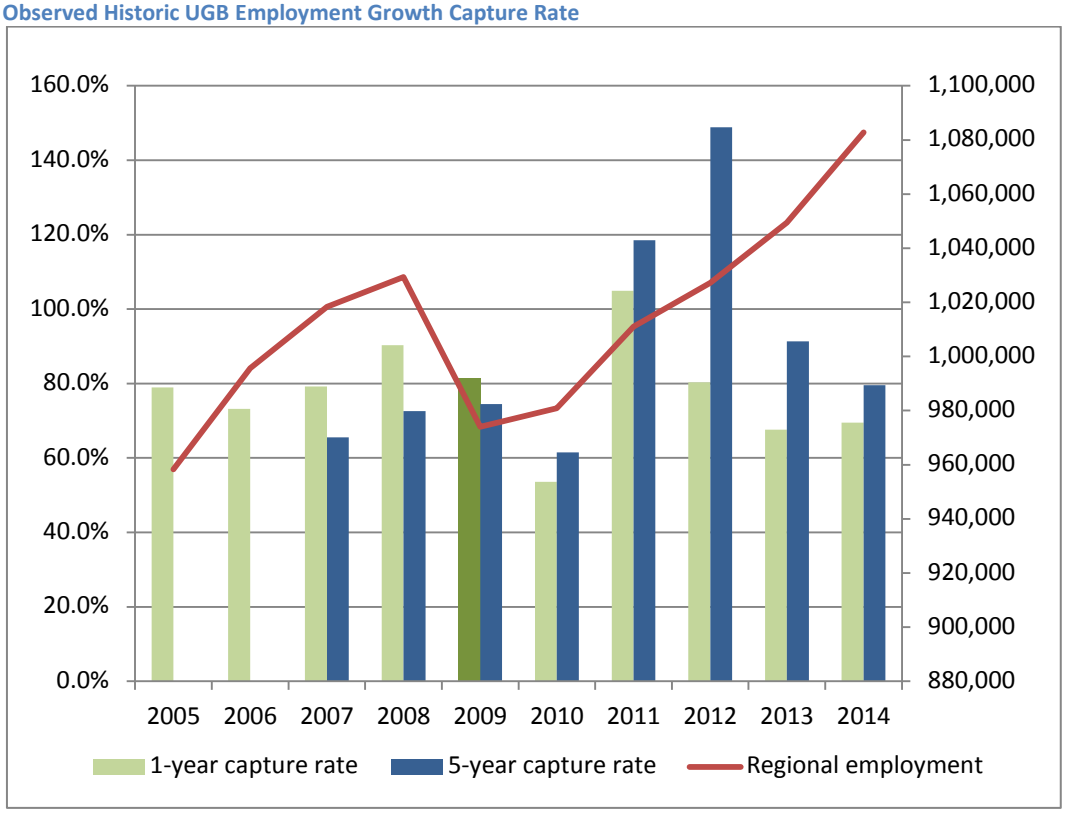
service = NAICS81 + NAICS22 + NAICS42 + NAICS51-56

industrial = NAICS48_49 + NAICS31_33

other = NAICS11 + NAICS21 + NAICS23 + NAICS61 + NAICS62 + public sector

Validation results

Figure 5: Observed Historic UGB Employment Growth Capture Rate



Note: employment declined from 2008 to 2009, with 81% of the loss occurring within the UGB.

Table 2: Forecast vs. Observed Total Employment UGB Capture Rates

Geography	Observed 2003-2008	Observed 2009-2014	Observed 2004-2014	Forecast 2010-2020
7-County MSA	112,991	108,793	158,368	272,742
UGB (defined by ezone)	82,055	86,551	123,485	201,666
% increment in UGB	73%	80%	78%	74%

Table 3: Forecast vs. Observed Supersector Employment UGB Capture Rates

Supersector	Observed 2003-2008	Observed 2009-2014	Observed 2004-2014	Forecast 2010-2020
Retail	74%	86%	81%	54%
Service	77%	86%	81%	71%
Industrial	66%	75%	27%	80%
Other	71%	73%	78%	85%

Discussion

The chart above illustrates the 1- and 5-year UGB capture rates observed since 2004. The 1-year rate has varied widely from a low of 54% in 2010 to a high of 105% in 2011 (implying a loss of employment outside the UGB while employment continued to increase inside the UGB). The 5-year capture rate for all employment has varied from 66% to 149%. The 5-year capture rates for 2003-2008 and 2009-2014 may be of particular interest because they cover two periods of consistent positive growth in employment in the region. These rates are 73% and 80% respectively, which may represent a reasonable forecast range for the employment capture rate over the long term. At the supersector level, the capture rates have ranged from 66% to 86% over the observed time periods, with an outlier of 27% for industrial employment from 2004 to 2014. Capture rates are uniformly higher across industries in the most recent 5-year period compared with earlier observations.

MetroScope under-predicts the share of total employment growth locating within the UGB compared with the most recent 10-year trend data, however, the forecasted capture rate is within the bounds set by the two 5-year capture rate statistics. The model's performance is less accurate at the supersector level. The forecasted capture rates for all four industry groups are outside of the range of observed historical capture rates. Retail and service employment are both under-predicted within the UGB relative to the rest of the region. This may be, at least partially, due to the sales tax difference between Oregon and Washington that is not currently accounted for in the model. Industrial and other employment are both over-predicted within the UGB.

INDICATOR: EMPLOYMENT GROWTH (DISTRICT SUMMARY LEVEL)

Background

How does Metro compute this variable? The change in employment across districts has been calculated as shares, so that shares across all districts adds up to 100%. None of the three validation time periods accurately match the nominal forecasted growth increment, so this treatment allows for the comparison of the spatial distribution of job changes despite this mismatch.

The four industry supersectors are defined as follows:

retail = NAICS44_45 + NAICS71 + NAICS72

service = NAICS81 + NAICS22 + NAICS42 + NAICS51-56

industrial = NAICS48_49 + NAICS31_33

other = NAICS11 + NAICS21 + NAICS23 + NAICS61 + NAICS62 + public

Validation results

Figure 6: Forecast vs. Observed Total Employment Growth by District

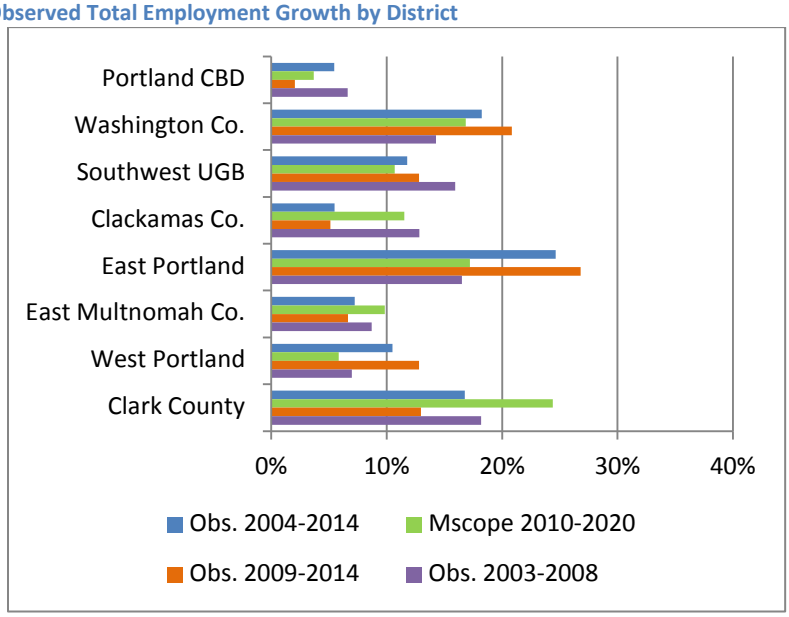


Figure 7: Forecast vs. Observed Retail Employment Supersector Employment Growth by District

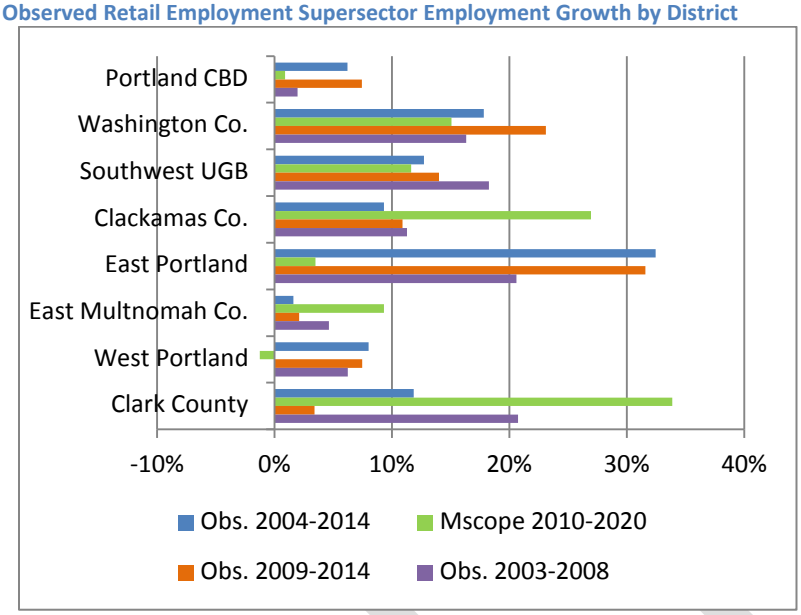


Figure 8: Forecast vs. Observed Service Employment Supersector Growth by District

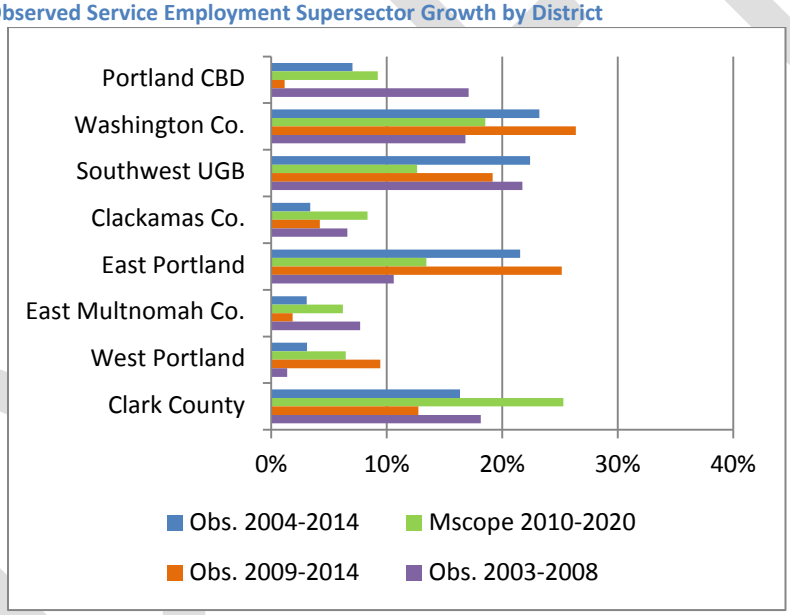


Figure 9: Forecast vs. Observed Industrial Employment Supersector Growth by District

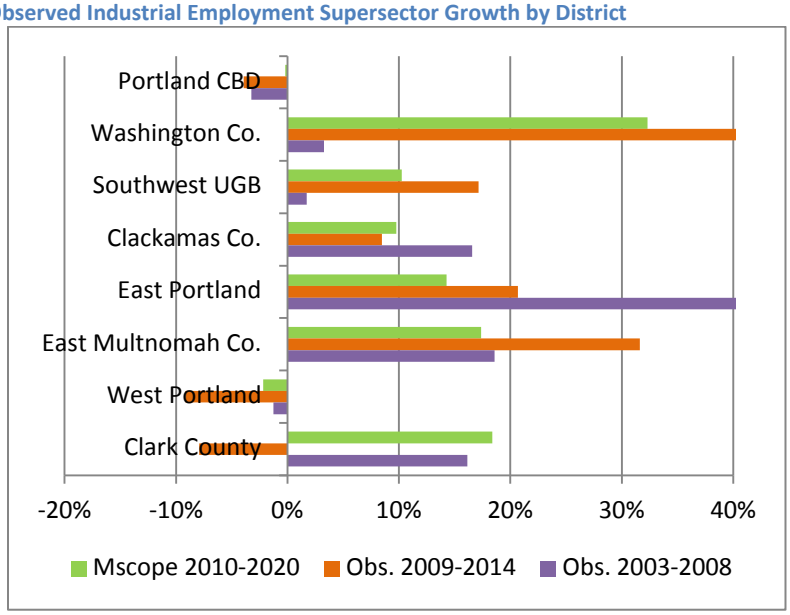
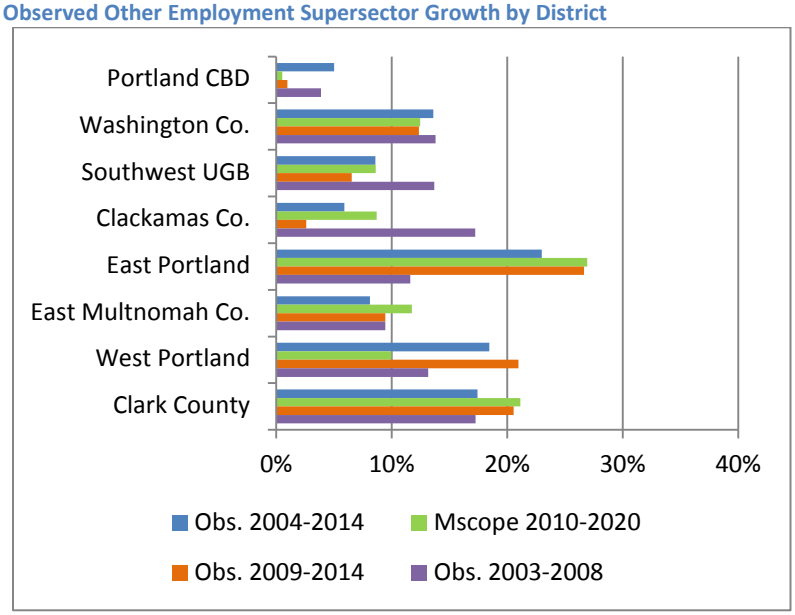


Figure 10: Forecast vs. Observed Other Employment Supersector Growth by District



Discussion

The model over-allocates employment to Clark County compared with recent employment trends. Staff note that there are some significant differences in the spatial patterns observed from 2003 to 2008 and 2009 to 2014. In the more recent time period, a much larger share of employment growth happened in East and West Portland (the close-in neighborhoods excluding the central business district) as well as Washington County. Actual employment growth gravitated away from Clark County, Clackamas County and the southwestern suburbs.

As previously noted, the model over-predicts retail employment in Clark County at least in part due to the sales tax difference between Oregon and Washington. The model also over-predicts retail

employment in Clackamas County, and significantly under-predicts retail jobs in the East and West Portland districts.

Historical growth patterns for service employment have varied widely over the last ten years, so using the 2003 to 2008 and 2009 to 2014 district shares as upper and lower bounds gives a wide range for reasonable forecast results. By that standard, MetroScope is performing within historical trends for most districts.

The 10-year time period from 2004 to 2014 was excluded from the industrial employment chart because industrial employment declined over that period and the resulting spatial pattern of those losses is not meaningful in these validation computations.

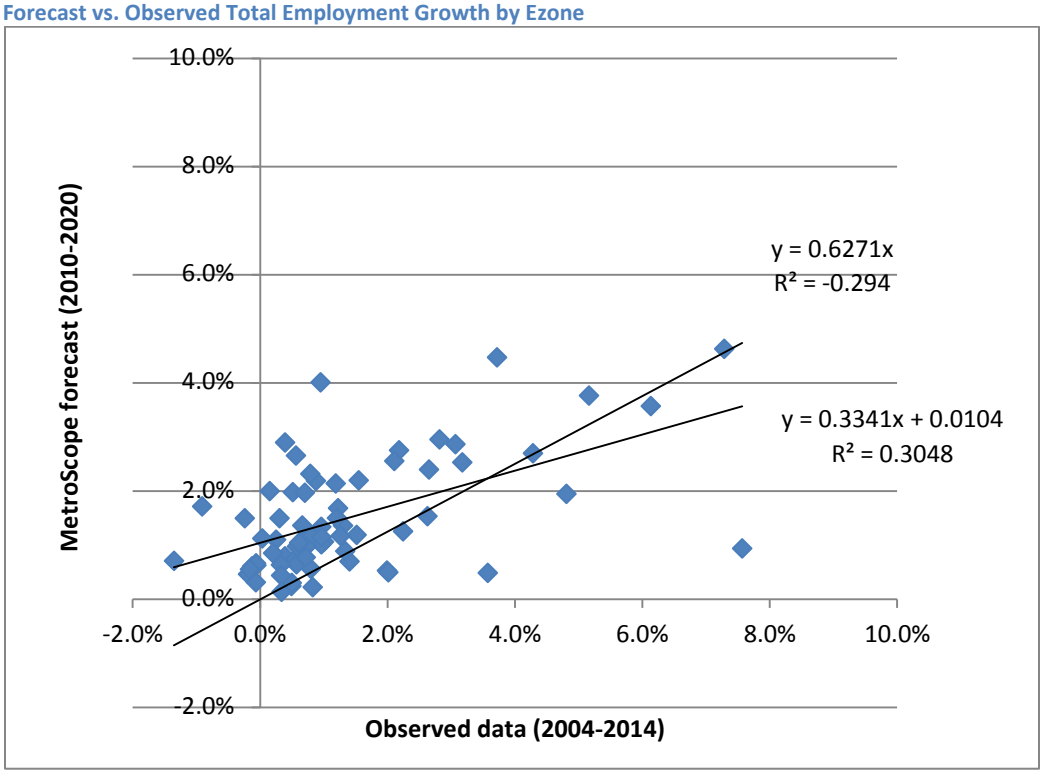
INDICATOR: EMPLOYMENT GROWTH (EZONE SUMMARY LEVEL)

Background

How does Metro compute this variable? Scatter plots quickly display a comparison between modeled and observed employment changes. The change in employment across zones has been calculated as shares, so that shares across all Ezones add up to 100%.

Validation results

Figure 11: Forecast vs. Observed Total Employment Growth by Ezone



Discussion

The spatial allocation of MetroScope employment has been plotted against observed data for the 10-year time period from 2004 to 2014. Perfect correlation between the two data sets would have all data points falling on a 45 degree line from the origin. Two different trend lines are included on this plot, with one forced through the origin and the other allowed to have a nonzero intercept. The trend line through the origin has a slope of 0.62, indicating correlation in the right direction, but the negative R^2 value indicates a very poor fit. The unconstrained trend line has a slope of 0.33, a positive intercept, and R^2 around 0.3.

RESIDENTIAL (HOUSEHOLD) SUB-MODEL VALIDATION

INDICATOR: RESIDENTIAL CAPTURE RATE (UGB SUMMARY LEVEL)

Background

How does Metro compute this variable?

The residential capture rate is a broad measure of household growth in Metro's Urban Growth Boundary (UGB). It is defined as a ratio of an increment of household growth in the UGB divided by growth for the entire MSA for a specified time period, represented as a percentage. Typically the residential capture rate appears as a 20 year projection and has been compared against various historic time spans of at least 5-years and up to a span of 20 or more years.

$$\text{Res. Cap. Rate} = \frac{(H_{t2}^{UGB} - H_{t1}^{UGB})}{(H_{t2}^{MSA} - H_{t1}^{MSA})}$$

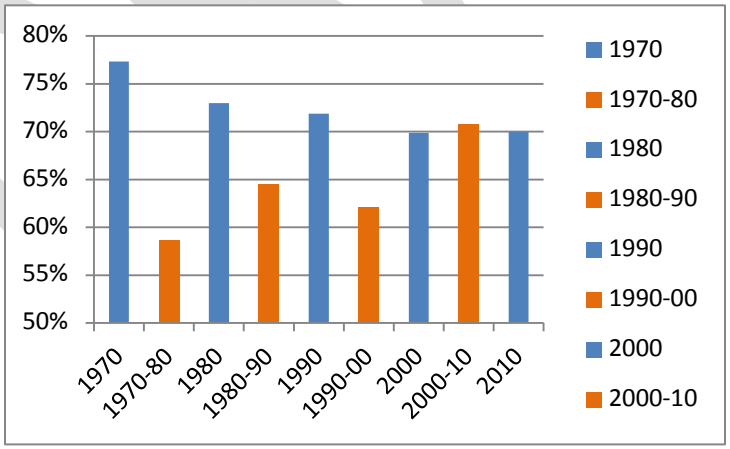
Where H is number of households, and t1 and t2 are time endpoints for a specified time span.

How does this variable inform decision makers, stakeholders and analysts?

Policy makers and stakeholders rely on a capture rate forecast as a headline performance indicator for forecasting housing demand. State law mandates Metro produce a 20-year housing need forecast. The capture rate projection thus represents "the number of units and amount of land needed . . . for the next 20 years" for the UGB [ORS 197.296] and is critical to Metro's key decision regarding land use: whether or not to expand the UGB.

How has the region performed historically?

Figure 12: Observed Historical UGB Capture Rate and UGB Household Share



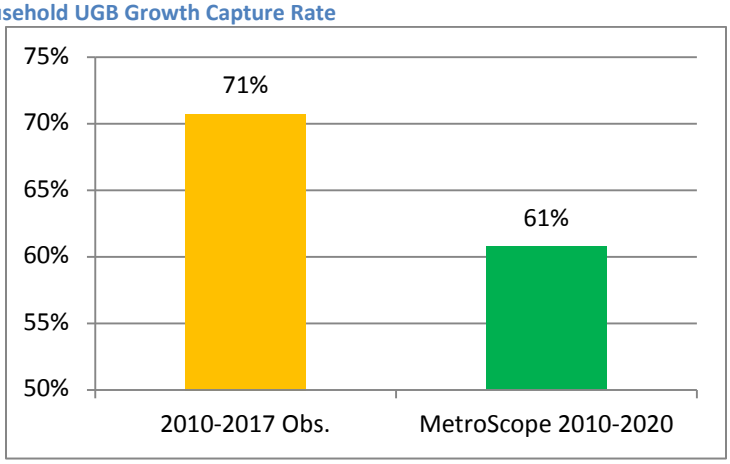
Blue bars indicate inside-UGB share of all households within the MSA from Decennial Census data.
(Share = ratio of UGB to MSA households)
Orange bars indicate capture rate
(% of incremental household growth between Census years occurring within UGB).

What should forecast consumers be aware of?

The Metro UGB line moves with future UGB amendments but for the validation tests the UGB is fixed. The UGB does not follow census tract boundaries exactly but for estimation purposes staff assume an aggregation of census tracts that approximates the actual UGB.

Validation results

Figure 13: Residential Household UGB Growth Capture Rate



Discussion

The model projects a lower capture rate (61%) than recent observations (71%). However, historic capture rates are not static. The rate has swung between 60 percent and 70 percent depending on the point in the business cycle. Recent data show the Metro UGB growing faster than its adjacent neighboring communities, but the MetroScope model is under-predicting this growth. This difference may in part be due to the model's previously-mentioned need to "ramp up". Second, the regional business cycles and the Great Recession temporarily decreased affordability with effects on the actual location choices of residents. Metro does not expect the model to forecast events such as recessions.

INDICATOR: TENURE CHOICE (UGB SUMMARY LEVEL)

Background

How does Metro compute this variable?

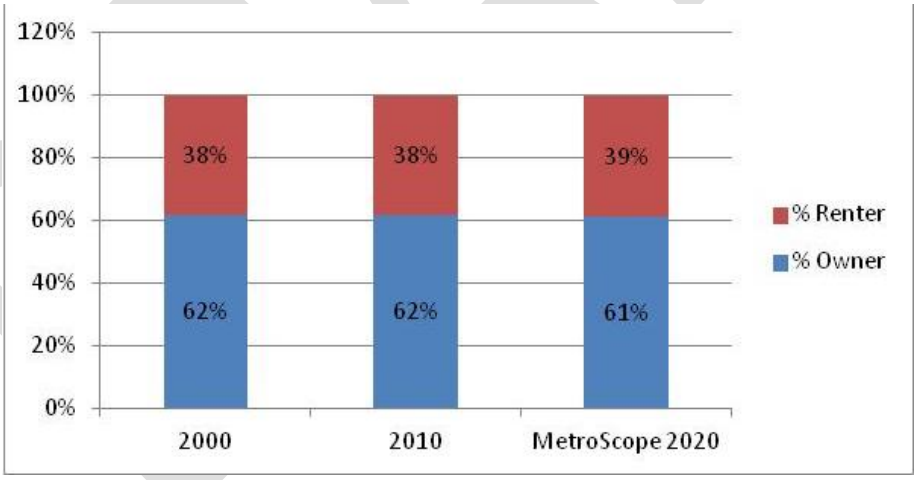
Tenure means the U. S. Census Bureau's definition of owner and renter occupied housing units. MetroScope forecasts growth in the number of households by census tract in 5-year increments. The model forecast tenure choice via a logit equation which estimates the probability of consumers to own as a function of travel times to work opportunities and socio-economic characteristics (household size, income, age bracket). Tenure choice equilibrates through iterative price adjustments to a set of weighted location (zonal) price indices. As mentioned above, observed data came from Census 2010 and ESRI sources.

How does this variable inform decision makers, stakeholders and analysts?

State law requires Metro to forecast "needed housing" by "housing types determined to meet the need shown for housing within an UGB at particular price ranges and rent levels" The law also specifies making available sufficient quantities of "single family and multi-family housing for owner and renter occupancy". [ORS 197.303] Residential tenure choice (percent of households owning in single-family and multi-family types) informs discussions about regional housing affordability and the demand for housing type.

How has the region performed historically?

Figure 14: Regional (all Districts) Historic vs. Forecast Housing Tenure Proportions for all Households



Note: 2000 and 2010 Census are based on total households, not growth increments

What should forecast consumers be aware of?

The current MetroScope model simulates consumer tenure choice but does not simulate suppliers' decisions to offer housing of different tenures (although Metro staff have begun developing enhancements that could do so). In order for MetroScope to solve for equilibrium, model users must assert a tenure assumption for residential and mixed use residential (MUR) zoning. In practice these assumptions enter the model as part of the buildable land supply inputs. The model's provision of housing by type (single-family and multi-family) and by location (tract or Rzone)

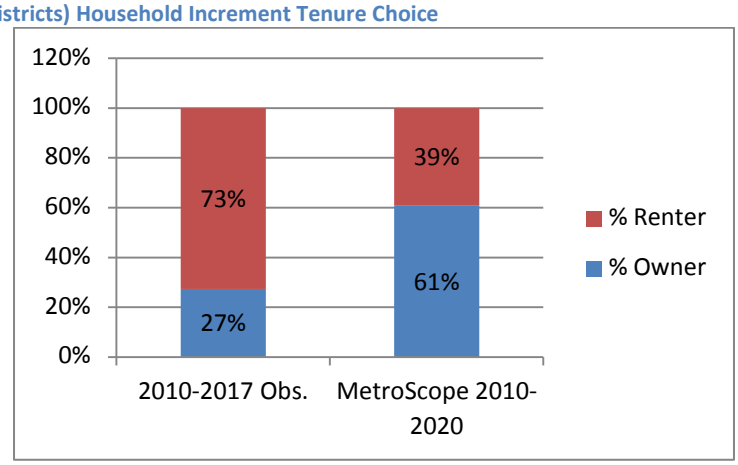
interact during model iterations to change the overall total rate of ownership as the model reaches equilibrium.

Buildable Land Supply Tenure Assumption

- Residential SF zoning: 80% own; 20% rent
- Residential MF & MUR zoning: 20% own; 80% rent

Validation results

Figure 15: Regional (all Districts) Household Increment Tenure Choice



Discussion

For model validation and calibration Research Center staff examine the tenure proportion both of total households within the region (see chart *Regional Historic vs. Forecast Tenure Proportions for all Households*) and of new (incremental) households within the region (chart immediately above). Since MetroScope allocates growth increments the latter is very important but should be interpreted in view of the total results.

While the model's incremental performance on tenure is consistent with the 2000 and 2010 Decennial Census data which indicates 62% of total households being owner-occupied in both years, the observed incremental tenure data is in marked contrast in showing an ownership choice rate of only 27%. Given this Metro staff would particularly value peer review input on the tenure validation and real-world conditions.

Recent economic worries and in flux social trends may be reasons underlying the recent drop in homeownership rates. Homeownership is affected by affordability concerns on two fronts – total cost of the home and the income to serve debt or ongoing rent of that home. The Great Recession, a slow job recovery, stagnant wages, and a much higher debt load of recent college graduates have likely combined to lower the income of first-time home buyers. At the same time regional home construction costs rose sharply due to higher labor costs and softwood lumber prices. Research Center staff welcome peer reviewer input on the tenure results and the ESRI data source.

INDICATOR: HOUSING STRUCTURE TYPE CHOICE (UGB SUMMARY LEVEL)

Background

How does Metro compute this variable?

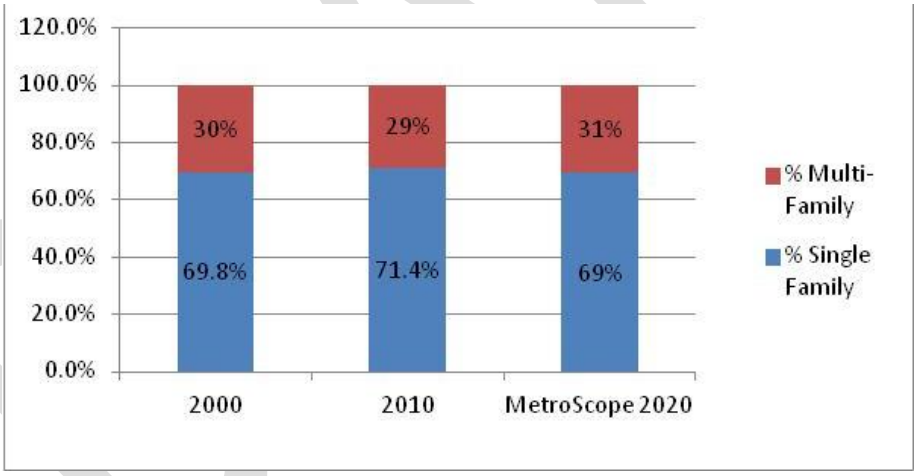
Single family (SF) housing type is defined as 1-unit detached, 1-unit attached and mobile homes as defined by the Census. Multifamily (MF) housing is defined as any structure with two or more units. MetroScope forecasts structure type choice by a set of four logit equations which estimate consumer utility by dwelling type as a function of a travel time index and socio-economic characteristics (household size, income, age bracket). These utilities inform the probabilities that a household type will reside in a SF or MF structure. Structure type equilibrium is reached by iterative price adjustments to a set of weighted location price indices. Observed structure type comes from Metro's own RLIS housing datasets.

How does this variable inform decision makers, stakeholders and analysts?

Housing type is one of several key performance metrics identified under Oregon law. State law requires Metro to evaluate UGB management on the basis of needed housing by type (and tenure). [ORS 197.303]

How has the region performed historically?

Figure 16: Regional (all Districts) Historic vs. Forecast Housing Type Proportions for all Households



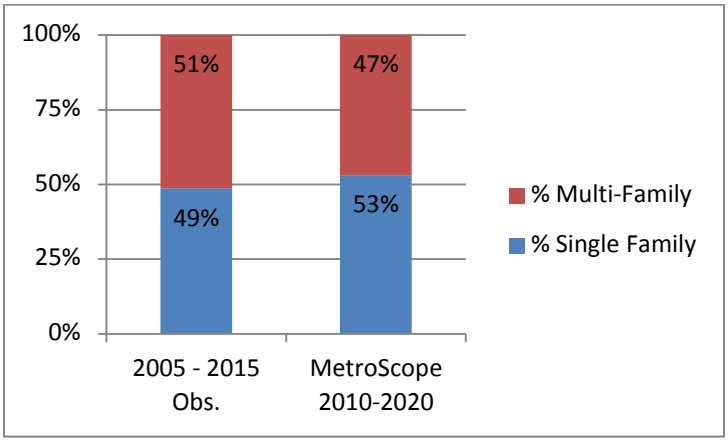
What should forecast consumers be aware of?

Accessory dwelling units (ADU) are an emerging development type that MetroScope does not explicitly forecast. ADU's are excluded from this analysis.

Metro staff believe that there is great uncertainty in the Census ACS housing type data. This may be attributable to sampling error. For type comparison staff turned to Metro's RLIS Tax Lot databases to compute observed single and multifamily counts (2005 to 2015).

Validation results

Figure 17: Regional (all Districts) Household Increment Type Choice



Discussion

As with housing tenure choice, for validation Research Center staff examine the type proportion both of total households within the region (top chart) and of new (incremental) households within the region (bottom chart).

Both observed and forecast data show similar SF / MF splits. However, neither set of rates closely match the 2000 and 2010 Decennial Census type proportions of all households within the region. 2000 Census reading of the percent of housing units in the MSA which are 1-unit attached, 1-unit detached or mobile home category add up to be 69.8 percent. In the 2010 Census, the reading was 71.4 percent.

Metro staff invite peer reviewers to comment on the type validation and the real-world conditions that may affect the recent observations.

INDICATOR: HOUSEHOLD LOCATION CHOICE (DISTRICT SUMMARY LEVEL)

Background

How does Metro compute this variable?
Location choice is determined after tenure and type choices are made. The model distributes households by four types (OSF, RSF, OMF, and RSF)[1] in locations where the supply is available to accommodate this array of housing demand. Iterating housing costs by each type and household market segments' income constraints produces a market clearing equilibrium solution.

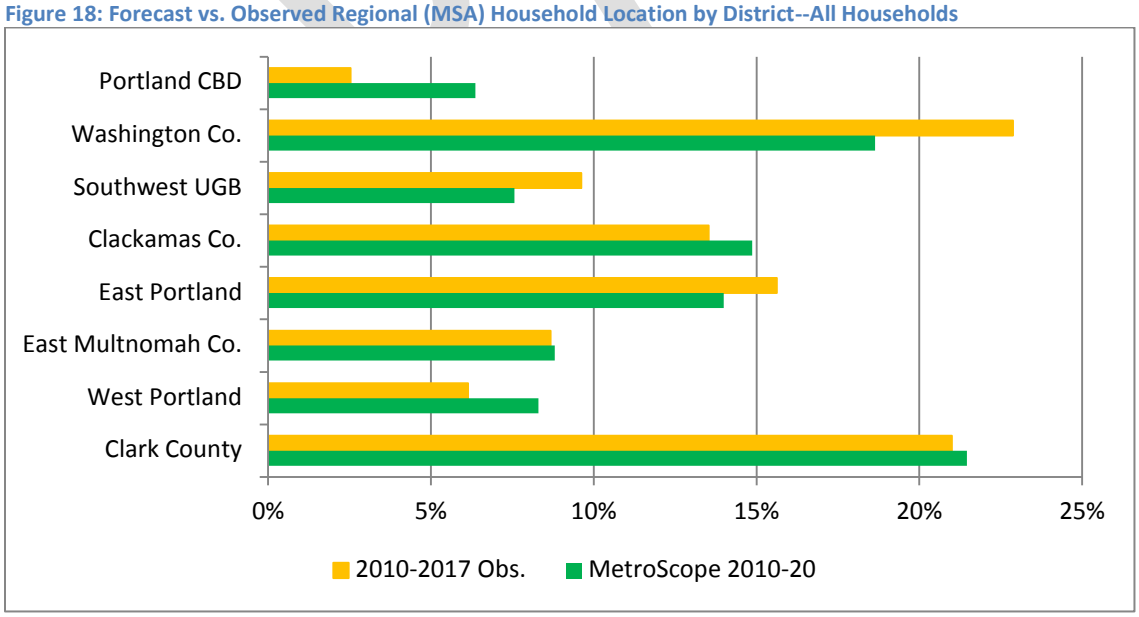
How does this variable inform decision makers, stakeholders and analysts?
District household location summaries provide staff a first-pass view of how well the model allocates households spatially. The districts used were defined to assist travel demand forecast model calibration and validation, based on observed travel flows within the region. The district summaries thus show at a high level whether travel forecasts based on MetroScope land use allocations are likely to be robust.

What should forecast consumers be aware of?

Household location choice is particularly sensitive to the aforementioned model "ramp up" phenomenon in the first forecast five-year cycle. Despite base year calibration, the model still seems to require an extra period to adjust itself. The observed data also covers both the tail end of the recession and a post-recession surge of demand and housing prices across the Portland area.

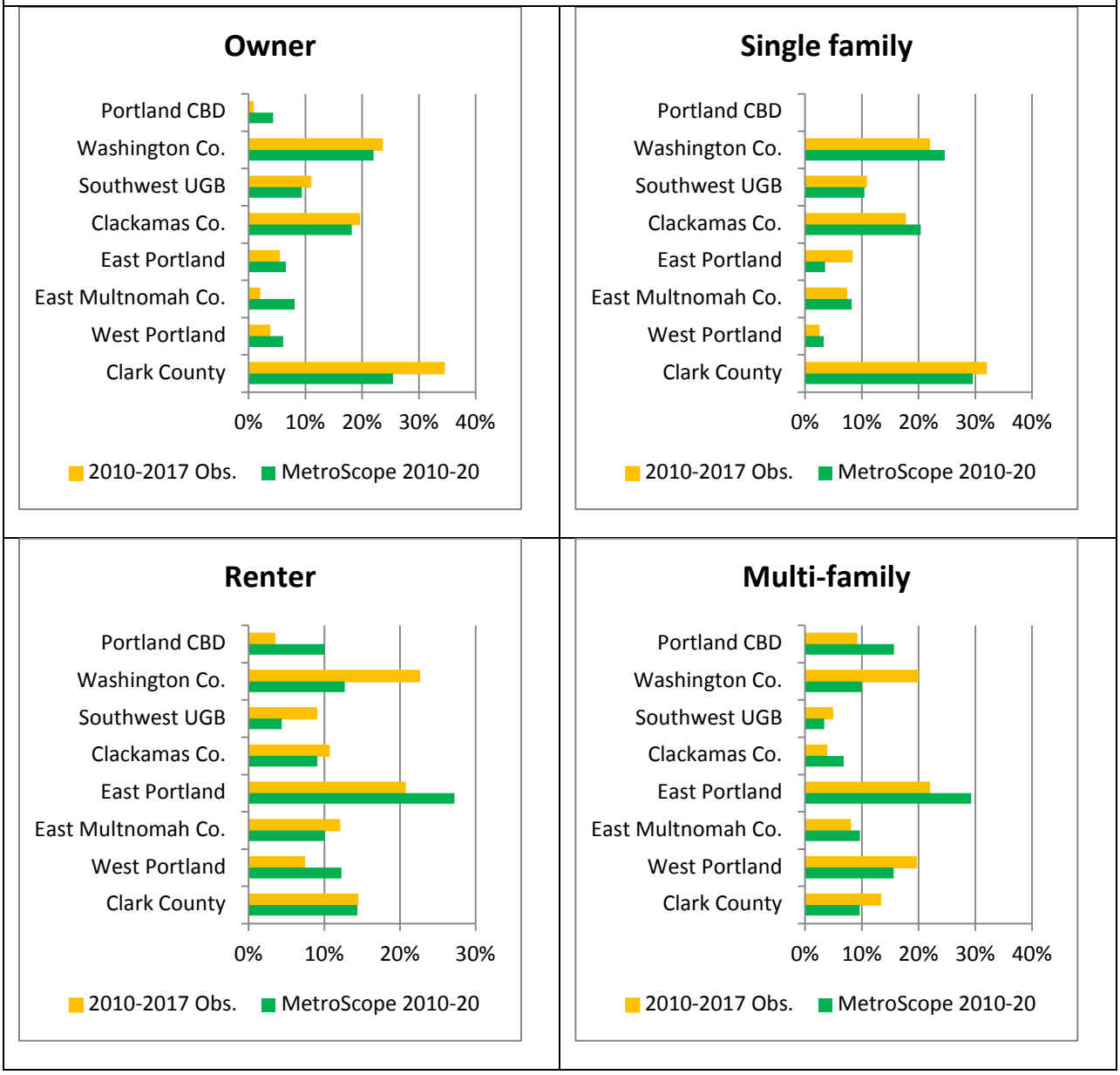
Validation results

Figure 18: Forecast vs. Observed Regional (MSA) Household Location by District--All Households



[1] Owner Single Family (OSF); Renter Single Family (RSF); Owner Multifamily (OMF); Renter Multifamily (RMF)

Figure 19: Forecast vs. Observed Regional (MSA) Household Location by District, Households by Type or Tenure



Discussion

The MetroScope forecast for all households is on target for Clark county and East Multnomah County districts. The greatest discrepancies in all households between the observed and forecast data appear in Washington Co. and the Portland CBD districts.

This mismatch with observed history may be due in part due to production swings caused by the Great Recession, the model's time scale being insensitive to short-term oscillations in business cycles.

INDICATOR: HOUSEHOLD LOCATION CHOICE (EZONE SUMMARY LEVEL)

Background

How does Metro compute this variable?

For purposes of validation, coincidence ratios are used to compare observed and forecasted geographic distribution of households. In using the coincidence ratio, the ratio in common between two distributions is measured as a percentage of the total area of those distributions.

$$CR = \left\{ \frac{\sum_T [min(PM_T, PO_T)]}{\sum_T [max(PM_T, PO_T)]} \right\}$$

Where CR is the Coincidence Ratio; PM_T is the proportion of modeled distribution in interval T; PO_T is the proportion of observed distribution in interval T; and T is the Ezone index

Staff calculated coincidence ratios for the following variables to test the accuracy of the household locations at the smaller Ezone summary level:

- Total new households(growth increment)
- New owner household location choice
- New renter household location choice
- New SF household location choice
- New MF household location choice

How does this variable inform decision makers, stakeholders and analysts?

MetroScope uses Ezones (Ezones are aggregations of Census tracts; there are 72 Ezones in the model space) as the geographic unit at which to examine travel time between potential household locations and their work opportunities. Staff use Ezone summaries of household location choice as a second-pass (after the district summaries shown above) look at how well the model allocates households spatially.

What should forecast consumers be aware of?

Coincidence ratios are calculated on the incremental share of observed history (2010 to 2017) and MetroScope forecast (2010 to 2020). Applying the ratio using seventy-two Ezone bins may be subject to some aggregation bias; staff welcome expert panel advice on using this test this way.

Validation results

Validation Term	Coincidence Ratio (Ezone summary level)
• Total household count (growth increment)	0.596
• New owner household location choice	0.378
• New renter household location choice	0.548
• New SF household location choice	0.646
• New MF household location choice	0.562

Discussion

MetroScope explains about sixty percent of the observed distribution of total households by Ezone, about 65% of SF household location, and about fifty-five percent of renter household location by Ezone. Owner location by Ezone is the weakest fit at about thirty-eight percent.

INDICATOR: HOUSEHOLD LOCATION CHOICE (RZONE SUMMARY LEVEL)

Background

How does Metro compute this variable?

For purpose of validation, we calculate an absolute percent difference for the following variable set:

- New owner HH location choice
- New renter HH location choice
- New SF location choice
- New MF location choice

How does this variable inform decision makers, stakeholders and analysts?

Oregon land use regulations guide development inside UGB's to preserve farm and forest lands. Metro code and municipal comprehensive plans provide broad guidance on what form of development can exist by zoning district.

Household location forecasted within the MetroScope Rzone (Census tract) system underlies the regional capture rate and thus drives policy discussions about UGB expansion (although small-geography details do not inform UGB decisions); it is also a crucial input to later work that allocates growth to traffic analysis zones for transportation planning analytics.

For model calibration and validation, staff can see at the tract level how closely forecasts replicate a period in history at the geographic scale native to the model.

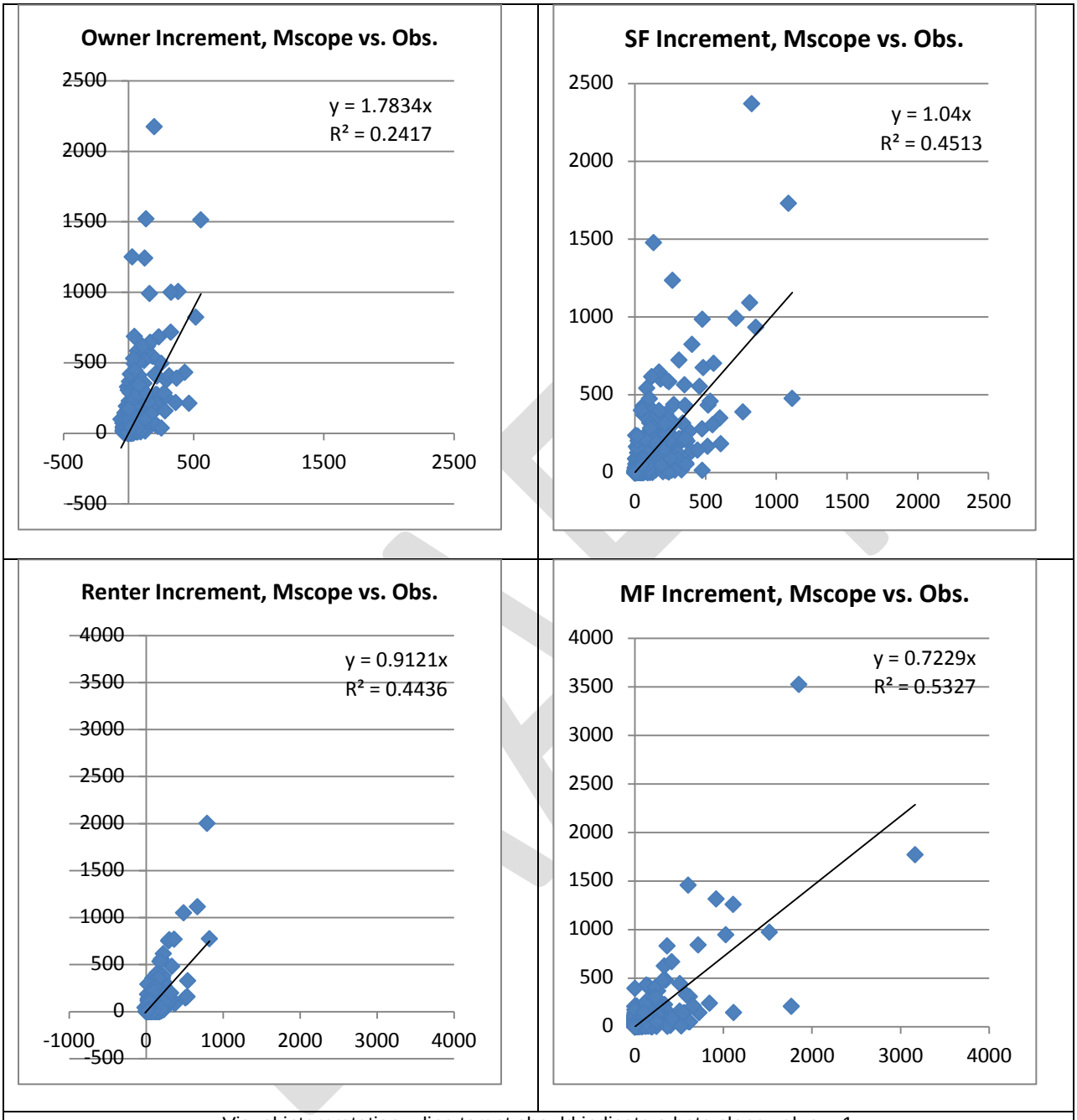
What should forecast consumers be aware of?

Observed tenure data are from Census and ESRI. Observed SF and MF housing type are tabulated from Metro's RLIS database. The scatterplot is a common visual tool for examining model fit. The R-squared values must be interpreted with caution since the model does not estimate household location directly by linear regression, but the they do give an at-a-glance appreciation of the model's success at the zonal level spatial allocation and the slope of the linear trendline gives staff and stakeholders an understanding of whether the model generally over- or under-allocates households by type or tenure at the Rzone (tract) level.

Validation results

Scatterplots, below, show the degree of fit between observed and forecast estimates for housing by tenure and by structure type.

Figure 20: Forecast vs. Observed Location Choice by Rzone, Incremental Households by Type or Tenure



Visual interpretation – line target should indicate a beta slope value = 1

Note: x-axis is observed data and y-axis is the MetroScope forecast

Discussion

The results show dispersion between observed and forecast values, based on the relatively low R-squared fit. Based on the trendlines and R-squared the model appears to deal fairly well with the location of SF and renters.

The fit for owner increment appears worse than it may actually be because the observed data from 2017 ESRI sources contains a fairly sharp drop in estimates of ownership in the region.

INDICATOR: RENTER HOUSING COST – GROSS RENT

Background

How does Metro compute this variable?

Rents are defined by the Census definition of *gross rents*, which include the *contract rent* plus an estimate of *utility fuel cost*. Census ACS 2015 5-year (Table B25063) is the data source for the observed data. The data are total price, not price increments. The comparison of gross rents is made between the observed 2015 and MetroScope forecast of 2015 level price data.

The gross rent data is sample information obtained in the year of the survey. The 5-year ACS data set is a moving 5-year survey window. The accuracy of the survey data is subject to sampling error, possible error in estimating utility costs and the consumer price deflator used to adjust inflation. Values are adjusted to 2015 dollars.

MetroScope calculates an equilibrium bid price for renter-occupied units across eight price bins which staff later disaggregate into twenty-one different price bins for comparison to Census data Bar charts for each of the eight district summary levels visualize the high-level fit of forecast rents to observed rents. Staff computed the coincidence ratio of forecast-to-observed distributions for each Rzone for the twenty-one price bins, then charted the distribution of Rzone-level coincidence ratios by ratio bins.

How does this variable inform decision makers, stakeholders and analysts?

Analysts compare model results to determine how tight land supplies are relative to latent demand. Policy makers may include this forecast information as a means of gauging the degree of housing affordability or testing the relative economic welfare of growth scenario alternatives.

Since the model adjusts prices during its iteration toward equilibrium and price outputs are valuable information for stakeholders, accurate price estimation should be a sign of robust model performance. The district-level comparative distributions give a broad sub-regional look at how well the model forecasts prices, while staff use Rzone-level coincidence ratios (not shown) to examine example zones during model calibration. The distribution of Rzone-level coincidence ratios gives an aggregate indicator of how well the model is fitting its price distributions looking at all Rzones taken together.

What should forecast consumers be aware of?

The set of charts below compare the rent distribution of households by Census rent categories. The shares of renter households add to 100% in each district.

Supply conditions (which are input at the Rzone level) can have a profound effect on the model's price estimation, since many other factors may make certain locations attractive to households.

Validation results

Figure 21: Forecast vs. Observed Incremental Renter Price Distributions, by District (yellow=observed; green=MetroScope forecast)

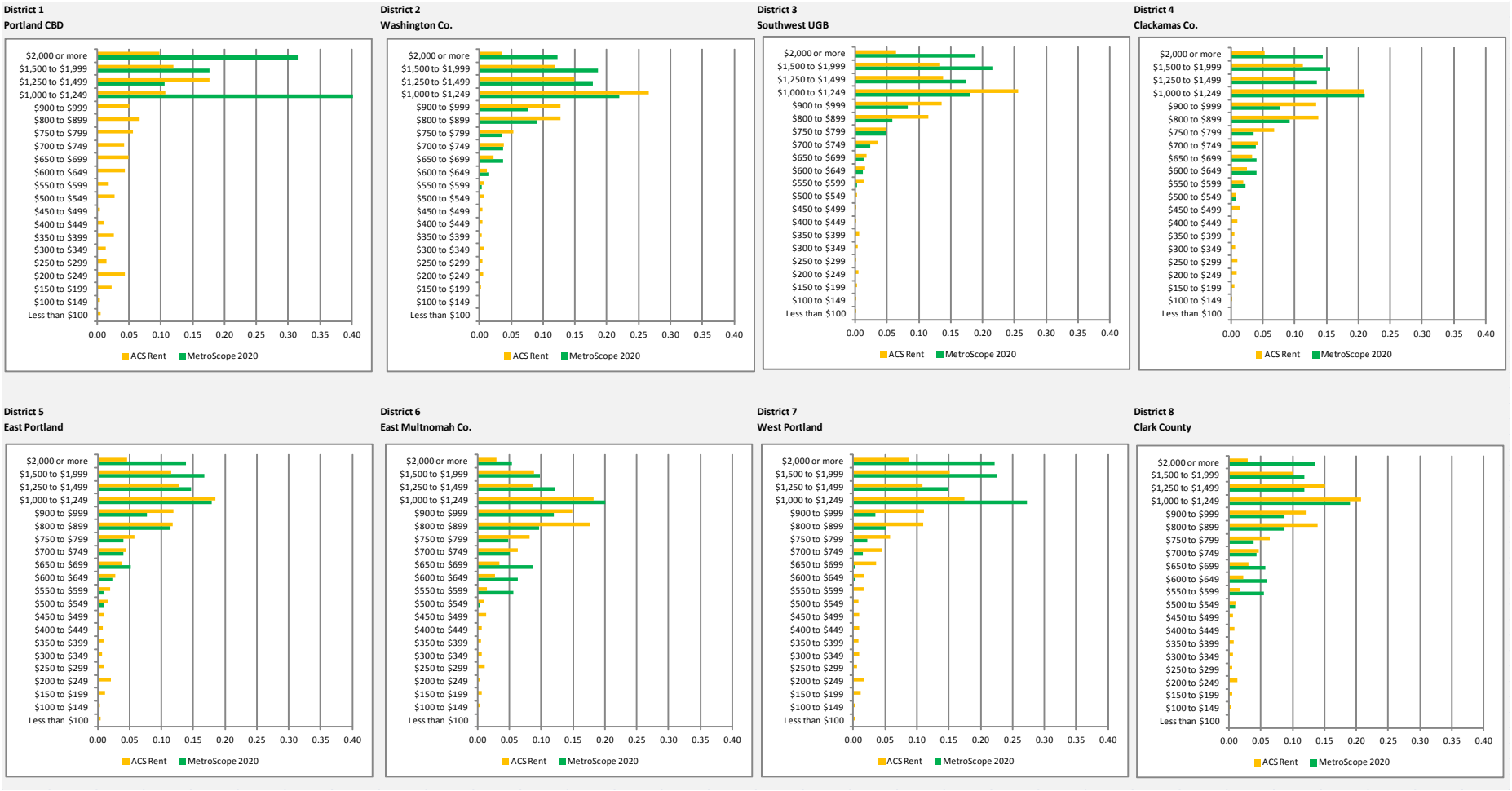
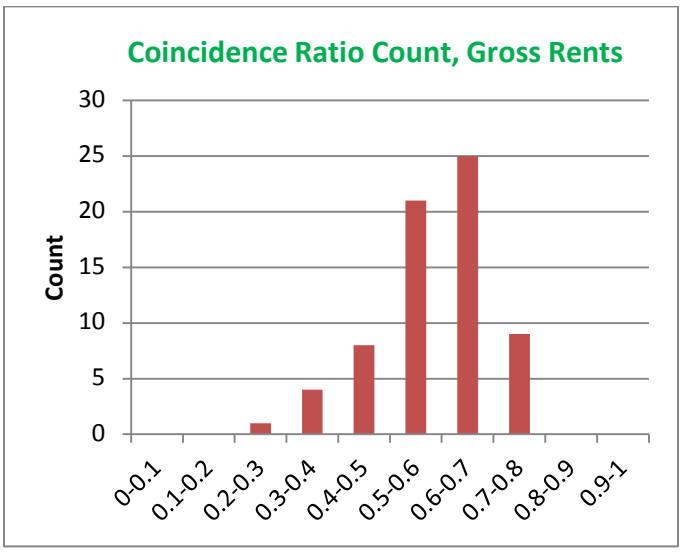


Figure 22: Observed vs. Forecast Renter Price (Gross Rents)—Distribution of Rzone Coincidence Ratios by Ratio Bin



(revised chart)

Discussion

The coincidence ratios reveal half of the Ezones with a ratio greater than 0.6 for gross rents, indicating that the model matches a good part of observed price distributions in about half of the region. This is consistent with the district level compared distributions which in general show that the majority of the forecast price distributions by district coincide with the observed distributions.

Rent forecasts in the Portland CBD (district 1) do appear higher than observed, perhaps due to the fact that the model does not account for the fairly large number of low-end rents from single room occupancy (SRO) and subsidized units for low income residents in the CBD.

INDICATOR: OWNER HOUSING COST – VALUE

Background

How does Metro compute this variable?
Housing value is defined by the Census definition in which the surveyee estimates the property worth if it were for sale. Census ACS 2015 5-year (Table B25075) is the data source for the observed data. The data are total valuations, not price increments. The comparison of housing value is made between the observed 2015 and MetroScope forecast of 2015 level price data. The data on value is also referred to as "asking" or "ask" price.

MetroScope calculates an equilibrium bid price for owner-occupied units; this is as if the simulated household market segment was buying the property on the open market.

How does this variable inform decision makers, stakeholders and analysts?
Analysts look closely at the owner price statistics since Metro has fairly good data on residential owned housing unit pricing. Policy makers also tend to pay close attention to the owned price index as they discuss the meaning of forecast scenarios.

As with rental units, MetroScope uses owned unit prices as a lever to move the model toward convergence in an iterative process. Accurate price estimation would be a sign of robust model performance. The district-level comparative distributions give a broad sub-regional look at how well the model forecasts owned unit prices, while staff use Rzone-level coincidence ratios (not shown) to examine example zones during model calibration. The distribution of Rzone-level coincidence ratios gives an aggregate indicator of how well the model is fitting its price distributions looking at all Rzones taken together.

What should forecast consumers be aware of?

The set of charts compare the distribution of owner valuations of households by Census value categories. The shares of owner households add to 100% in each district.

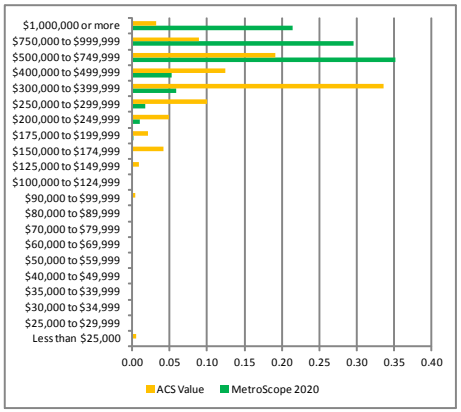
The observed value data is sample information obtained in the year of the survey. The 5-year ACS data set is a moving 5-year survey window. The accuracy of the survey data is subject to sampling error, possible respondent error in judging estimated sales value and the consumer price deflator used to adjust inflation. Values are adjusted to 2015 dollars.

As with the renter price indicator, supply inputs have a significant effect on the model's price estimation since many other factors may make certain locations attractive to households.

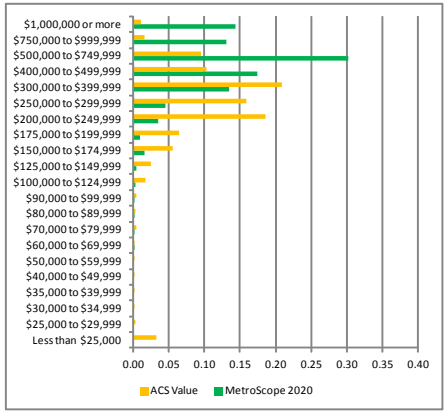
Validation results

Figure 23: Forecast vs. Observed Incremental Owner Value Distributions, by District (yellow=observed; green=MetroScope forecast)

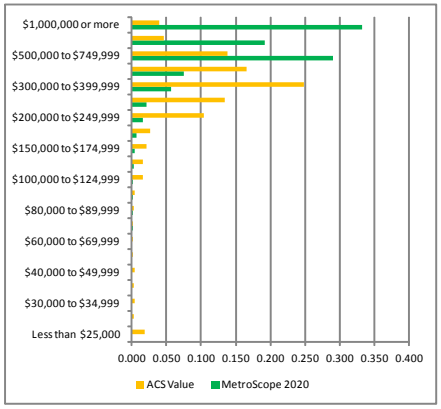
District 1
Portland CBD



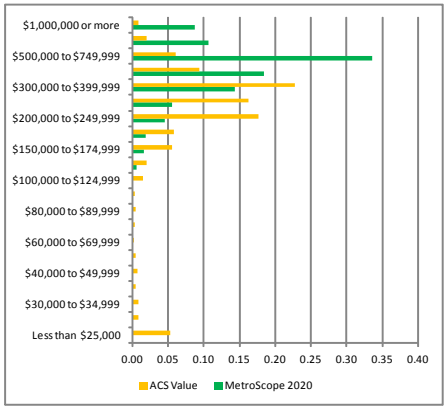
District 2
Washington Co.



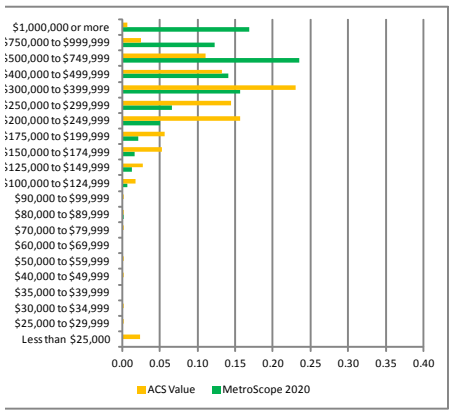
District 3
Southwest UGB



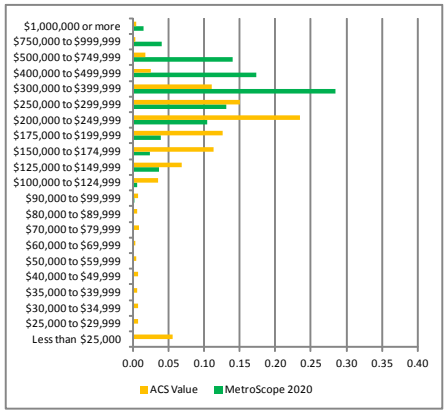
District 4
Clackamas Co.



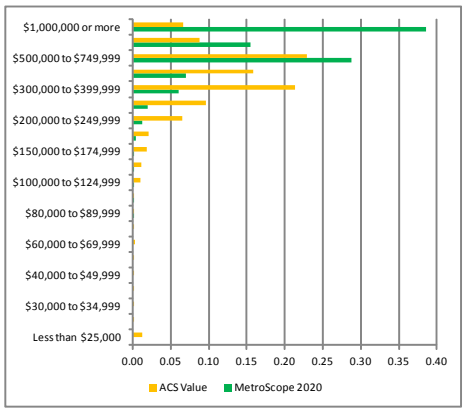
District 5
East Portland



District 6
East Multnomah Co.



District 7
West Portland



District 8
Clark County

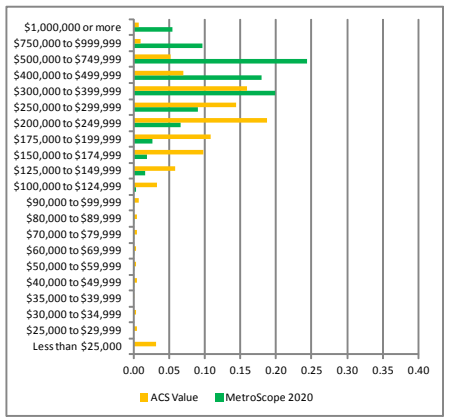
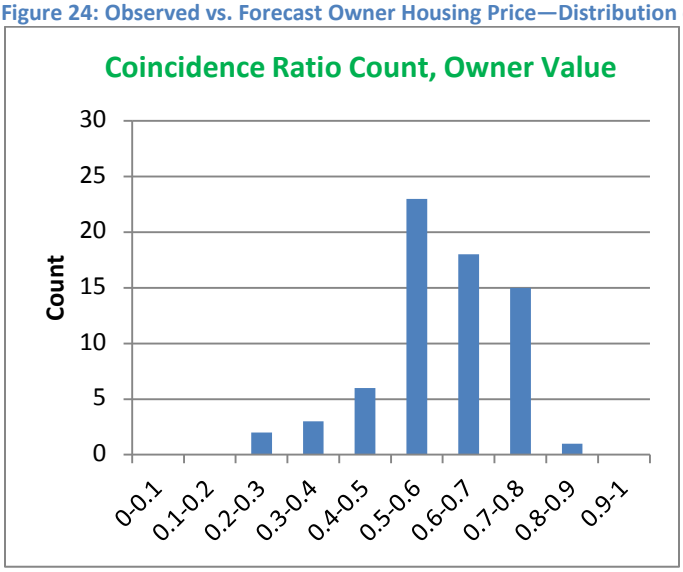


Figure 24: Observed vs. Forecast Owner Housing Price—Distribution of Rzone Coincidence Ratios by Ratio Bin



(corrected chart)

Discussion

MetroScope owner valuations reflect the willingness to pay given the economic ramifications asserted in the forecast drivers and budget constraints of each household type. Forecast ownership valuations are generally greater than the observed values, with more households forecast at higher price points as shown in the district-level compared distributions. This may be because Census values are based on owner perceptions of own home values which can lag real market values.

The Rzone-level coincidence ratios cluster around the 0.5 and 0.7 range, indicating that the forecast of owner valuation matches fairly well against the observed housing valuations.

Research Center staff welcome peer review feedback on this validation test and especially the quality of the ACS price data used for the comparison above.

SENSITIVITY TESTS APPENDIX

Sensitivity test findings comprise the second part of this validation report. They are packaged in a separate document file.

OVERALL VALIDATION FINDINGS

Model Purpose

As mentioned in the MetroScope methodology documentation, this model has two primary purposes: to forecast household and employment spatial allocations to inform Metro Council's cyclical decisions on whether to expand or not expand the Urban Growth Boundary (UGB), and to provide household and employment allocations to serve as inputs into a separate process that sub-allocates growth to Transportation Analysis Zone (TAZ) geographies for other planning purposes. The UGB decision must (by law) be made on a region-wide basis while the TAZ-level data product is by design intended to be accurate at a much finer level of geographic detail for transportation and additional land use planning applications. Other model outputs, especially housing price, may be relevant to both purposes.

Discussion

As peer reviews pointed out, data limitations preclude Metro from forecasting precisely the same time span for which observed data is available. Allowing for that, Metro observes that MetroScope performs reasonably well at geographically allocating households and employment at the regional scale. This is evidenced by reasonable fit shown in the capture rate and allocation-by-district validation criteria. The land use model estimates of housing prices perform adequately for regionwide reporting of consumer housing prices and rents for comparative purposes. This is evidenced by the counts of zonal-level price distributions and coincidence ratio tests which show that the model's forecast distributions by zone replicate much of the variability in the observed distributions for a large majority of zones. MetroScope seems to slightly over-estimate prices at the district scale for owned housing, but this may be because observed prices are based on perceptions in owner surveys instead of actually reported sales figures.

This report suggests several points regarding model limitations. First, additional research is recommended to modernize and fine-tune the model for smaller-scale applications such as the Distributed Forecast TAZ-level product. Second, the market segmentation in MetroScope does not include race and ethnicity – MetroScope forecasts thus do not provide specifics on questions of racial equity. Third, in general the model was not validated at the level of individual household and employment-type market segments and thus should not be used to draw conclusions about these market sub-group delineations.